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Differentiation of Natural vs. Drilling Induced Fractures in Shale Gas Wells Using Borehole Images– Critical for Determination of In-situ Stress

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SUMMARY

Natural and drilling induced tensile fractures are routinely interpreted from borehole images; they provide a unique, high-resolution, borehole centric indication of the distribution and orientation of fractures for use in reservoir characterization, fracture modelling, geomechanics and comprehensive stress analysis. In shale gas wells in particular, the correct determination of in-situ stress direction is critical and misinterpretation can lead to serious errors, not only in the stress analysis, but in the overall characterization and development of the reservoir. Unfortunately, drilling enhanced natural fractures and drilling induced tensile fractures can have similar appearances on the borehole images. This paper concentrates on demonstrating a number of criteria that can be used to differentiate natural from drilling induced fractures.

Abstract

Natural and drilling induced tensile fractures are routinely interpreted from borehole images; they provide a unique, high-resolution, borehole centric indication of the distribution and orientation of fractures for use in reservoir characterization, fracture modelling, geomechanics and comprehensive stress analysis. In shale gas wells in particular, the correct determination of *in-situ* stress direction is critical and misinterpretation can lead to serious errors, not only in the stress analysis, but in the overall characterization and development of the reservoir. Unfortunately, drilling enhanced natural fractures and drilling induced tensile fractures can have similar appearances on the borehole images. This paper concentrates on demonstrating a number of criteria that can be used to differentiate natural from drilling induced fractures.

The underlying criteria for recognition of a natural fracture is, “does a flexible sinusoid fit on the feature” (i.e. does it truly represent a planar natural fracture). This is because natural fractures are usually planar features, discordant to bedding. In vertical wells, dipping fractures appear as sinusoidal traces and vertical fractures appear as straight lines. In deviated and horizontal wells, naturally occurring fractures appear as sinusoidal traces and the flexible sinusoid will perfectly fit on the fracture trace.

Ideally, drilling induced tensile fractures can be distinguished in a vertical well because they form a pair of borehole parallel symmetrical fracture tracks (180° apart), striking parallel to the principal stress direction, as explained by Anderson’s Theory of Faulting. Drilling induced fractures develop asymmetrically in the wellbore and are generally non-planar, therefore, they do not readily fit to a sinusoid.

We have to consider, however, that often we are dealing with partial or incomplete features that do not completely circumvent the borehole wall. In these less well-formed, imperfect cases such as the curved terminations of “J-hook” induced fractures at bedding surfaces or the inclined en- echelon drilling induced fracture sets in deviated or horizontal wells, it is more difficult to differentiate natural or drilling enhanced fractures from induced ones. With selected examples, we aim to demonstrate that with careful application of the basic criteria, we can correctly distinguish natural from drilling induced fractures.

In-situ stress analysis is critical in shale gas fields to define the orientation of maximum horizontal stress direction and to predict the style of the propagation of drilling induced tensile fractures. Distinction of natural vs induced fractures is a fundamental prerequisite.