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Inelastic compaction in porous carbonates

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The analysis of deformation and failure in many sedimentary settings hinges upon a fundamental understanding of inelastic behaviour, failure mode of porous carbonate rocks and their implications on fluid flow at various scales. The mechanical compaction behaviour of carbonate rock of a broad range of porosity has been investigated in the laboratory over a wide range of stress conditions in the last decades. The phenomenology of brittle failure and inelastic compaction in this rock type with often bimodal pore size distribution was found similar to that of sandstone. Inelastic compaction in limestone involved primarily cataclastic pore collapse and micromechanical analysis showed the strong influence of the micropore size on the yield stress. Compaction experiments on porous limestones also revealed a broad spectrum of complex failure modes. In situ X-ray Computed Tomography imaging combined with Digital Volume Correlation provided the first observations of discrete compaction bands in a high porosity limestone. Permeability variations in carbonates associated with shear-enhanced compaction and these failure modes were found significantly smaller than variations previously reported in porous sandstones of comparable porosities.

In geophysical applications such 4D reservoir monitoring and the production of geothermal reservoirs, an understanding of the mechanical and chemical effects of pore fluid is fundamental. The mechanical influence of pore fluid on different properties is characterized by effective pressure coefficients. For limestone with dual porosity, both effective stress coefficients for permeability and pore volume change were observed to be consistently greater than unity. This implies that microscopic homogeneity is not a valid approximation for a limestone with dual porosity, and a realistic model must explicitly differentiate between the macropores and micropores, as well as account for their interplay in controlling the hydromechanical behaviour. Recent data showed that a significant weakening effect of water could also be expected in most carbonates.