Reducing Reservoir Model Uncertainties with Real-time Fluid Contact Mapping Using Extra-Deep Azimuthal Resistivity - Case Study from a Mature Oilfield, Offshore China

Viet Nguyen[1], Gao Xiaofei[2], Sanjun Chen2, Lei Yu[2], Hai Wang[1,2], Hai Wang[1,2], David Holbrough[1]

[1]Baker Hughes
[2]CNOOC China Limited

Abstract

Oil field A is currently operated by CNOOC in Shenzhen area, southeastern China. Up to the present date, there are over 30 directional and horizontal wells drilled with conventional tools for sustaining production, which has been on-going for over 13 years. Early 2022, production reached approximately 45% recovery, and 95% average water cut. After a multi-disciplinary study of by-passed oil distribution, the residual oil is believed to be located as a very thin oil column at the structure top or trapped within thin beds of the highly heterogeneous formation. As the field becomes more mature, it is essential to accurately identify the dynamic oil-water interface, optimizing the stand-off and maintaining the wellbore position within 1-2 m of the roof of the reservoir. Previous wells utilized deep azimuthal resistivity technology that supported accurate and informed reservoir navigation decisions. The real-time decision-making process in these wells greatly depended on the quantification of distance between the wellbore and nearby layers based on the resistivity contrast. With the presence of intra-shale layers, the interpretation is limited to the mapping of the reservoir top and the intrashale layer. Aiming to solve these challenges, the extra-deep azimuthal resistivity technology, associated with automated inversion processing, was introduced to the latest planned horizontal well in the field. The deployment of this technology was a significant milestone for the A field. Using the new approach, CNOOC accomplished all reservoir navigation objectives. During real-time operations, an instantaneous distance-to-boundary calculation, using shallow and deep resistivity measurements, was provided with detection ranging up to 4.5 mTVD. Based on which, timely steering decisions were made to maintain the well within a 1-meter-thick sand lobe. Also, the automated inversion processing used all shallow, deep, and extra-deep resistivity measurements to delineate resistivity-based earth models along the wellbore up to 20 mTVD around the wellbore. This supported seamless mapping of the reservoir top, a near-by intra-shale layer, and the oil-water contact, approximately 10 mTVD below the wellbore. The interpretation of all reservoir layers, including the remote fluid contact was further assessed with real-time statistical uncertainty analysis. The inversion results, being displayed with its confidence range. As the first deployment of extra-deep resistivity technology in the field, this success brought more insights to help CNOOC calibrate their understanding of the reservoir heterogeneity, as well as the dynamic oil-water contact. Eventually, uncertainties in reservoir model can be further reduced to optimize the planning of future wells within the field.