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Effects of coupled structural and diagenetic processes on deformation localization and flow properties of deformation bands in sandstone

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Deformation bands tend to restrict flow perpendicular to the bands through the combined effects of porosity reduction, mechanical grain size reduction, and preferred cementation relative to the adjacent host rock. Thus, deformation bands may impart a permeability anisotropy to reservoir rocks. Deformation bands that occur in association with reservoir scale faults can impact reservoir-scale fluid flow and fault seal behavior. Using a combination of textural imaging including SEM-based cathodoluminescence imaging, compositional analysis, and lab petrophysics, this study is designed to (1) assess the effects of coupled chemical and mechanical processes leading to deformation localization in deformation bands and (2) to quantify the effect of these processes on single and multiphase fluid flow.
While the effects of mechanical processes including grain translation, rotation, and breakage have been described in detail, chemical reactions affecting flow properties have received less attention. Such chemical reactions include the precipitation of carbonate and quartz cement, dissolution and albitization of feldspar, and the neoformation and infiltration of clay minerals. It is shown that the mechanical process of deformation localization is strongly controlled by chemical processes including pre-kinematic pore-filling cement, syn-kinematic cement filling intra- and transgranular fractures, and stress-enhanced dissolution reactions. Prekinematic cements reduce the strength contrast between grain and aggregate thus favoring deformation localization into narrow, well defined deformation bands. Prekinematic cementation and compaction may even favor thoroughgoing opening mode fractures and prevent localization of deformation into deformation band. Synkinematic cements within deformation bands will result in local strain hardening of bands and thus oppose further deformation localization with increasing strain. Examples will be presented from the Mesozoic clastic sequence of the western US to illustrate these processes.