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SOME GEOMECHANICAL ISSUES OF RELEVANCE FOR ENERGY PRODUCTION

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Summary. Geomechanics plays a crucial role in the exploitation of hydrocarbon resources. At the well scale geomechanics is of paramount importance for the design of wellbores that shall remain stable during the whole productive life of the hydrocarbon field. Where possible, open hole completions are preferred to cased hole ones because they are less expensive, but in the first case borehole might collapse during production. Borehole stability depends on the orientation of the well with respect to the principal stress directions, on the magnitude of stress and pore pressure, on the mechanical behavior of the formation and on production history. Geomechanics is also fundamental for the prediction of subsidence phenomena and of possible fault reactivaction /earthquake triggering, for which a detailed knowledge of the mechanical behavior of the formation is required.

Adequate modeling using advanced constitutive and numerical models is possible, but challenged by scarcity of reliable data concerning the initial stress conditions and the mechanical behavior of the formation. Joint processing of geomechanical data with information proceeding from well logging can contribute improving the definition of both stress state and mechanical behavior. This contribution provides an overview of some methods proposed in recent years in this direction. Implications on engineering projects at (as in Figure 1) is then briefly discussed [1].

1 DETERMINATION OF IN SITU STRESS STATE FROM BOREHOLE DATA ACCOUNTING FOR BREAKOUT SIZE

Under most tectonic conditions, the vertical stress can be determined from the equilibrium in the vertical direction, while drilling-induced tensile fractures orthogonal to the minimum horizontal principal stress provide the principal stress directions. The magnitude of the minimum principal stress can be estimated from hydraulic fracturing and leak-off tests, while the pore pressure can be either measured directly or estimated with caution from geophysical data.

No direct methods are available to measure the intermediate principal stress, but simple analytical expressions for the back analysis of shear failures (break outs) detected with image logging along wells can provide a robust estimation. Elastic solutions for stress redistribution around a hole in plane strain conditions are used: the amplitude of zones where the redistributed stresses violate the failure criterion is coincident with the amplitude of the yielded zones predicted by more refined elasto-plastic simulations. This analysis is then a valuable support in defining the initial stress conditions [2].

2 STRUCTURAL REPRESENTATIVENESS OF SAMPLE DATA SETS FOR THE MECHANICAL CHARACTERIZATION OF DEEP FORMATIONS

The mechanical characterization of reservoirs benefits from joint interpretation of datasets of ultrasonic laboratory tests and of P and S waves logs. Ultrasonic tests allow determining the dependency on stress of the elastic wave velocities. At a reference stress, they also allow defining the relationship between elastic wave velocities and porosity for samples of a given rock formation. This relationship is a function of the structure of the samples. The stress-velocity relationship is used to refer log data to the reference stress, the porosity-velocity relationship is used to project the effects of the structure of the samples along the analyzed well. Local comparison of these two estimates defines an index which allows evaluating the representativeness of the samples (e.g. how much samples are damaged, but also the possible impact of fractures on the mechanical answer of the material in situ, undetected in laboratory measurements) [3].

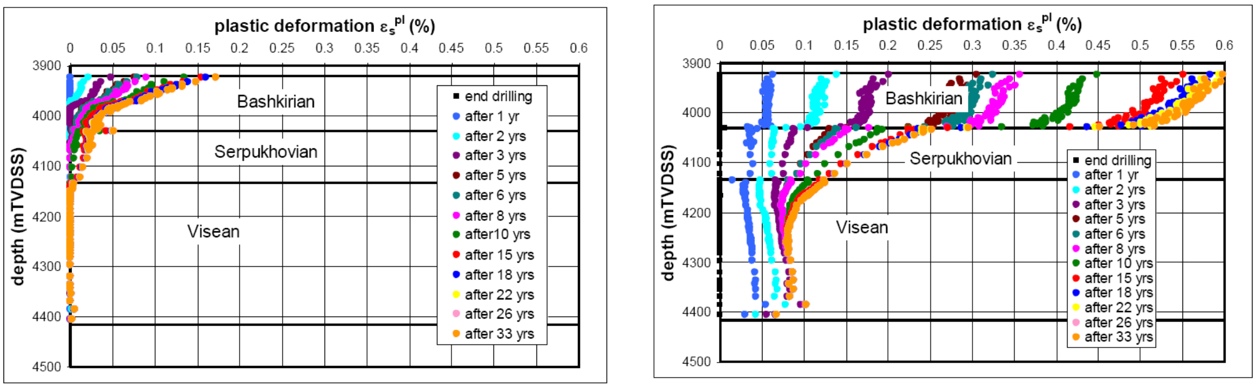

Figure 1 – Plastic shear strains, associated to wellbore instabilities, for two wells having the same production history but different orientation. Well A (left) has deviation 30° and azimuth 5°N. Well B (right) has deviation 30° and azimuth 95°N, the same of the maximum horizontal stress (intermediate stress). Modified from [1].

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