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DIFFERENT ANALYTICAL APPROACHES TO THE MICROSTRUCTURE OF A MICROCRYSTALLINE QUARTZ

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This work shows the results obtained by different kind of microstructural techniques (optical microscopy OP, X-ray texture analysis XRTA, and electron backscatter diffraction EBSD) to the study of an unusual type of texture of authigenic microcrystalline quartz samples.

This type of microcrystalline texture derives from pervasively silicified and variously mineralised horizons (Siliceous Crust-Type, SCT) linked to carbonate platform sequences of different ages (from Proterozoic to Tertiary) and geological setting (major occurrences observed: Alps, Sardinia, Calabria, Pyrenees, Cantabric Chain, China, Brazil) (Rodeghiero et al., 1996; Camana, 1999, Brigo et al., 2000). SCT horizons constantly mark palaeokarstic unconformity surfaces widespread in the uppermost levels of carbonate platforms and are covered by transgressive silicoclastic sequences. The major characteristic of SCT horizons is the almost total silicification of an original polymictic conglomerate-breccias constituted by carbonate fragments and rare siliciclastic rocks developed on palaeokarst landscapes. Geological, structural, compositional, and geochemical parameters indicate that the most likely source of silica in the case of the SCT horizons are basinal sedimentary sequences.

Microcrystalline quartz (average quartz grain size 30-50 μm) is the only silica phase present in SCT horizons; macrocrystalline quartz only occurs in fractures or voids with palisadic and/or mosaic morphologies. Under the optical microscope the texture is particularly evident when observed with the gypsum plate inserted, where the quartz crystals describe a grid pattern, with two populations of elongated grains arranged in sub-perpendicular directions (i.e. blue and yellow grains). Other more or less elongated grains appear reddish and rotating the plate of the microscope of 45° the iso-oriented elongated quartz grains switch alternatively from extinction position (red) to light positions (blue and yellow), while the poorly elongated grains remain almost always red. Because of its morphological features this texture has been labelled "grid-work" texture. Only in a few limited domains the quartz microcrystals show a near random distribution or a gradual transition to textured domains. In this respect, we couldn't find any evident relationship between the presence of grid-work texture and other mineralogical, chemical or macroscopic parameters. Only in the case of Calabria and some French Pyrenees SCT occurrences, the grid-work texture is missing probably related to post-diagenetic metamorphic processes which eliminated the original rock features.

X-ray powder diffraction analysis has been performed on 30 quartz samples of different SCT occurrences. The Rietveld refined coefficients of the pseudo-Voigt function used to model the diffraction peak broadening of quartz in the different samples show a remarkable consistency, in agreement with the optical microscopy observation that quartz is well crystallized and relatively homogeneous in grain size for most of the SCT horizons. The average size of the coherently scattering domains, extracted from the refined Lorentzian coefficient by means of the Scherrer equation (Scherrer coefficient K=0.9) is about 20.9 µm which is in reasonable agreement with the indication of optical microscopy. Only the samples from Calabria and French Pyrenees show a Lorentzian broadening coefficient slightly lower than average, and correspondingly ~~they show~~ a slightly larger mean crystallite size. Moreover, in the case of a Miocene quartz sinter sample from Sardinia, the refined peak profile parameters are more than twice the ones extracted from the SCT samples, consistent with the broader observed Bragg peaks and consequently a much smaller average crystallite size (about 8.5 µm).

The texture of 11 bulk samples associated to different SCT occurrences has been analysed by X-ray diffraction using the CPS120 curved position sensitive detector (PSD) from Inel-S.A. and a Huber four-circle goniometer and a copper K_α radiation. The recalculated 001 and 100 pole figures for all the samples lead to very similar texture patterns. The 001 pole figures, characterizing the c-axes distribution, exhibit a principal component at about 35° from the normal to the surface of the sample due to quartz grains cut sub-perpendicularly with respect to the c axis, which remain extinct at the microscope (i.e. red with the gypsum plate inserted). A second orientation component is related to quartz crystals having the c axes oriented at about 75° from the normal to the surface of the sample, due to quartz crystals cut sub-longitudinally to the c axis and appearing blue or yellow upon rotation of the plate of the microscope.

Electron Backscatter Diffraction (EBSD) analyses have been executed using an HKL Technology EBSD System (Channel Five). Textural maps and parameters are in good agreement with the previous observations especially with optical orientation indications; no other major components of orientation may be certainly at the moment distinguished besides the two X-ray textural components individuated.

We tentatively explain the grid-work texture in SCT horizons as originated by a rather fast surface nucleation effects on the morphological faces of quartz crystals such as the prism $m\{100\}$, or the positive and negative rhombohedra $r\{101\}$ and $z\{011\}$. This mechanism does not require large chemical, temperature, or pressure gradients and it may therefore be consistent with the observed three-dimensionality of the grid-work texture and the homogeneous spatial distribution of the texture components in the samples.

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