Geophysical Research Abstracts
Vol. 12, EGU2010-410-3, 2010
EGU General Assembly 2010

Compaction localization in Saint-Maximin limestone: Spatial evolution of damage and acoustic emission activity

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The analysis of deformation and failure in many sedimentary settings hinges upon a fundamental understanding of inelastic behavior and failure mode of porous carbonate rocks. Previous laboratory studies on low to intermediate porosity limestone showed that even if porosity had several important effects on the overall mechanical behavior, a similar phenomenology of failure was observed in rocks with porosity ranging from 3 to 18%. Dilatancy and shear localization developed under low confining pressure, while strain hardening and shear-enhanced compaction were observed at elevated confining pressure. Samples deformed in the compactive regime failed by homogeneous cataclastic flow. However, recent field observations revealed the development of deformation bands in higher porosity carbonates. To investigate the development of compaction localization in carbonate rocks, we have conducted a systematic study of deformation and failure in Saint-Maximin limestone of 37% porosity.

To investigate the development of compaction localization in carbonate rock, we have conducted a systematic study of deformation and failure in Saint-Maximin limestone of 37% porosity. Two series of conventional triaxial experiments were performed in parallel at room temperature, constant strain rate in both dry and wet conditions at confining pressures between 3 and 50 MPa. Wet experiments were carried out with water in drained conditions at 10 MPa of pore pressure. The first series of experiments were performed at IPG Strasbourg on relatively small samples. The failure modes and spatial distribution of damage were studied systematically in these samples. The second series of experiments were performed on larger samples at ENS Paris. Acoustic emission activity was recorded during these tests. The events were located via 12 piezoelectric transducers attached to the samples. The evolution of P-wave velocity in four directions was also recorded during these experiments.

Shear enhanced compaction was observed at all pressures conditions. Compactive shear band developed at low effective pressures, while more complex failure modes involving deformation bands of variable orientations were observed at higher effective pressures. A significant weakening effect of water was also observed in Saint Maximin limestone.

Our new data showed that the onset of inelastic compaction in Saint Maximin limestone was, like in porous sandstone, marked by a clear increase in acoustic emission activity both in dry and wet conditions. A relatively modest decrease of Vp was observed during the experiments. Strain gage data, acoustic emission and velocity data confirmed that compaction localization occurred in both dry and wet conditions.

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