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A first comparison of natural and artificial shear bands in porous carbonate grainstones

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In the last few years, a new faulting mechanism was discussed in high porosity carbonate grainstones (mean porosity 30%, mean bulk density 1,85 g/cm3) which encompasses structures that form by compaction and shear strain into narrow tabular bands, called compactive shear bands (CSB. CSB are easily recognizable in the field, because are light-colored with respect to the host rock or show a positive relief due to their increased resistance to weathering. Microstructural and textural analyses documented a series of interactive deformation processes involving strain localization into bands, pressure solution and subsequent shearing and cataclasis. Notwithstanding this study, some intriguing questions remain unsolved such as the transitions from one deformation process to another, the anisotropy resulting from these changes and possible changes in the orientation and magnitude of applied stresses.

In order to investigate some of these problems a set of conventional triaxial experiments has been performed on representative samples of carbonate grainstones and a comparison among natural and laboratory deformed samples carried out.

Following previous hydrostatic compression experiments which highlighted significant water weakening effects, the new triaxial experiments have been performed under wet conditions with pore pressure of 10 MPa and effective pressures ranging from 5 to 20 MPa. The deformed samples display a shear-enhanced compaction behavior. Detailed microstructural analysis shows diffuse stress-induced cracking and calcite mechanical twinning. At 5 MPa of effective pressure a compactive shear band formed at high-angle to the direction of the major principal stress. This structure is a few hundred microns thick and is characterized by grain size and pore size reduction. Grain crushing is the main responsible for the comminution observed, whereas the collapse of preexisting pores, is responsible for pore size reduction. The quantification of damage around the compactive shear band has been obtained by a crack density analysis.

The comparison between natural and laboratory observations shear bands, documents strong discrepancies among the interactive failure processes responsible for the nucleation and growth of compactive shear bands. Results suggest that further laboratory experiments taking in account the role of temperature, fluid chemistry and of a wider range the strain rate are needed in order to constraint the deformation processes observed in natural samples.