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Earth Modeling: A Key Tool to Perform a 3D Sweet Spot Analysis by Integrating Petrophysical and Geophysical Information

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ABSTRACT

This paper describes an effort to improve the understanding of an unconventional reservoir in a 3D perspective by using geostatistics as a tool to integrate petrophysical and geophysical properties. Petrophysical data are one-dimensional, and do not provide a clear understanding of the spatial distribution within the reservoir. Conversely, geostatistics is the science of simulating the rock properties in a 3D grid. These two methods, combined with seismic data, provide a holistic understanding of the rock and fluid properties in a formation.

First, several seismic attributes that depict the discontinuity of the seismic reflector, including curvatures, were studied to understand the orientation of fractures. The orientation and dimensions of all faults and fractures are automatically tracked from the seismic volume, and then validated with the borehole image log to understand the dominant fracture orientation in the study area. The results indicate that the orientation of the faults and fractures interpreted from the fault likelihood volume closely correlates with those of the image log data and the regional literature. Consequently, the fault likelihood volume, along with the negative curvatures, can be used as a proxy to generate a natural fracture network (NFN) model. A petrophysical analysis was performed from the well logs; variogram mapping, a common geostatistical technique, was used to analyze the spatial data from these petrophysical properties to quantify a direction of continuity for the regional variable. The combination of fracture orientations, fracture density, and seismic and petrophysical attributes were used to create a 3D sweetness grid.

The 3D sweetness grid enables operators to optimize the completion design, well spacing, and trajectory to ultimately maximize the recovery of hydrocarbons. Finally, the ongoing work includes calibrating the sweetness grid with the existing production data. The workflow helps improve decisions for exploration targets.

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