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# Quartz morphostructural groups and their mechanical implications

*Arturo de Lombera Hermida* *' **

Directed by : X.P. Rodríguez Álvarez ,* R. Fábregas Valcarce **

*Institut Catalá de Paleoecologia Humana i Evolució Social (IPHES). Área de Prehistoria, Universitat Rovira i Virgili, Tarragona (Spain).
* * Grupo de Estudos para a Prehistoria do Noroeste (GEPN). Universidade de Santiago de Compostela. Santiago de Compostela (Spain).
alombera@prehistoria.urv.cat

## Abstract

Quartz is one of the main raw materials used by the prehistoric communities from the Lower Paleolithic to the Neolithic. Due to the low morphological standardization of the products, traditional typological studies have usually rated quartz as a secondary lithic source and linked it to opportunistic and little complex strategies. Our research shows that quartz petrological features and formation processes are closely related with the morphostructural varieties and the mechanics of flaking.

Le quartz est l'une des principales matières premières utilisées dans les communautés préhistoriques depuis le Paléolithique Inférieur jusqu'à le Neolithique. En raison de standardisation morphologique bas des produits, dans les études typologiques classiques, le quartz est traditionnellement considérée comme un lithique secondaire, preuve de stratégies opportunistes et peu élaborées. Les caractéristiques pétrologiques sont directement liées aux processus de formation, aux variétés morpho-structurelles ainsi qu'à le mécanique de percussion.

**Keywords**: Quartz, technical analysis, discoidal method, raw materials.

## Introduction

Due to its high resistance to weathering quartz is one of the most ubiquitous raw materials, explaining its high frequency in many Paleolithic sites, usually linked to expeditive strategies. Traditionally, it was considered a second-rate resource because of its bad knapping quality, a view originated by the extrapolation of flint technical criteria to other materials (quartz, basalt, quartzite, etc.) and the use of exclusively typological and morphological approaches to classify lithic industries. Also, traditional approaches speak of the homogeneity of this raw material, and about quartz's limited knapping qualities. But new studies regarding quartz formation processes show that there is some variability that affects its mechanical properties.

This paper is a brief introduction to a work aimed to understand the quartz management strategies in three sites from the Middle and Upper Pleistocene: *Locus* I from As Gándaras de Budiño (Galicia, Spain), La Jueria (Catalunya, Spain) and Payre (Ardéche, France). An experimental program and technological approach, applying the Logical Analitical System (LAS) (Carbonell *et al.* 1983, 1992), were carried out to analize these lithic assemblages.

## Petrological characterization

Quartz is a mineral from the techtosilicate group ($SIO_2$). It is one of the most frequent minerals on the Earth and a constituent of sedimentary, metamorphical and intrusive rocks (sandstone, quartzite, granite, etc.) (Bons, 2001; Luedtke, 1992).

Quartz has been traditionally considered as a homogeneous raw material, classified following its external aspect, colour and opacity. Two main types can be observed: hyaline and milky quartz (or vein quartz) (Prous & Lima, 1990). This classification does not take into account the petrological characteristics, neither distinguish the different knapping qualities of the raw material. Due to this apparent homogeneity, technical selection criteria and economical implications are not usually considered (Llana, 1991). For that reason, quartz formation processes must be taken into account in order to establish a good petrological classification and characterization. While the formation processes of quartz and flint (criptocrystalline variant of quartz) are the same, their origin depends on a number of factors and variations in temperature and pressure (Bons, 2001).

Regarding to crystal habit we can establish two large groups within the quartz (Mourre, 1996, 1997): Quartz hyaline (automorph quartz) and vein quartz (xenomorph). Both have a single vein source but differences in environmental conditions give rise to the different varieties.

Automorph quartz, usually called *hyaline* or *traslucent* quartz, need conditions of great stability in terms of pressure and temperature, a large amount of time and enough space between crystals to allow their growth that sometimes reaches decimetrical dimensions (Luedtke, 1992).

The group of vein quartz (xenomorph) presents a greater variability. Precipitation conditions of silica fluctuate with the degree of saturation, temperature and pressure of the solution, giving rise to different types of siliceous rocks. They are polycrystalline massive aggregates whose size depends on temperature differences and cooling rates, density of cores for the formation of crystals, etc. Quartz formed at low and medium temperatures (350 ° and 400 ° C), have larger crystals and the rock may acquire a grainy texture (Bons, 2001; Luedtke, 1992).

In some cases within a single vein various textures can occur due to differences in the speed of cooling (Collina-Girard, 1997). In the outer part of the vein cooling goes faster and there is a greater presence of crystallization cores (impurities from the host rock) so that small crystals are formed, giving the mineral a grainier texture. On the other hand, in the inner part of the vein cooling rates are slower and, if there is enough space, larger crystals can be developed resulting in a macrocrystalline texture. At the same time, disruptions in the flow of the silica solution, inclusions of other minerals, or tectonic forces that affect the vein can produce secundary crystallization surfaces or internal flaws (Bons, 2001; Degorge & Castel, 2006). Thus, for the purpose of distinguishing morphostructural groups of quartz, we shall look at the presence/absence of these variables (texture and internal flaws), we shall distinguish four morphostructural groups of quartz (Martínez & Llana, 1996) (Fig.1):

Grain (G): Distinguishing from grainy quartz (xenomorph) and macrocrystalline quartz (automorph). The first group can be subdivided into fine-grained or coarse-grained quartz.

Plane (P): applied to quartz with internal flaws or crystalline surfaces.

In this way quartz artefacts are classified into four morphostructural groups: NN: no grain, no plane; NS: No grain, plane; SN; grainy, no plane; SS: grainy, plane. This morphostructural classification, related to the formation and mechanical properties of the quartz, allow us to ascertain whether technological or economic criteria have been applied to the selection of quartz artefacts, following social demand (Llana, 1991; Seong, 2004; de Lombera, 2006).

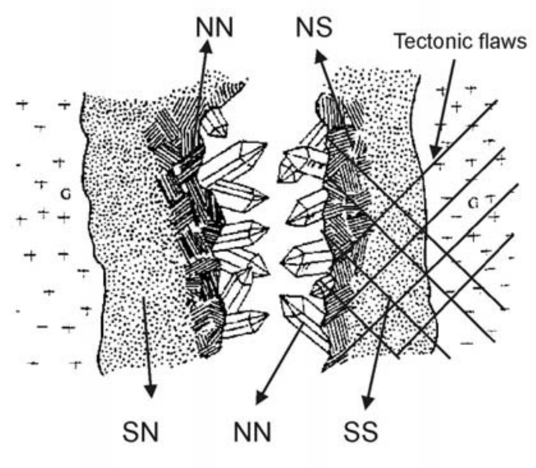


**Fig. 1.** Vein quartz formation and morphostructural groups (Collina-Girard, 1997).

## Mechanical properties

Formation processes and the petrological nature of quartz determine its mechanical properties. Firstly, quartz is not an *homogeneous* material because of the presence of internal flaws and crystalline surfaces, that provoke nonintentional breakage. Only the upper part of large quartz crystals (apice) is homogeneous. Quartz *fracture* ranges from conchoidal to uneven and its *strength* is the same as flint (7 in Mohs scale).

Hence, the resistance of its cutting edges is similar to flint, but its lower elasticity produces much faster edge-breakage and rounding, although this implies some resharpening of the cutting edges, thus prolonging its efficiency (Bracco & Morel, 1998; Knutsson 1988). Quartz *anisotropy* depends on the crystalline structure and its orientation. Due to the crystalline structural weakness (*cleavage*), quartz crystals normally break following oblique orientations.

This pattern is shown in some laminar *hyaline* cores in Upper Paleolithic and Mesolithic sites (Villar, 1991) and by natural fire breakage (Novikov & Radililovsky, 1990; Ramil & Ramil, 1996). Internal flaws and diaclases are more related to the material homogeneity rather than anisothropy *sensu stricto*.

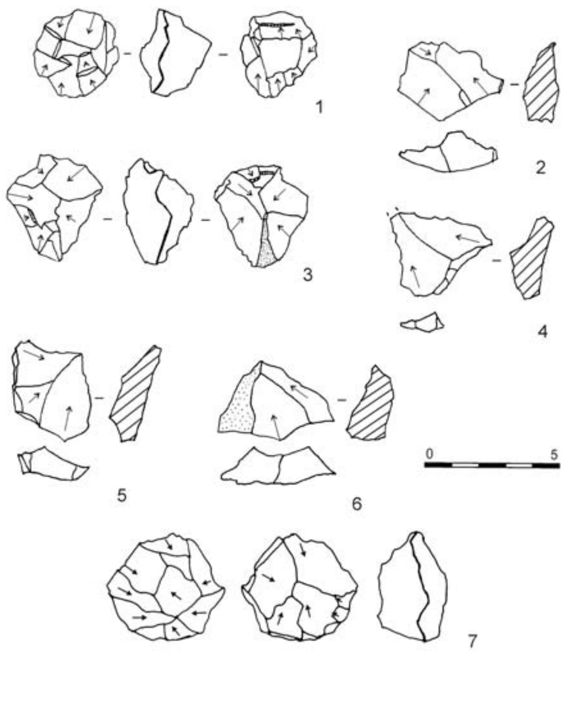


**Fig. 2.** Discoidal products. 1 and 3: NN quartz cores from la Jueria. 2-6: SN quartz flakes from la Jueria. 7: NN quartz core from Payre.

Cleavage planes are not as developed as in schist, therefore not affecting in a significant way the knapping results, although induce a preferential breaking direction (as seen in laminar reduction) and interfere the hertzian fracture pattern (Novikov and Radililovsky, 1990).

Therefore, we can consider internal flaws and homogeneity as the main limiting factor in quartz knapping. On grainy quartz (as sandstone), the breakage plane does not pass through the crystals, but follows its surfaces. So, crystal anisotropical characteristics do no affect the breakage plane (Andrefsky Jr, 1998). According to this, grainy quartz may develop some typical characteristics of herztian fracture such as bulbs (*isotropie de compensation*) (Mourre, 1996). On the other hand, the grainy texture can absorb the strength of the percussion strike in a better way, increasing its elasticity. In that way, internal flaws or diaclases can be avoided, producing less broken flakes and fragments and providing a better reduction control during knapping sequences. Hence, besides homogeneity and presence of internal flaws (Plane), morphostructural characteristics (Grain) must be taken into account, also.

There is a close relationship between quartz formation processes and mechanical properties that is profitted by paleolithic knappers through the reduction sequences. When internal flaws occur in quartz cores, complex reduction sequences involving a high degree of standarization and predetermination cannot be applied. In this case, those are based on unipolar and orthogonal series, as we can see at *Locus* I lithic assemblage. Nevertheless, when the quality of the material allows it (grainy texture, no planes), the reduction sequences can approach those developed on sílex or similar materials. In the assemblages of La Juería and Payre the quartz products associated with the discoid method are of SN and NN morphostructural groups, so that planes are absolutely avoided. The largest products belong to the SN group, whereas small cores and flakes fall within the NN group.

The absence of internal flaws is the main factor at the time of applying strategies that need certain technical complexity and high control of the reduction process. On quartz with a grainy texture and absence of planes (SN), discoidal reduction is applied from the beginning of the sequence, obtaining medium- and large-sized flakes. On the other hand, the small size of the NN group products indicates that the discoid method is applied at the final moments of the reduction sequences, once the internal flaws have been obliterated, thus maximizing the use of the core (Fig. 2).

On grainy quartz (SN and SS groups) with a high quality and very thin-grained, even Levallois method can be applied because of the *isotropie de compensation*, that allows a very good knapping control, much in the same way as with flint or quartzite. Levallois cores on quartz in Rescoundudous (France) (Mourre, 1994) and L´Arbreda (Spain) (Duran and Soler, 2006) are good examples of the different knapping qualities and mechanical properties of the morphostructural groups and its adequacy to the most demanding technological needs.

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