Application of Sonic-Resistivity and Density Methods in Total Organic Carbon Estimation, a Case Study for Lower Goru-Sembar Shales, Lower Indus Basin Pakistan

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Abstract

Well logs have been routinely used in order to evaluate total organic carbon (TOC) potential of shales around the world. Two established techniques, the Delta-log R method and Density method, are used to calculate log TOC in Lower Goru and Sembar Shale intervals. TOC's estimated with these techniques are calibrated with lab measured TOC's in several wells, and a comparison have been made regarding the accuracy and applicability of these methods in the study area, located in Lower Indus Basin.

The sonic-resistivity method appears to have a decent correlation with lab measured TOC's, especially when maturity data is also available for a given formation. A background TOC of 1 to 1.5% is added in the log measured TOC's, as baseline TOC encountered in Lower Goru and Sembar Shale lies in this range. It is known that in mature, organic rich shales, both sonic and resistivity values increases but in case of Lower Goru / SembarShales in the study area, it is observed that the delta-log R separation is mainly due to increase in resistivity values, except some intervals. This owes to the fact that shales are mature but do not have high TOCs as compared to several North American shales over which this method was developed.

The density method for TOC estimation appears to correlate well with measured TOC's only in some parts of the study area. It is observed that density of matrix, which is a key input in the original derivation, should be determined with care as it appears to be influenced by heavy minerals in many wells of the study area. Presence of heavier minerals like chlorite, dolomite, siderite and anatase in Lower Goru/Sembar Shale intervals, confirmed by XRD analysis, suggest that a greater value for density of matrix should be used than what's originally used in the parent equation. It is proposed that TOC should be calculated in most parts of the study area using formula "TOC = (146.57/RHOB) - 52.035" rather than originally proposed "TOC = (154.497/RHOB) – 57.261". The tailored equation for the study area appears to have much improved correlation with the measured TOC values. The applicability of the proposed equation is valid for wells located in and around the study area where mineralogy is similar and effected by heavier minerals while in other wells, where matrix density is relatively low (~2.68g/cc) the original equation seems to work fine.

It is proposed that, in absence of lab measured TOC data, the sonic-resistivity method and density method are applicable for accurate measurement of log derived TOC's in and around the study area with some caution, as discussed ahead.