EGU2020-19297
https://doi.org/10.5194/egusphere-egu2020-19297
EGU General Assembly 2020

On the causes of brittle nucleation of shear zones: the example of Cap de Creus, Eastern Pyrenees (Spain)

Claudio Rosenberg[1], Loïc Labrousse[1], Nicolas Landry[1], Elena Druguet[2], and Jordi Carreras[3]
[1]Sorbonne Université, Paris, ISTeP, Case 109, Paris, France (claudio.rosenberg@upmc.fr)
[2]Departament de Geologia, Universitat Autònoma de Barcelona, 08193 Bellaterra, Barcelona
[3]Sa Tórtora 8, 17488 Cadaqués, Girona

The area of Cap de Creus, at the eastern termination of the Axial Zone of the Pyrenean Belt, exposes some of the most famous outcrops of ductile shear zones and shear zone networks (Carreras, 2001). Recent studies proposed that the nucleation and growth of such shear zones may have taken place by brittle processes (Fusseis et al., 2006; Fusseis and Handy, 2008).

The present study investigates the geometrical relationships between fracture systems and some shear zones, the deformation temperature of these shear zones, and the processes leading to the nucleation and growth of shear zones along fracture planes. We selected two areas of the Cap de Creus, the Cala d'Agulles, and the Punta de Cap de Creus, because they are most intensely dissected by subparallel sets of shear zones and fractures. The orientation of the average shear zone planes is sub-parallel to the orientation of the major set of fractures, and the great extent and close spacing of some shear zones that we characterized by aerial photos from a drone, is similar to the distribution and extent of the fracture planes. These observations, in addition to those of Fusseis et al. (2006) suggest that the shear zones nucleated on previous fracture planes.

These fractures are surrounded by haloes of nearly 1 cm thickness affecting the fabric of the country rock, an amphibolite-facies, biotite-andalusite bearing schist. Microscopic observations show that the haloes correspond to the wide-spread presence of thin (less than 2μm thickness) phosphate seams coating the grain boundaries, preferentially those oriented at low angle to the fracture plane, and to the alteration of plagioclase to white mica and sericite, and to the growth of tourmaline, also related to grain boundaries and micro-fractures.

Deformation temperature in the shear zones is assessed by white mica thermometry and pseudosections. The calculated T of at least 350-400° C is consistent with qualitative observations showing the presence of stable biotite within very fine-grained (<< 10 μm) shear bands and the recrystallization of quartz by rotation of sub-grain boundaries.

In summary, fractures formed at high temperature, possibly associated with the intrusion of tourmaline-bearing pegmatites and fluids, which predate the ductile mylonitic event (Druguet, 2001; Van Lichtervelde et al., 2017). Fluids altered and weakened a volume of approximately 2 cm thickness all along the fracture planes, whose extent may reach > 100 m. The inferred, relatively high T of ca. 400° C indicates that fracturing is not due to the proximity of the brittle-ductile transition. In addition, no significant micro-fracturing of the mylonites is observed in thin sections. Therefore, fracturing precedes the ductile shear zones, which nucleate on some of the “inherited” sets of thin, planar, weakened structures, the large majority of which remains undeformed. These observations raise the question on whether nucleation and propagation of ductile shear zones is mechanically unrelated to brittle fracturing. Their weakening of planar structures would originate from fluid migration along fracture planes, but fracturing would no longer be active during ductile deformation.