Low Resistivity Low Contrast Pay Sands

For a change, instead of posting presentation files, I will post some short articles that I have written over the years. Hopefully, these will be of interest to the petrophysics community at large. Way back in 1996, I presented a paper titled “Efforts Toward Improving Formation Evaluation”, at the Petroleum Geology Conference 96, organized by the Geological Society of Malaysia. In that presentation, I mentioned several challenges faced in evaluating the hydrocarbon bearing reservoirs in Malaysia. One of these challenges is the so-called “Low Resistivity Low Contrast Pay Sands” or LRLC Pay Sands. The challenges in evaluating LRLC pay sands still exist today, not only in Malaysia but also in other places in the world. Here is a short article that I wrote on this subject. I apologize for the poor quality of the log plots, as I had to copy and paste them from a PDF file. I could not locate my original Microsoft Word document for this article.

Low Resistivity Low Contrast (LRLC) pay zones are hydrocarbon bearing reservoirs with low resistivity or low contrast in resistivity log responses due to the influence of a variety of factors associated with mineralogy, water salinity, and microporosity, as well as bed thickness, dip, and anisotropy. Low-resistivity pay is generally characterized by pay zones that cause deep resistivity log curves to read low, usually around 0.5 to 5 ohm-m. This is often attributed to a combination of shale content, mineralogy, microporosity and thin beds. Low-contrast pay implies a lack of resistivity contrast between pay sands and adjacent shales or wet zones. This problem is most commonly seen when the resistivity tool encounters a zone that contains fresh water (or waters of low salinity). As salinity decreases, the electrical pathway through a body of water becomes weaker and more dispersed, thus causing the water to become less conductive (or conversely, more resistive). Therefore, while the resistivity of the pay zone may not be low, the resistivity of the water leg is high enough to make it difficult to distinguish between pay and wet zones.

Causes of Low Resistivity or Low Contrast Pay Zones

A number of factors have been found to act on the logging tool to produce low resistivity or low contrast pays. In Moore (1993), Darling and Sneider cite the following causes:

**Bed Thickness**: some pay zones are simply too thin to be resolved by the logging tool.

**Grain Size**: very fine grain size can lead to high irreducible water saturation.

**Mineralogy**: conductive minerals (such as pyrite, glauconite, hematite, or graphite) or rock fragments can have a pronounced effect on resistivity response.

**Structural Dip**: dipping beds produce significant excursions on the resistivity log when orientation between the tool and the bed deviates from normal.

**Clay Distribution**: classified as either dispersed, structural, or laminated - all capable of holding bound water.

**Water Salinity**: high salinity interstitial water causes low resistivity within the pay zone, while low salinity water can cause low contrast pays.

Any combination of the above: often a combination of inter-related factors, causes the logging tool to read lower resistivity than normal inside a pay zone. Of all the factors listed above, probably the most common cause of low resistivity pay is the simple combination of
thin beds containing highly conductive shales (and their associated bound water), along with thin pay sands which are below the vertical resolution of the logging tool. (Source: IHRDC).

Fig 1: A core through a laminated interval. (Source: IHRDC)
Fig. 2 – Low resistivity gas sand. The main target sand is gas bearing although the highest resistivity in this sand is only 2.5 ohm-m. This field tested 25 MMCSFD gas in each well from this sand.
Fig. 3 – Low resistivity (3 ohm-m) oil sand. DST results: 2600 BOPD on 96/64” choke. No water production. Average Sw = 70% computed from conventional logs. Nuclear Magnetic Resonance Log indicates movable hydrocarbon.
Fig. 4 – Low contrast in resistivity pay sand due to fresh or low salinity formation water. Wireline formation tester recovered an oil sample from the upper sand. The lower sand, with similar resistivity, tested very fresh water with salinity of of 1,800 ppmNaCl equivalent.
Fig. 5 – Very low resistivity gas sand. Resistivity is less than 1 ohm-m. Tested 3.6 MMSCFD of gas from the perforated interval (1354–1397) mMDDF interval.