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Unconventional Geomechanics

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Summary

Geomechanics for unconventional reservoirs. Geomechanical properties of the subsurface greatly influence both the drilling and hydraulic fracturing of a well in an unconventional reservoir. A MEM is an estimate of the subsurface mechanical properties, rock strength, pore pressure, and stresses, and can be used to quantify the geomechanical behavior of the subsurface. These components in the MEM are described in this presentation, with an emphasis on applications to developing unconventional reservoirs.

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Introduction

The discipline of geomechanics impacts nearly all phases of oilfield operations, from drilling to production. For unconventional reservoirs, the geomechanical properties of the subsurface greatly influence the processes of both drilling and hydraulic fracturing. A mechanical earth model (MEM) can be a useful tool for quantifying the subsurface elastic properties, rock strength, and earth stresses. Each component of the MEM is described in this paper, followed by a discussion of the geomechanical implications of both drilling and hydraulic fracturing.

Method and/or Theory

A MEM (Figure 1) is an estimate of the subsurface mechanical properties, rock strength, pore pressure, and stresses, and can be used to quantify the geomechanical behavior of the subsurface. These components in the MEM are described in this paeper, with an emphasis on applications to developing unconventional reservoirs.

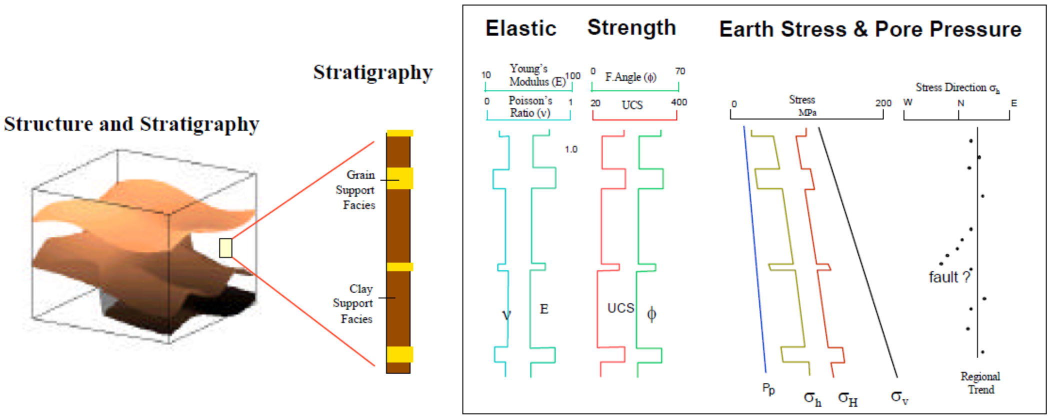

Figure 1 *Mechanical Earth Model. (SPE/IADC 59128).*

Mechanical Properties

For unconventional reservoirs, the source rock and reservoir rock may often be shale or some other finely layered formation, for which the assumption of isotropy is usually not valid. Mechanically this means that elastic properties vary depending on the direction in which they are measured. It is possible to quantify mechanical properties in multiple orientations using acoustic measurements and cores taken in different directions to bedding.

Pore Pressure

Pore pressure (Figure 2) is the pressure of the fluid in the pore spaces within the subsurface. In unconventional reservoirs pore pressure is important but challenging to quantify. It has a direct impact on the state of stress, it impacts flow rates and production, during drilling it can cause kicks from permeable formations, and it influences borehole instability in all formations.

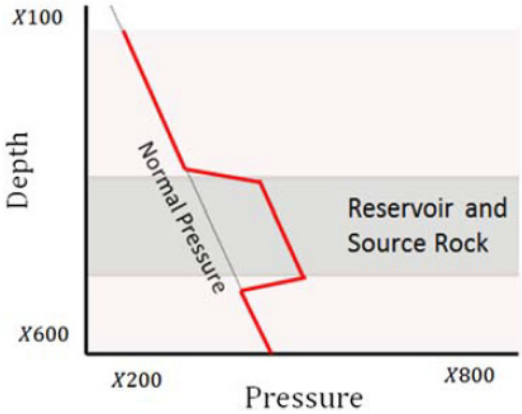

Figure 2 *Pore Pressure for Unconventional Reservoirs. (Unconventional Oil and Gas Resources Handbook-Evaluation and Development, Y. Zee Ma, Stephen A. Holditch, Elsevier, 2016.)*

Stresses

The in-situ stress state is a fundamental component of any geomechanical model and has a significant impact for both drilling and completions of unconventional hydrocarbon reservoirs. The stress state can be represented by three perpendicular principal stresses. If one of the principal stresses is vertical, caused by the overburden stress for example, then the other two are horizontal. These are the minimum horizontal stress and the maximum horizontal stress.

Drilling and Completion Applications for Unconventional Reservoirs

Economic production of hydrocarbons from unconventional reservoirs often requires drilling deviated or horizontal wellbores to maximize contact with the reservoir. Hydraulic fracture propagation and geometry are strongly dependent on the formation geomechanics, particularly the in situ stresses.

Conclusions

The topic of geomechanics plays a vital role in subsurface oil and gas exploration and development. The MEM, describing mechanical properties, pore pressure, and earth stresses, has an important role in both drilling (Wellbore Stability, Well Azimut, Casing Point, Mud Weight) and hydraulic fracture stimulations (Fracture Geometry, Oriented Perfs).

References

Unconventional Oil and Gas Resources Handbook-Evaluation and Development, Y. Zee Ma, Stephen A. Holditch, Elsevier, 2016.

The Mechanical Earth Model Concept and Its Application to High-Risk Well Construction Projects. Plumb, SPE, Edwards, SPE, Pidcock, SPE, Lee, SPE, Schlumberger. SPE/IADC 59128.