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Deformation Bands in Sandstones: Fluid Pathways or Barriers?

Deformation bands typically have different hydraulic properties than the surrounding undeformed sandstone. Based on petrographic and SEM observations, we suggest that the hydraulic properties of deformation bands depend on the specific deformation mechanisms that are primarily a function of consolidation, initial porosity, and stress boundary conditions, and secondarily on mineralogical composition and host rock cementation.

A decrease in permeability is inferred for deformation bands that form in unconsolidated to weakly consolidated sand of high porosity under low overburden load where grain sliding and rotation lead to porosity reduction without any significant grain breakage. Entrainment of fines and localized cement precipitation within the deformation bands may result in further permeability reduction. In weakly to well-cemented sandstone under higher overburden load, porosity and permeability reduction are dominated by grain comminution and physical compaction. A further decrease in permeability may result from mineral alteration and cementation reactions that are kinetically favored by mechanical grain comminution.

An increase in permeability is inferred for some well-compacted sandstones due to connected transgranular opening-mode fractures that form at an early stage of deformation band development and that predate grain size reduction. An increase in permeability is also inferred for some deformation bands that form parallel to the regional shortening direction in unconsolidated sands. This latter type of bands is associated with pure dilatation and a resulting increase in porosity.

In clay-rich sandstone we infer that the permeability across deformation bands is generally reduced due to the preferred alignment of clays during slip resulting in a foliated fabric.