Wireline log-based petrophysical characterization of reservoir intervals within the Kohat Basin, NW Pakistan

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Abstract

This study deals with the qualitative and quantitative analysis of the wireline logs for the reservoir units in four different drilled wells i.e. Kahi-01, Manzalai-01, Sumari DeepX-01 and Mami Khel-01 well within the Kohat Basin to evaluate the potential of the productive zones. In addition to series of manual, graphical and theoretical contributions, Interactive Petrophysics (IP) software was used for computing results for different petrophysical properties. The Lumshiwal and Hangu formations, having diverse thickness throughout the Kohat Basin, were selected for detail petrophysical investigation after thorough analysis of well logs and twelve potential reservoir zones (three (03) in Hangu Formation & nine (09) in Lumshiwal Formation) qualifying the criteria of cut-off factors were identified in these formations.

Based on Pickett Cross-plots and various litho-logs, the transect lithology evaluated for Hangu formation consists of fine to medium grained, light grey siliceous sandstone with inter-beds of shale and patches of carbonaceous claystone at the top and bottom, while the Lumshiwal formation comprises mainly of fine to medium grained, dark grey to greenish grey, quartzitic, abrasive sandstone with carbonaceous, glauconitic shale, siltstone and sandy limestone intercalations at places. The less volume of shale calculated through minimum of GR log, significant values of effective porosities, up to 6.1% determined stepwise through various equations, high permeabilities assessed through Timur's equation, prominent gas effect by the cross-over of neutron and density logs and low values of water saturation calculated through Archie's equation, confirm the reservoir potential of the specified zones within Hangu and Lumshiwal formations. The dominant grain size of the reservoir units within Hangu and Lumshiwal formations determined from bulk volume of water (Vb.w) values ranges from coarse to fine grained with an increase in grain size in the south, east and southeast directions and the constancy in Vb.w values in all the reservoir units reveals water-free hydrocarbon production in them.

Cut-off values of 25-45% of volume of shale, 3.5-6% of effective porosities and 40-60% of water saturation were applied accordingly to all the reservoir zones as reference parameters that distinguished between the pay and non-pay intervals.The well correlation shows that the depths of these formations increase towards the south. The effective thickness of the Hangu Formation increases in the NW while in case of Lumshiwal Formation; it increases towards the north and northeastern part of the Kohat Basin. Sequence stratigraphic analysis of various trends in gamma ray log reveals deltaic depositional settings for Hangu Formation and pro-deltaic and inner to middle shelf settings for Lumshiwal Formation.Taking into consideration the cut-off factors applied, the overall reservoir capability of the Lumshiwal formation decreases towards the western and northern margin while Hangu formation towards the central and southern part of the Kohat Basin.