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Tectonic regime and strain localization in porous sandstones (Provence, France).

G. Ballas (1), R. Soliva (1), A. Taboada (1), and A. Benedicto (2)

(1) U.M.R. C.N.R.S. 5243 Géosciences Montpellier, Université de Montpellier II, U.F.R. Sciences et Techniques, Place Eugène Bataillon, 34095 Montpellier cedex 5, France. (gregory.ballas@gm.univ-montp2.fr), (2) AREVA NC, BU Mines Direction Geosciences, 92084 La Défense, Paris, France.

In the porous Montmout Sandstone (Provence, France), we observe two sets of deformation bands: (1) a set of shear enhanced compaction bands and (2) a set of compactional shear bands.

Shear enhanced compaction bands are observed as kinematically consistent with the Pyrenean shortening. These bands show small reverse shear displacement (about 1/10th of band thickness) and thickness ranging from 0.1 to 5 cm. These bands are organized as a distributed network especially localized in coarse sandstone layers. They show slightly cataclastic microstructure revealed by a small grain comminution and an increase of microfracture density. The force chains (subparallel to sigma 1) within the granular framework are oblique to the bands with an angle of 45°.

Compactional shear bands are observed as normal bands associated to the Oligocene-Miocene extension. These band network shows shear localization along conjugate band clusters that cut the entire sandstone layer. They show variable shear displacements ranging between 0.1 cm and 70 cm and thicknesses ranging between 0.1 cm and 28 cm. Three types of shear bands can be identified according to their geometrical attributes (shear-displacement, thickness, number of strands…): single-strand, multi-strand and cluster. These bands are cataclastic; they show different intensities of cataclasis in their microstructure: damage zones, protocataclasis, and cataclasis, as a function of increasing shear displacement. The force chains within the granular framework are oblique to the bands with an angle of 30°.

These observations show large differences between these sets of bands, in particular in their organization and microstructural deformation. We discuss their formation using (i) a stress path model taking in account the burial conditions and the applied tectonic stresses, and (ii) theoretical yielding envelopes for porous sandstones defined by a frictional law and a cap. The yielding envelopes are calculated following the equation from Davis and Selvadurai (2002), where the envelope in a Q-P space is a function of grain size, porosity and friction angle. The stress path for burial and tectonic scenario is estimated using realistic values of Earth pressure coefficient at rest (K0) for such porous frictional material. Our analysis shows 2 contrasting behaviors: 1) strain localization along cataclastic shear bands in extensional context when the stress path intersects the cap in its upper part; and 2) strain distribution as compaction bands with moderate cataclasis in compressional context, when the stress path intersects the cap in its lower part. Two stress permutations are predicted in compressional context: the stress state is successively normal, strike-slip and reverse, for an increasing compressional tectonic stress. Values for the tectonic stress path have been calculated in Q-P space as a function of K0 < 1. For large values of K0, as expected for this rock material, the stress path corresponding to strike-slip regime is reduced to a small linear segment having little probability of intersecting the cap (i.e. Q « P). This is in agreement with the absence of evidence for strike-slip shear bands initiation in the study area and their rare description by previous works from the literature.