True Formation Resistivity: A Comparative Study of True Formation Resistivity Inverted from Laterolog and EM Resistivity Sensors in a High-Angle Well – A Case Study from Oman

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Abstract

In the exploration and characterization of subsurface formations, the accurate determination of formation resistivity is crucial for evaluating reservoir properties and making informed decisions in oil and gas exploration. This study focuses on comparing two distinct resistivity measurement techniques—lateral resistivity and electromagnetic (EM) resistivity—in high-resistivity formations. The objective is to assess the performance and reliability of these methods for accurately capturing formation resistivity in challenging subsurface conditions. Laterolog and EM resistivity tools are both commonly utilized in the oil and gas industry to measure resistivity at various depths in a borehole. However, their responses in high-resistivity formations may differ significantly due to the characteristics of the formation and the limitations of the tool designs. This research investigates the inversion process applied to the data obtained from these tools, aiming to highlight the strengths and limitations of each technique.

Deep EM resistivity imaging was utilized for reservoir mapping, utilizing long transmitter-receiver spacings and a multi-frequency design to provide high-definition data. The sensor also provided measurements of resistivity anisotropy.

The lateral-resistivity measurements, along with high-resolution micro-resistivity images, were utilized to reveal geological features and detect the presence of fractures. An advantage of the small button electrodes utilized in the micro-resistivity sensor is their ability to acquire high-resolution images. However, their signal-to-noise ratio can be low in high-resistivity formations, so the inclusion of larger buttons provides an optimum design for such environments and increases confidence in the images acquired, leading to a clearer geological interpretation.

The high-definition deep resistivity signature revealed variations in reservoir boundary positions and dip changes, which were important for well-placement decisions, and resolved the thickness of the target layer in a laterally heterogeneous reservoir.

The results of the comparative analysis reveal insights into the sensitivity, resolution, and depth of investigation of each resistivity tool in high-resistivity formations. Factors such as tool response, formation anisotropy, and invasion effects are considered in the evaluation. Additionally, the study explores the impact of different parameters, such as permeability, bed boundary position, and hole enlargement, on the performance of the inversion techniques. This knowledge is valuable for optimizing well-logging strategies and improving the interpretation of subsurface resistivity data, ultimately aiding in more accurate reservoir characterization and efficient resource recovery in similar geological environments.

The use of inversion from lateral resistivity tools in high-resistivity formations is instrumental in overcoming challenges associated with conventional resistivity measurements. It provides a more detailed and accurate characterization of the formation, supporting better reservoir management and decision-making in the exploration and production of hydrocarbons. This research underscores the significance of integrating multiple measurement techniques to obtain a comprehensive understanding of subsurface formations in the quest for efficient and sustainable energy exploration and production.