GSP06

Simplifying Geosteering Interpretation and Decision-Making in Complex Environments Using Deep Resistivity Images

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SUMMARY

Directional drilling, particularly in conjunction with geosteering, is used to land wells at preplanned points in a reservoir. The objective is to optimize wellbore placement of production sections with respect to reservoir boundaries, fluid contacts, and reservoir quality, by adjusting well trajectories in real time. Geosteering is accomplished and facilitated by the recognition of approaching conductivity contrast boundaries not yet penetrated by the wellbore by the use of deep reading tools and geologic models used to predict the boundaries approach.

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The interpretation of real-time formation evaluation data and the decision-making process must be swift and efficient, keeping with the pace of drilling. The use of deep reading resistivity images and example templates for interpretation assists in timely decision-making and aids in simplifying what is often a complex problem. The efficacy of the deep resistivity image interpretation concepts are illustrated by comparison of motifs observed in field data in complex channel sand environments to synthetic models and numerically modeled images of observed instrument responses.

Addition of receiver antennas transverse to the axis of the coaxial antenna array permits acquisition of information on the direction to the boundary or contact. The physics of the method dictate that there is little or no detectable signal from the formation except in the presence of a conductivity contrast boundary within the (relatively large) volume of investigation of the antenna array. Electromagnetic radiation propagates considerable distances into resistive reservoir rocks and fluids, enabling electromagnetic loggingwhile-drilling instruments to detect such boundaries and estimate their orientation and distances in space relative to the wellbore. Images constructed from a combination of the usual coaxial dipole electromagnetic signal augmented by signals from transversely mounted receiver coils offer a visual interpretation option for the responses of loggingwhile-drilling propagation instruments.

However, methods for interpretation of standard borehole resistivity images cannot be applied directly to the interpretation of deep resistivity images. These deep resistivity images vary with hole inclination, conductivity contrasts, and geologic structure, but usually produce a recognizable pattern, called a motif, that can be diagnostic of the geological structure in the vicinity of the well path. Moreover, the motifs can be organized into a manageable number of themes that aid in their interpretation. Proper interpretation of the themes and motifs not only aids in geosteering decisions, but also enhances conventional formation evaluation by bringing an element of directionality to resistivity measurements that has not been possible in the past.

In this paper, we present and discuss examples from a challenging environment in the Middle East, where simple motifs can help identify common responses and, in the future, speed and aid interpretation and decision-making for both the contractor and the client.