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Microscopic analysis of technical and functional traces as a method for the use-wear analysis of rock crystal tools

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ABSTRACT

Rock crystal is a high-quality quartz variety with an excellent aptitude for knapping. Although it is relatively uncommon, in certain geological contexts such as that of our case study, rock crystal can serve as the raw material for a substantial number of tools. Nevertheless, very little research has been devoted to the study of this material. This lack of interest may stem from a variety of sources, from the difficulty of analysing a translucent material to its direct attachment to the symbolic world. Here we propose a methodology for the microscopic analysis of rock crystal artefacts in order to establish a better approach for understanding the functionality of this raw material. We comprehensively analysed a series of experimental tools before use by means of different microscopic equipment (OLM with a Nomarski prism and SEM). After the initial documentation, the tools were used in a sequential experimental programme in order to monitor and document the development of use-wear traces. Fourteen experiments were conducted on different materials and with different actions in which the different use traces as well as their respective orientations and sizes were recorded over a series of established times. The set of experiments resulted in different associations of use-wear traces (striations, chipping, rounding and polish) characteristic of the various worked materials and actions employed. We also documented how a technical mark such as the lancet can provide functional information. This is due to the formation process of the mark by percussion or pressure. While lancets formed from the impact point on the ventral side are distributed radially, those created by flake removal follow the kinematics of the tool. Finally, we demonstrated that rock crystal is a material that offers great possibilities for use-wear analyses once a set of technical and functional associations of mark analyses have been determined. Furthermore, although OLM with a Nomarski prism proved to be highly suitable in the analysis of rock crystal, its combination with other techniques such as SEM can provide additional information.

1. Introduction

Research on rock crystal industries, as well as that conducted on other ‘rare’ raw materials, is still very scarce despite recent methodological developments related to their study. Raw materials other than flint still do not receive the same analytical treatment, as discussed in various works (e. g. Driscoll and Warren, 2007; Ballin, 2008; Driscoll, 2010, 2011) or even in specific monographs on this topic (Moloney et al., 1996; Bracco, 1997; Sternke et al., 2009). This research behaviour has been termed ‘flint-centric‘ (Rodríguez Rellán and Fábregas Valcarce, 2006; Fábregas Valcarce and Rodríguez Rellán, 2008), mainly because of the persistence of the French typological approach and the typological lists established with regard to the morphological characteristics of the conchoidal fracture of flint (which are harder to interpret on other raw materials).

Not all non-flint rocks and/or minerals have received the same consideration (or lack thereof); for example quartzite and obsidian have been quite studied. This is because they both exhibit conchoidal fracture, which makes their technical analysis closer to that of flint. Moreover, quartzite is a very frequent in archaeological assemblages.

In any case, the study of rock crystal is unusual for a few different reasons. Firstly, it is a scarce material in the archaeological record. Its prismatic morphology and, above all, its hyaline character have made it the focus of very little research (Eigeland, 2009). These two characteristics are also the reason for the multiple

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magical-symbolic ascriptions to these materials, which often lack any functional approach (Petrin et al., 2012). In this same sense, rock crystal is sometimes considered a non-utilitarian material both in its natural form and when knapped (Moncel et al., 2012).

The aforementioned attributions must be carefully tested, especially through functional analyses of traces and residues. A used artefact cannot be considered non-utilitarian, but those attributed to magical-symbolic uses are much more difficult to contextualise. Ethnographic and ethnoarchaeological works provide a wealth of data about the use of crystals (Levi, 1978; Brady and Prufer, 1999; Koerper et al., 2006). They are often part of the shaman's toolkit (Brady and Prufer, 1999), while at other times they may be used as talismans (charmstones) (Levi, 1978) or even as containers of the soul or living stones (Levi, 1978). When a crystal acquires the category of a living stone its use has to be controlled by a shaman, and it therefore cannot be knapped or modified (Levi, 1978).

Thus, crystals modified to serve as ornaments cannot be categorised as magical or living stones. This does not mean that the same societies that venerated crystals did not knap or modify them, but that some of them were invested with a sacred character (Levi, 1978). In fact, they have been recovered from sites modified or with asphalt (Koerper et al., 2006). At any rate, it must be pointed out that many of the ethnographic references to rock crystal are references to other crystallised minerals, mainly those with prismatic shapes (Levi, 1978; Brady and Prufer, 1999; Koerper et al., 2006).

Leaving aside the possible unproven functional attributions of rock crystal, we should point out another aspect that hinders the study of this raw material. This aspect responds undoubtedly to the fact that rock crystal is a variety of quartz, so many times its study is merely an element count (e. g. Ortega and Maroto, 2001). In the 1990s, technological work with quartz and rock crystal began to take on some relevance (Chelidonio, 1990; Novikov and Radililovsky, 1990; Villar Quinteiro, 1991; Villar Quinteiro et al., 1992; Mourre, 1996; Ramil Rego and Ramil Soneira, 1997). Despite the innovations represented by these works – mainly in the identification of *chaînes opératoires* of quartz and rock crystal – the technological study of these materials continues to be scarce (de Lombera Hermida et al., 2011).

The behaviour of rock crystal when knapped, as well as how it responds to pressure and how it wears, is different to both quartz and flint. It is therefore necessary to understand the specific characteristics of this raw material, as well as the formational processes that differentiate it from quartz.

1.1. *Formation of rock crystal prisms*

To understand the formational processes of rock crystals it is necessary to understand *grosso modo* the formation of quartz, because rock crystal is simply a high quality variety of quartz. Quartz is formed in veins after the cooling of hydrothermal fluids ascending through fractures in the rock or by mobile hydrofractures (Bons, 2001). Such fluids are composed mainly of SiO_2 (tectosilicate group) and are divided into two groups based on the temperature of ascension: α group for temperatures lower than 573 °C, and β for temperatures between 573 °C and 867 °C, although both end up acquiring the structure of the first (Luedtke, 1992). The cooling process of the fluid, as well as the morphology and characteristics of the fracture (i.e. the host rock) will influence the composition (different kinds of inclusions) and the texture of the quartz (Collina-Girard, 1997; Sachanbiński et al., 2008; de Lombera Hermida, 2008, 2009). Although quartz veins are formed in almost every geological environment – sedimentary, metamorphic and volcanic – volcanic environments are the most suitable for these formations because of their siliceous composition, among other factors (Luedtke, 1992). Vein quartz, also generally called milky quartz due to its appearance, is part of the petrographic group of xenomorphic quartz, or crystalline agglomerates (Mourre, 1996).

Rock crystal is generally formed inside these veins, usually creating druses in the geodes or in the hollows. Very stable temperature and pressure conditions (Luedtke, 1992) are required for the crystals to form. These conditions give rise to nucleation by which the silica tetrahedrons start to join, growing spiral shapes that will eventually become the rock crystal prisms (Dibble, 2002). This process can happen in three different ways: first, from floating particles (bipyramidal crystals are formed); second, by fixing to a quartz particle; and third, on top of a crystal of another type (Dibble, 2002).

Rock crystal is a monocrystal that belongs to the group of automorphic quartz (Mourre, 1996). This quartz group has the highest quality, both in composition and in morphostructure (Llana Rodríguez, 1991). The concept of morphostructure is used to divide groups of quartz according to the presence (S) or absence (N) of grains and planes or internal flaws (Llana Rodríguez, 1991; Martínez Cortizas and Llana Rodríguez, 1996; de Lombera Hermida, 2009) (Fig. 1). In this way, these elements can be grouped into four morphostructural groups, with those of the highest quality, like rock crystal, categorised as NN.

However, rock crystal is not completely homogenous. Beyond the inclusions that are incorporated during the growth of the crystal, the quality of the structure varies from the base to the point of the apex. This is because the base is formed on the vein, giving it a higher concentration of inclusions, but also of fracture planes (Ramil Rego and Ramil Soneira, 1997). The apex is the only completely homogenous area of the prism because it is the point from which the prism grows (Ramil Rego and Ramil Soneira, 1997; de Lombera Hermida, 2008; Petrin et al., 2012).

1.2. *Characteristics of the crystals*

Rock crystal is a six-faced prism (Hurbult, 1959; Fábregas Valcarce, 1983; Mourre, 1996; Dibble, 2002). Any prism with a different number of faces is another type of mineral. It is a very brittle material under the stress of shocks, but at the same time it is tenacious enough to knap and has a hardness grade of 7 on the Mohs scale. Its monocrystalline character gives rise to conchoidal fracture because it has no internal fracture planes guiding the impact force, in contrast to all other members of the quartz group (Cotterell and Kamminga, 1987). Nevertheless, knapping rock crystal is not easy. Its behaviour is anisotropic, so the energy does

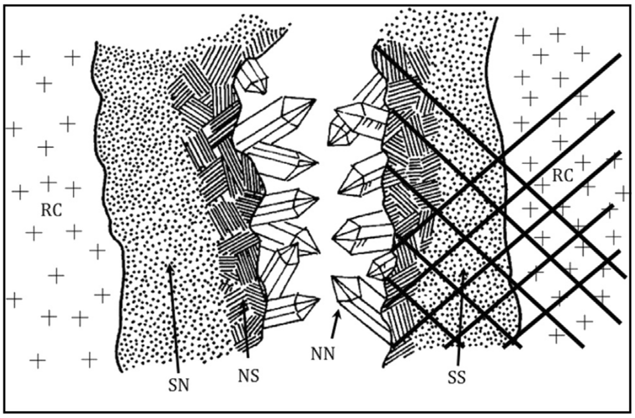

Fig. 1. Vein quartz formation and morphostructural groups (modified from de Lombera Hermida, 2008).

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