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# Microwear features on vein quartz, rock crystal and quartzite: A study combining Optical Light and Scanning Electron Microscopy

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ABSTRACT

In general, quartz and most of non-flint rocks have not been extensively studied from a functional point of view. Very frequently the definitions of micro-features connected with flint surfaces have been used to describe those encountered on non-flint tools. This circumstance has repeatedly posed serious methodological problems for evaluating the accuracy of functional results when analysing use-wear on quartz and quartzite implements. This is due to the intrinsic divergences in morphology and distribution of use-wear with regard to the different lithic raw materials.

Even though important efforts to systematise use-wear features on quartz have been done almost since the beginning of the discipline, there continues to be confusion and lack of standardisation regarding terminology in this aspect.

In this paper, we try to contribute to new insights in this research by means of selecting examples from an extensive experimental programme involving different raw materials: from rock crystal (the purest form of quartz found in nature) to vein quartz and quartzite, with the latter two materials extensively used for knapping throughout Prehistory and still poorly understood in terms of microwear. For data recording, we preferentially used sequential experiments and resorted to both Optical Light and Scanning Electron Microscopy.

We focused our interest on describing the main groups of wear features. The results obtained allowed us to assess the different mechanical behaviours under the stressors induced by tool-use from a group of raw materials with the same chemical composition but very different in structure. Furthermore, we propose the revision of some terms commonly employed when documenting micro-wear on quartz and similar rocks, as well as recurring concepts coming from materials and geological sciences (e.g. tribology, quartz exoscopy...).



## 1. Introduction

Use-wear studies of non-flint/chert raw materials have not been sufficiently developed in the past and for this reason functional interpretation of such materials is still problematic. This relies on the fact that analysts concentrated their efforts in analysing assemblages mainly composed by flint or chert (generically referred thereafter as chert), because of the feasibility of these material to the easy observation of wear with light microscopy. Therefore, based on wide reference collections, analysts came to broadly know the specific use-wear patterns connected with different actions and worked materials contributing to the creation of a solid methodology (e.g.Semenov, 1964; Tringham et al., 1974; Keeley, 1980; Vaughan, 1985; Van Gijn, 1990).

Most attention is presently paid to the improvement of the technological studies of assemblages composed by quartzose materials (quartz and quartzite), as demonstrated by the contributions to this volume. To join this increasing interest in those materials, it

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is worth reviewing their role within the history of lithic use-wear analysis, and evaluating the methodological problems connected with detecting use-wear on them. For instance, previous studies (e.g. Grace, 1990; Igreja, 2009; Borel et al., 2014) have discussed the difficulty of microscopically analysing coarse materials, such as quartz, quartzite and basalt (as well as for other rocks including coarse particles of other minerals). This can be explained sometimes by the high reflectivity and the resulting bright diffraction halo of the rocks analysed (quartz, quartzite, rock crystal or hyaline quartz) and sometimes by the great irregularity of the flaked surfaces (sandstone, quartzite, basalt, rhyolite). However, a paradox on the suitability of use-wear analysis of quartz using the standard high-power method, especially when post-depositional processes affect the lithic assemblages, has been highlighted (Knutsson, 1988b:122).

At the same time, when definite circumstances promoted the functional study of non-chert raw materials, very extensive and complete methodologies have been constructed (Knutsson, 1988a; Knutsson et al., 1988; Richards, 1988; Sussman, 1988; Hurcombe, 1992; Clemente-Conte, 1995/2008). Usually, this occurred when the great abundance of these types of rocks in some regions was largely reflected in the archaeological lithic assemblages coming from those regions (e.g. Kamminga, 1982; Knutsson, 1988b; Derndarsky, 2009; Eigeland, 2009; Kononenko, 2011). Although based on very in-depth investigations, those contributions alone were not enough to establish a universally recognised method to perform use-wear analysis of those materials. In some cases (Knutsson, 1988a) a very thorough description was presented, combining specific traces with relative actions and worked material, which resulted in very useful comparative tables. Of course, the fact that the method did not reach a general acknowledgement has nothing to do with the quality of the method as such, but with the fact that, in this case, quartz hardly gained the interest of use-wear analysts.

Often the analyses of those materials required procedures to overcome the methodological limitations posed by the classical microscopic analysis, which is based on the reflected light observation. Other microscopic techniques have been employed to improve the potential of use-wear analysis on non-flint materials. Among these techniques, the Scanning Electron Microscope (SEM) revealed to be very useful for imaging purposes from almost the beginning of the discipline (Borel et al., 2014; Ollé and Vergès, 2014, and references therein), and, more recently, the Laser Scanning Confocal Microscope (LSCM) ushered a really promising progress in terms of wear quantification (Derndarsky and Ocklind, 2001; Evans and Donahue, 2008; Stemp et al., 2013; Ibáñez et al., 2014).

Moreover, terminological confusion introduced new problems in an already complicated discipline predominantly dependant on the personal experience of the analyst (Grace, 1996). In fact, very frequently different terms were employed to define the same use-wear trait or sometimes the same term was used to describe different traces. Also, direct analogies between traces found on chert and non-chert implements were made, underestimating the fact that use-wear develops differently on distinct raw materials (Greiser and Sheets, 1979; Clemente-Conte, 1995/2008, 2015; Lerner et al., 2007; Clemente and Igreja, 2009).

Quartzose materials were extensively used in the knapping activity in Prehistory and so it would be desirable to improve use-wear analyses on them. Beside, these materials tend to present better preservation conditions than chert, for example, which is more resistant to post-depositional processes (Knutsson, 1988b). Actually, sometimes use-wear analysts are not able to analyse chert artefacts because of the presence of strong patinas or desilicification processes. This is one of the reasons why we initiated an extensive experimental programme aimed to monitor use-wear formation on lithologies with a very similar basic chemical composition (vein quartz, rock crystal and quartzite). All of those materials are formed by macrocrystalline quartz crystals, but their structures are very different (grain size, flatness, etc.). This programme is currently being built to assist the study of the archaeological materials from the following Palaeolithic sites: Gran Dolina-TD10, Burgos, Spain (Ollé et al., 2013), Santa Ana, Cáceres, Spain (Carbonell et al., 2005), Payre, Ardèche, France (Moncel et al., 2008) and Cova Eirós, Lugo, Spain (Rodríguez et al., 2011).

The main aims of the current project are to assess the degree to which inter-rocks variability among quartzose materials affects use-wear formation and development and also to assess the point at which they present a similar use-wear pattern. For this reason, we highlight the need to precisely and independently describe the main groups of use-wear features on each lithology, to then later compare them. In parallel to the general description of the use-wear patterns associated to each raw material, we consider some propositions on terminological aspects to describe use-wear on quartzose raw materials.

Additionally, we explore the advantages and disadvantages of different microscopic techniques in relation to each of the materials taken into consideration. In fact, the type of microscopic equipment employed to perform functional studies, and the specific expertise of the analysts in doing it, might influence the description of use-wear to some degree. For example, use-wear traits are imaged differently depending on the employed microscope and analysis conditions, and also some traces may or may not be detectable depending on the resolution reached by each observation technique and settings chosen.

## 2. Materials and methods

### 2.1. Experimental programme

Experiments and results shown here do not take part of an *ad hoc* programme, but derive from different recent or still ongoing programmes aimed to furnish the needed reference collections to interpret the results obtained in the aforementioned archaeological sites (Ollé, 2003; Martin, 2012; Fernández-Marchena, 2013; Aranda et al., 2014; Pedergnana and Ollé, 2014; Fernández-Marchena and Ollé, 2016; Pedergnana and Ollé, 2016; Pedergnana et al., 2016). All these experimental programmes share the use of different quartzose materials, from different varieties of quartzite to vein quartz and rock crystal. Although these programmes include traditional, controlled and sequential experiments (Ollé and Vergès, 2014), we especially selected examples of the latter type, as they allow the subsequent phases of surface modification to be monitored and the evolution of the micro-relief to be precisely tracked throughout the course of the activity performed.

The monitoring of the wear process was especially interesting in this context because we did not aim to offer a catalogue of wear traces, but to learn how the main wear features originate and evolve on the selected materials after having performed similar actions. In other words, we study the mechanism of wear formation from the progressive development of a worn surface, tracing its progressive modification at single points throughout the use process.

The detailed procedures and general advantages of such sequential experiments have been recently discussed (Ollé and Vergès, 2014). In short, we systematically record the development of use-wear traces at several points in order to document the variability of the effects of a given action on the active edge of a tool as closely as possible. Thus, the experimental tools were analysed before use and then at specific intervals during their use.

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