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Mechanical compaction in Bleurswiller sandstone: effective pressure law and compaction localization

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We performed a systematic investigation of mechanical compaction and strain localization in Bleurswiller sandstone of 24% porosity. 70 conventional triaxial compression experiments were performed at confining pressures up to 200 MPa and pore pressures ranging from 5 to 100 MPa. Our new data show that the effective pressure principle can be applied in both the brittle faulting and cataclastic flow regimes, with an effective pressure coefficient close to but somewhat less than 1. Under relatively high confinement, the samples typically fail by development of compaction bands. X-ray computed tomography (CT) was used to resolve preexisting porosity clusters, as well as the initiation and propagation of the compaction bands in deformed samples. Synthesis of the CT and microstructural data indicates that there is no casual relation between collapse of the porosity clusters in Bleurswiller sandstone and nucleation of the compaction bands. Instead, the collapsed porosity clusters may represent barriers for the propagation of compaction localization, rendering the compaction bands to propagate along relatively tortuous paths so as to avoid the porosity clusters. The diffuse and tortuous geometry of compaction bands results in permeability reduction that is significantly lower than that associated with compaction band formation in other porous sandstones. Our data confirm that Bleurswiller sandstone stands out as the only porous sandstone associated with a compactive cap that is linear, and our CT and microstructural observation show that it is intimately related to collapse of the porosity clusters. We demonstrate that the anomalous linear caps and their slopes are in agreement with a micromechanical model based on the collapse of a spherical pore embedded in an elastic-plastic matrix that obeys the Coulomb failure criterion.