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Effective stress law for permeability and deformation of clay-rich sandstones

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The study on effective stress law is a fundamental research in rock physics about how the interplay of confining pressure and pore pressure influences geophysical properties. In a microscopically homogeneous assemblage, the effective stress coefficients for permeability, strain and pore volume change are predicted to be equal to or less than unity. In contrast, the effective stress coefficient for permeability was observed to be greater than unity in clay-rich sandstones, and extensive investigation has been made to measure this effective stress coefficient in sandstones with high-clay content. However, the effective stress coefficient for pore volume change has not been systematically investigated. We are currently conducting an integrated investigation of the effective stress behaviors of both permeability and deformation in two clay-rich sandstones (Berea and Boise) under hydrostatic loading with the confining pressure ranging from 16 to 28 MPa and pore pressure ranging from 10 to 14 MPa. Our results show that the effective stress coefficients for permeability of the Berea sandstone are uniformly greater than one, which accords with the published data. Our systematical measurements also show that the effective stress coefficient for pore volume change in Berea sandstone is less than but close to one. The effective stress coefficient for axial stain in Berea sandstone is less than one, comparable to the published ones. Berryman (1992) developed a model for clay rich sandstone. For an assemblage made up of two porous constituents, he derived a relation among the three effective stress coefficients for permeability, pore volume change and strain. For the first time we measured these three coefficients data simultaneously on sandstone sample, which provides critical data to validate Berryman's model.