Experimental Studies of Re-Pressurization and Boundary Conditions Effects on Stress Path Coefficient in Unconsolidated Sands

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Abstract

The stress path coefficient is defined as the change in total stress value per unit change in pore pressure. For the changing horizontal stress conditions, they are named as depletion or injection coefficient when the pore pressure is decreased (depressurized) or increased (re-pressurized), respectively. To simulate far field or reservoir deformation conditions, such as reservoir compaction, laboratory tests apply the uniaxial strain boundary conditions. To simulate near wellbore deformations, such as borehole failures, tests use the plane strain boundary conditions. This experimental study investigates the variability of horizontal stress path coefficient as a function of changing pore pressure loads (depressurization and re-pressurization) and boundary conditions (uniaxial and plane strain) in unconsolidated sandstone reservoirs. Synthetic sandstones test samples were made from sand packs by consolidating them under isostatic stress path at ambient pore pressure. The sample is then loaded to desired stress and boundary conditions. Two sets of experiments were performed, one with uniaxial strain and the other with plane strain boundary conditions. For each one of these test conditions, the changing pore pressure would follow a series of pressure loading (depressurization) and unloading (re-pressurization) cycles to measure the corresponding depletion and injection coefficients and hysteresis values. We found the depletion coefficient is lower than the injection coefficient in the first load-unload cycle. The first loading stage yielded the material and expanded the existing yield surface. The following unloading stage kept the material within this expanded yield surface. It explains the lower value of

depletion coefficient than the injection coefficient. This observation is consistent whenever a loading stage expands the yield surface. However, for subsequent load-unload cycles, the depletion coefficient equals to the injection coefficient and they remain the same because the materials stayed in the expanded yield surface. Application of this research includes more accurate modelling of injectors at both near wellbore (plane strain conditions) and on reservoir scales (uniaxial strain conditions) i.e. different values of horizontal stress path coefficients should be applied.