Methodology to Estimate Thermal Maturity from Petrophysical Calculations of Gas/Oil Ratios

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Abstract

Thermal maturity is routinely calculated from analysis of vitrinite reflectance (Ro), and is important in the understanding of the type of hydrocarbons – oil vs gas – that will be produced. However, in areas where Ro has not been run, and where there are no producing wells, there is no current method of predicting thermal maturity from other available data.

There are direct relations between vitrinite reflectance and Gas/Oil Ratios (GOR). A prior publication of Holmes (SPWLA 1990), describes a petrophysical method of calculating GOR using density, neutron, and resistivity well log responses. Correlation of GOR with Ro has been defined by Dow (1977) and Jarvie et al (2015).

The basis for quantifying the degree of gas saturation from petrophysical analysis is the effect of gas on density and neutron log responses. Gas increases porosity on the density log, and reduces porosity on the neutron log (the so called “density/neutron cross-over effect”). Care must be taken to apply the correct lithology, since this must be known to calculate porosities from both logs. If available, descriptions from core or cuttings data should be examined. Also, responses of density, neutron, and Pe logs using a Matrix Identification Plot (comparison of apparent matrix density and Apparent Matrix Volumetric Cross Section) should be examined. Total hydrocarbon saturation is determined from a standard porosity vs Resistivity (Pickett) plot. By subtracting gas saturation, oil saturation is available, allowing for the calculation of gas/oil ratio.

In this publication, we have analyzed eight Niobrara wells from the Denver – Julesburg Basin, which have a large range of GOR as determined from production data. All wells have the requisite log suite to calculate GOR. We demonstrate good comparison between the two sets of GOR. We also have vitrinite reflectance data on all wells, provided by Grant Zimbrick of the Dolan Integration Group.

From the vitrinite reflectance data, values of GOR are shown to be significantly lower than actual GOR. This suggests that the hydrocarbons have migrated from levels of higher thermal maturity. For these wells, the most likely explanation is lateral migration from a fairly close “hot spot”.

These findings are significant for a number of reasons. Thermal maturity can be estimated from petrophysically generated GOR, even if no Ro data are available. If Ro information does exist, comparisons can be made with petrophysically determined GOR, to analyze the likely provenance of the hydrocarbons. A knowledge of thermal maturity is required to calculate volumes of total organic carbon (TOC) from well logs. These calculations are equivalent to “organic porosity” which is a significant source of unconventional reservoir hydrocarbons.

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