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The Influence of Stress Evolution on Hydrocarbon Production

Using a formalism known as the Deformation Analysis in Reservoir Space (DARS), we demonstrate that the mode of deformation in a producing reservoir (reservoir compaction and/or production-induced faulting) is highly dependent on the initial stress state and the change in horizontal stress as a result of depletion (also known as stress path $A=\Delta S/\Delta P_P$). One of the advantages of using DARS is the capability it provides of predicting the evolution of deformation during depletion. For a known stress path, estimates of both production-induced compaction and the potential for induced faulting within the reservoir can be made. For reservoirs in a normal faulting stress regime, we demonstrate that production-induced faulting will accompany production if the reservoir depletes along a relatively steep stress path ($A > 0.67$). In contrast, with a shallower stress path ($A < 0.67$), deformation associated with depletion will be predominantly related to compaction rather than induced faulting. We can also use DARS to estimate how a reservoir loses permeability as a result of production. We apply this methodology to several reservoirs in the Gulf of Mexico (GOM) and the North Sea. Deformation in the two GOM fields we investigate is dominated by compaction with significant permeability loss, and production-induced faulting is unlikely to occur ($A \sim 0.57$). In the North Sea chalk reservoirs we studied, production-induced faulting is the dominant mode of deformation accompanied by minor compaction.