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Fluid-rock interaction controlling clay-mineral crystallization in quartz-rich rocks and its influence on the seismicity of the Carboneras fault area (SE Spain)

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The Carboneras Fault zone is one of the longest fault in the Betic Cordillera (SE Spain) and it would be a good candidate to generate large magnitude earthquakes (Gracia et al., 2006). Seismicity in the region is characterised by low to moderate magnitude events, although large destructive earthquakes have occurred, which reveals significant earthquake and tsunami hazards (Masana et al., 2004).

Due to the internal architecture of the fault zone, shear lenses of post-orogenic sediments of Miocene and Pliocene age including marls and sandstones sequences are juxtaposed to the predominant slaty gouges of the Alpine basement. Microcataclasites and gouges of the quartz-rich post-orogenic sediments are also developed as cm- to m-scale bands, allowing the comparison between the deformed materials and their protoliths. Red, yellow and white sandstones and their respective cataclasites can be identified. This communication is concerned with the clay mineral crystallization events in these materials and its possible influence on the seismicity model of the region.

The presence of phyllosilicates in fault zones as either neoformed or inherited clays is commonly related with fluid circulation and a mechanically weak fault behaviour (e.g., Wang, 1984). A critical factor for the understanding of the mechanical role of clays in fault rocks is to determine the timing of formation of mineral assemblages and microstructure of fault rocks and protolith. The effects of post-faulting alteration limit inferences about fault behaviour that can be made from exhumed rocks. The Carboneras fault zone provides good opportunities to study mineral processes enhanced by deformation, given that it is located in a region of arid climate and shows outcroppings of quartzitic rocks included in slaty rocks.

Combined XRD, optical microscopy and SEM analyses reveal that deformed quartzitic rocks are enriched in phyllosilicates, increasing especially the amount of chlorite. The samples strongly damaged are characterised also by the presence of dolomite and gypsum. The deformation is highly localized, developing phyllosilicate-rich bands highly foliated due to the presence of fine-sized aligned clays (chlorite and mica). In some undeformed lenses of the cataclastic rocks, variable-sized patches of phyllosilicates containing random oriented stacks of chlorite and mica are developed. BSE images reveal that the stacks are made of two intergrown compositional types of chlorite.

These results lead to conclude that limited clay growth during faulting occurred. The absence of significant compositional differences between undeformed and deformed phyllosilicates suggests that whereas fluids were present during strike-slip faulting, fluids were not preferentially focused along the quartz-rich rocks of the fault zone by phyllosilicates avoiding the development of the synkinematic clay alteration process. However, clays played an important role for the mechanical behaviour of the quartzitic rocks in the fault zone. Deformation is highly localized in chlorite-rich sandstones. These sandstones show substantial clay crystallization which texture can be related with a hydrothermal origin before strike-slip faulting, likely associated with the volcanic activity of the area leading to form of chlorite/mica patches.

These data indicate that, although elevated fluid pressure confined by clay fabric cannot be appealed for the mechanical behaviour of the sandstones of the Carboneras fault, clay fabrics developed during deformation dominated the fault-weakening mechanism. We consider that lubricating properties of phyllosilicates in the quartzitic rocks were an important factor controlling movement mechanisms promoting the predominance of creep as regards seismic stick-slip (Bedrosian et al., 2004) reducing the possibility of larger seismogenic events that nucleate on localized fault planes developed within quartzitic rocks contained within the fault zone.

Finally the crystallization of dolomite and gypsum in the highly damaged areas of the microcataclasites could be related with recent low-temperature and high-salinity water circulation episodes, suggesting that cataclasis may control pathways and focus circulation of the current aquifer systems.

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