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In both natural and engineering conditions, carbonate rocks exhibit deformation modes ranging from localized brittle fracture to non-localized plastic flow, depending on overburden pressure, deviatoric stress, temperature, strain-rate, pore geometry, and the pressure and chemistry of the pore-fluid. At relatively low temperatures and confinement, the strength of low porosity carbonates is relatively rate-insensitive, even the deformation mechanism include a mixture of twinning, slip, and local cataclasis, and brittle fracture is generally accompanied by dilatancy and permeability enhancement. But, in rocks with even modest porosity, non-localized flow can induce transitions from brittle fracture to compactive flow, and thus, permeability may either decrease with further straining. As temperature is elevated, variations in temperature, strain rate, and pore fluid chemistry also affect the yield stress, the strain to failure, and the ultimate failure strength. For example in Solnhofen limestone, the stress required for the inception of dilatancy and localization decreases considerably when samples are saturated with water. Even when temperature, pressure and strain rate are such that deformation is accommodated by an increasingly large proportion of crystal plastic processes, carbonates with small amounts of porosity still exhibit a double-surface yield cap. When subjected to triaxial deformation at elevated temperatures, calcite-quartz aggregates with porosity of 20% or less exhibit shear-enhanced compaction. Interestingly and somewhat counter to intuition, the permeability of these rocks deforming under triaxial loads was not as sensitive to porosity changes as that for the same material during isostatic compaction. In addition, the percolation threshold for the triaxially deformed material is lower than that during isostatic compaction. The bulk and shear viscosity of these creeping aggregates are functions of both mean and deviatoric stresses.