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# Compactant and dilatant failure in porous carbonate rocks

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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. We have conducted a systematic investigation of dilatant and compactant failure in limestones with porosities ranging from 3% to 38%. We observed several important effects of porosity on the overall mechanical behavior. Compressibility and porosity are positively correlated. Brittle strength decreases with increasing porosity and the critical stresses for the onset of pore collapse under hydrostatic and nonhydrostatic loadings also decrease with increasing porosity.

A similar phenomenology of failure was observed in samples of Solnhofen, Tavel and Indiana limestone with porosities 3%, 10% and 16%, respectively: dilatancy and shear localization developed under low confining pressure, while strain hardening and shear-enhanced compaction were observed at elevated confining pressure. After a certain amount of strain hardening, the samples consistently switched from compaction to dilatancy. Our microstructural observations showed that dilatancy arised from stress-induced microcracking leading to shear failure at low confinement. At higher confinement the three limestones failed by homogeneous cataclastic flow, but significant differences were observed in the micromechanics of failure. That seemed to be controlled by geometric complexities of the pore space and involved crystal plasticity (twinning and/or dislocation slip) and microcraking.

A somehowhat different phenomenology was observed in weaker carbonate rocks such as Majella and Saint-Maximin limestones with porosities of 31% and 38%, respectively. The deformation was purely compactant in these rocks and preliminary microstructural analysis using a new generation field emission scanning electron microscope (FESEM) suggested the development of compaction localization at the onset of the shear-enhanced compaction.