EBSD Evidence of Fluid Circulation enhanced by Deformation in the Carboneras Fault Area (SE, Spain)

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INTRODUCTION

The Neogene and Quaternary faulting activity in the southeastern Iberian Margin (Trans-Alboran Shear Zone) is dominated by a large NE-SW sinistral strike-slip system including the Carboneras fault (Faulkner et al. 2003).

This fault zone juxtaposes lithologies subjected to intense cataclasis that can affect to the regional fluid flow and to the mechanical behaviour of the faults. Shear lenses of post-orogenic sediments of Miocene and Pliocene age including marls and sandstones sequences and volcanic rocks are juxtaposed to the predominant slaty gouges of the Alpine basement (mica schist, phyllite and quartzite derived from Permo-Triassic sediments).

This paper aims to present petrological and hydrochemical evidence of the effect of deformation in quartz-rich rocks from the Carboneras fault zone on the fluid circulation through these rocks.

PETROGRAPHY AND EBDS DATA

Quart-rich damaged rocks have been collected from the Rambla de la Granatilla valley in the Carboneras fault area. This area exposes sections for a thickness of nearly 200 m of fault gouges and protoliths showing a complex arrangement of shear lenses of the different fault rock types.

The optical microscopy study of the quartz-rich rocks reveals a heterogeneous distribution of deformation in the fault zone rocks. There are numerous, individually recognisable high-strain zones, with well-developed gouge material. Between them lie less strained lenses consisting of variably damaged protolith. The deformation between the lenses is highly localized, developing highly foliated phyllosilicate-rich bands due to the presence of fine-sized aligned clays (chlorite and mica). Fault deformation also produces grain-size reduction of quartz grains by brittle fracturing (intragranular and intergranular cracking) and grain-boundary sliding.

Large quartz grains appear as isolated clasts that can exhibit intragranular fracturing, as well as fragment rotation, and in some cases faint signs of crystal plasticity such as undulose extinction. BSE images show that intragranular fractures area commonly filled by large dolomite crystals (Fig. 1). Small quartz grains are included inside these dolomite cross-cutting veins. Electron probe microanalyser (EPMA) data revealed that large host quartz grains are richer in Al, Fe and Ti than quartz grains included into the dolomite veins.

Electron backscattered diffraction (EBSD) data, obtained with either a CamScan X500 Crystal Probe SEM fitted with a field emission gun and a FASTRACK stage or a Philips XL30 SEM fitted with a tungsten filament, show that large dolomite crystals do not show any evidence of internal misorientation (Fig. 2).

Texture component maps and pole figures of the quartz grains reveal strong internal misorientation in the large host quartz grains (different colours in the host quartz grains in Fig. 2). Their crystallographic axis have been rotated around the [c]-axis. On the other hand, small quartz grains do not show internal misorientation, showing a general slight orientation among them according to the dolomite vein direction.

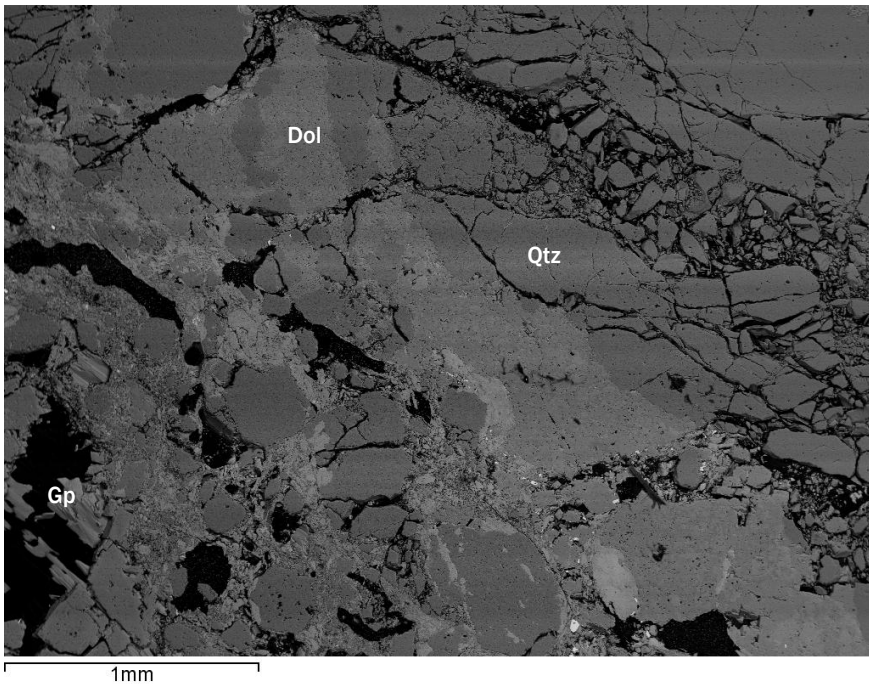

fig 1. *BSE images showing intragranular fractures of quartz filled by dolomite. Dol: Dolomite. Qtz: Quartz, Gp: Gypsum.*

palabras clave: EBSD, Quartz, Dolomite, Fluid circulation, Fault

key words: EBSD, Cuarzo, Dolomita, Circulación de fluidos, Fallas

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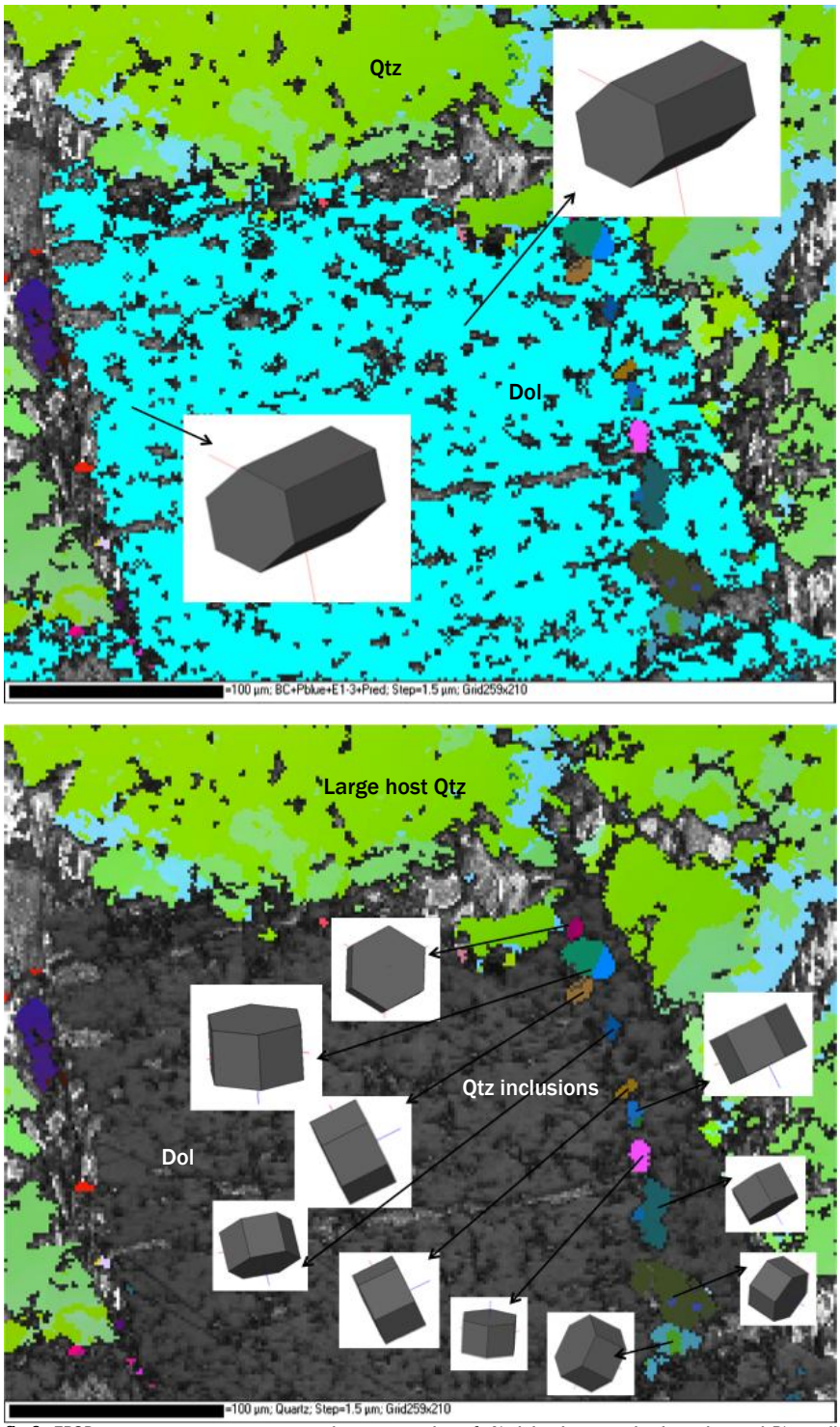

fig 2. *EBSD texture component maps and representation of: A) dolomite crystal orientation and B) small quartz grains included in dolomite xenoblasts.*

HYDROCHEMICAL DATA

Samples coming from aquifers affected by the fault in this area are characterized by high to medium electrical conductivity (from 1940 µS/cm up to 6222 µS/cm) with Na–Cl–SO_4 facies. These groundwaters show medium to high ion enrichment (from 18 up to 70 meq/l) and they evidence saturation and oversaturation in carbonate materials (calcite and dolomite). Temperatures were generally above the hydrothermalism (around 26 °C). With regard to the presence of boron, abnormally high traces of boron were measured in these waters with contents between 0.36 and 0.46 ppm.

CONCLUSIONS

EBDS and microcomposition data allow to us distinguish two generations of quartz formation. The strong internal misorientation of the large quartz grains reveal their prekinematic origin. The mechanism of deformation was predominantly semibrittle produced by slip plane. Small quartz grains grew inside the microfractures of the large quartz grains produced by the cataclasis related to the fault activity. The fast growth of their c axis looking for the available space inside the fractures produced slight orientation. A final stage of post-kinematic dolomite crystallisation in the highly damaged areas of the microcataclasites sealed the microfractures. This stage could be related to low-temperature and high-salinity water circulation episodes, suggesting that cataclasis may control pathways and focus water circulation in the fault system. These waters might be related to evaporite and carbonate dissolution along deep faults (see e.g. Cerón et al. 2000) as indicated by the abnormal boron concentration. The fact of the thermal water occurrences along this fault area appears to be favoured by the great depth of the fractures affecting the substratum. This allows the rise of groundwater enriched in CO_2 gas.

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