Compaction Localization: Effects on Permeability and Reservoir Mechanics

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Compaction localization in rock is a newly observed, fundamental deformation mechanism for porous rock. Under stress, some porous sandstones exhibit non-uniform compaction. The compaction occurs as a localization process, analogous to shear localization, but results in a thickening, tabular zone of compaction as opposed to culminating in a shear fracture. The results of experiments on a sandstone, measuring simultaneously, stress, strain, acoustic emission locations, and permeability, showed that compaction localization produces up to a two-order-of-magnitude decrease in permeability in the compacted zone. Correlation of local strain measurements and acoustic emission locations made on the same specimen show that the compaction process proceeds as a propagating front approximately 20 mm thick. Because of the inhomogeneous nature of compaction produced by compaction localization, and its temporal evolution, a number of phenomena related to fluid flow are predicted by the model, including locally increased pore pressures and spatial changes in the effective permeability. Implications of the results for future experimentation and for reservoirs are briefly discussed; in particular the interaction between compaction-induced fluid pressure and compaction localization should lead to a phenomenon analogous to dilatancy hardening, impeding the propagation of compaction bands.

If compaction localization occurs in reservoir rocks, then the associated decrease of permeability would be significant both in terms of economic and operational aspects of reservoir management. From a geophysical point of view, localized compaction would produce a very different pattern of pore pressures and deformation than would be expected for homogeneous compaction.