Geophysical Research Abstracts
Vol. 12, EGU2010-3569, 2010
EGU General Assembly 2010

Fault growth in high porosity sandstones: Porosity and permeability study in the "Bassin du Sud-Est", Provence, France

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Understanding the evolution of fault geometrical and hydromechanical properties during fault growth and network development is of major importance in fluid flow prediction in the crust. This question is particularly important for high porosity sandstone reservoirs, where brittle deformation generated low permeability cataclastic structures. Predicting the effect of these structures on bulk flow is crucial in the context of hydrocarbon production from faulted reservoirs.

This contribution is based on laboratory data of cataclastic deformation bands (CDBs) and larger ultracataclastic faults, from the Upper Cretaceous high-porosity sands and sandstones in the “Bassin du Sud-Est”, France. Different methodological approaches are used in order to estimate the impact of the different geological factors which control distribution and localisation of deformation in sandstones. This study is based on three main research axes: (i) A systematic sampling on a large range of structures, kinematics and lithologies; (ii) A microstructural and a statistic porosity and granulometry analysis on SEM photomicrographs completed by laser granulometry measurements on the same samples; (iii) A permeability study based on the same large range of samples. Based on our different methods of analysis, the main results can be summarized as follows:
(1) The SEM photomicrographs show: (i) A grain size reduction by grain crushing within the deformation bands; (ii) The grain-size and the porosity reduction evolve with increasing displacement and thickness.
(2) The grain and pores size reduction is quantified by image analysis, and shows a two order of magnitude reduction between the host rock and a mature fault. The grain size reduction is confirmed by laser granulometry measurements.
(3) There is a permeability reduction of 1 – 2 orders of magnitude from the host sands to the thin CDBs, but this becomes around 4 orders of magnitude perpendicular to the larger ultracataclastic faults.

These different analytical methods demonstrate the evidence of a transition in growth mechanism from thin CDBs to larger ultracataclastic fault zones. These larger fault zones form preferentially in contexts where a previous generation of CDBs already exists, suggesting the influence of previous structural heritage on further fault network growth and bulk reservoir permeability reduction.