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## **Geomechanics in Integrated Reservoir Modeling**

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### **Abstract**

This paper will discuss the current state of reservoir geomechanics and consider several areas of reservoir development and management where geomechanical influences are important. In order to better integrate our workflows, coupled simulation is often used to exchange parameters between individual modules that are typically run in standalone mode for reservoir flow simulation, seismic modeling or geomechanical modeling. This paper will discuss coupled geomechanics and flow simulation to illustrate several impacts of reservoir depletion (e.g. compaction and subsidence, stress arching in the overburden and casing shear in the wells) and examine the connection between geomechanics and geophysics and areas where coupling of these disciplines can benefit exploration and production. Two generic examples are presented - one representing North Sea chalk reservoirs and the other representing deepwater turbidites.

Reservoir compaction and resulting subsidence are well known examples of geomechanical behavior. During depletion, the reservoir pressures decrease and effective stresses increase. The rocks deform through a combination of elastic (recoverable) and inelastic (permanent) strain, with plastic deformation occurring primarily as the stresses increase beyond the compaction limit or "collapse" stress. The deformation creates a "compaction drive" (additional pressure support) in the reservoir that can improve recovery. However, one must also deal with the undesirable effects - the environmental impact of subsidence, possible fault reactivation, and integrity of wells crossing faults etc. – and geomechanics allows us to evaluate these effects.

In other applications, incorporating geomechanics in the interpretation of repeat 4D seismic surveys improves our ability to isolate and resolve the signatures of variations in fluid saturations. Finally, the primary concern in drilling and completion engineering is wellbore stability during drilling and well integrity during the producing life of the well. The heterogeneity of stress changes in layered reservoirs and overburden due to depletion-induced differential reservoir compaction poses specific technical challenges e.g. casing shear deformation – and geomechanics plays an important role in modeling studies associated with the evaluation of such challenges.

### **Scope of reservoir geomechanics**

Under the umbrella of geomechanics, we can collect all problems that have some component of rock and soil mechanics or fracture mechanics. Usually, these involve coupled solution of fluid flow and stress or deformation problems, often accompanied by temperature changes, while accounting for the coupling physics between them. In other disciplines (such as hazardous waste disposal) such processes are often referred to as THM (thermo-hydro-mechanical) problems. In the petroleum industry, geomechanics is encountered in a variety of different situations, either on a single well basis or in a field-wide setting, that cover drilling, completion, stimulation, production and reservoir engineering. Some examples follow:

- In drilling and completion engineering, the primary concern is with wellbore stability during drilling and well integrity during the production life of the well. The former has been the traditional concern of geomechanics, while the latter has been the focus of attention recently, notably in older fields. The stress changes in reservoir and overburden due to depletion-induced reservoir compaction poses specific technical challenges, like the prediction of the changing fracture gradient and its impact on the drilling window, often resulting in high costs for rigtime and drilling equipment.