Understanding Local Differential Stress and the Implication on Horizontal Well Completion Design

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The History

Reservoirs with “challenging matrix” characterization are routinely understood in today’s terminology to mean shale. Because of the low permeability nature of these reservoirs, they are typically drilled and completed using horizontal well technology to facilitate the creation of transverse hydraulic stimulation planes. Electrical logs (which might appear as “railroad tracks” to the inexperienced) may lead to the inaccurate conclusion of a simplistic homogeneous reservoir model. Natural fractures, thought to be the catalyst for the creation of new surface area, may or may not contribute. Frequently the natural fractures are restricted in height by the internal bedding laminations.

A New Opportunity

Image data is routinely used to develop and understand the structural dip and folding of a reservoir. First order fold analysis historically has not found the magic bullet to the identification of local stress or the prediction of natural fractures. Frequently, in petroleum bearing reservoirs multiple orders of folds exist that are not recognized on inter-well correlation or seismic data. Incorporating high resolution image data to define 2nd and 3rd order bedding deformations can uncover locally significant curvature. Gauging the curvature to its position within a reservoir's mechanical unit we can predict local differential strain for inclusion to the completion program. The local structure along a horizontal well can be dead flat to complex with multiple faults, tilted beds and changing thicknesses of mechanical units. Each structural domain defines a unique and specific situation. EXA: 100’ thick mechanical unit and a 2000’ radius of curvature generate differential strain exceeding 25000 psi.

Many of today’s completion designs are generic. This can leave many of the stages ineffective with little or no flow contribution. Understanding the differential stress will develop stage specific completion design recommendations to increase the percentage of stages that will flow.

Topics relevant to the puzzle include:

1. Horizontal well logging.

2. Railroad tracks, stress or fractures.

3. Orders of curvature.

4. Defining the mechanical unit.

5. Generation of local stress.

6. Modeling local structural curvature.

7. Vertical and horizontal examples.

8. Implications to completions.

9. Caveats during reservoir structural deformation, local strain is generated that may significantly overpower the rock strength mechanical properties as well as the far field stress.