Paper 5

Effort towards improving formation evaluation

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Some of the formation evaluation problems encountered in Malaysian oil and gas fields comprise sands with low formation water salinity, low resistivity low contrast pay sands, thinly laminated sand shale sequences, sands with high irreducible water saturation

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and presence of complex minerals. Evaluation of formations having low connate water salinity, sometimes close to being fresh, has always been difficult. In some cases, the resistivity contrast between hydrocarbon bearing sand, especially oil bearing zones, and water bearing sand is very low, making it difficult to determine the fluid type. Thinly laminated sand shale sequences which are present in Malaysian fields exhibit low resistivity and low contrast pay sands. High apparent water saturation values have been computed in zones which are known to produce clean oil with no water cut. This has been attributed to high irreducible connate water. In some cases, high water saturation is associated with the so called intermediate quality IQ rocks. The presence of some complex minerals such as siderite and limonite may cause underestimation of porosity if the gain densities of such minerals are not properly taken into account. This requires a complex model for mineralogical composition during formation evaluation. Several measures have been taken to overcome these problems in formation evaluation with the intention of better understanding the reservoirs and thus enhancing the hydrocarbon potential of the oil and gas fields in Malaysia.

Some of the approaches undertaken to resolve these problems are the use of nuclear magnetic resonance tools (CMR™ and MRIL™) to detect and confirm the occurrence of high irreducible connate water saturation. Resistivity logging tools with better vertical resolution such as the Array Laterolog Tool (ARI™), the Array Induction Tool (AIT™) and the Thin Bed True Resistivity Tool (TBRt™) have helped to a certain extent in resolving thinly laminated sand shale sequences. Measurements from the high resolution resistivity tools have led to better estimation of the formation resistivity leading to more reliable values of fluid saturations. In addition, application of more suitable water saturation models, such as Dual Water Model, has resulted in improved formation evaluation. Formation imaging tools such as the Formation Micro Scanner Tool (FMS™), Formation Micro Imager Tool (FMI™) and the Circumferential Borehole Imaging Tool (CBIL™), have been used to detect bioturbation which usually causes degeneration of reservoir quality. These imaging tools have also helped to resolve thinly laminated sand shale sequences. Another approach adopted to improve formation evaluation in laminated shaly sands is the use of resistivity modelling technique. Currently PETRONAS Carigali, in collaboration with Sarawak Shell Berhad, is conducting a modelling study of the laminated sand shale sequences in the West Lutong Field using the SANDWICH™ software. A project is presently being undertaken by PETRONAS Research and Scientific Services, together with Schlumberger, to improve formation evaluation of Low Resistivity Low Contrast pay sands by using resistivity modelling techniques. In view of enhancing formation evaluation capability, PETRONAS Carigali has adopted a probabilistic petrophysical evaluation method replacing the deterministic evaluation method previously used. This probabilistic method is able to model for complex mineralogical compositions. Furthermore, this probabilistic model takes into account uncertainties in tool responses, log calibrations etc., thus leading to more accurate evaluation results.

As a paradigm shift in petrophysical data acquisition, PETRONAS Carigali is using Logging While Drilling logs as the definitive logs in one of the oil fields in offshore Peninsular Malaysia. In the ongoing development drilling in this field, wireline conveyed logs are no longer run except for specialised tools such as the wireline formation tester or imaging tools. LWD logs are the main logs used for petrophysical evaluation of these wells. This approach has been taken for several reasons. Present day LWD tools are very reliable in performance and the basic data acquired by them are as good as those acquired by the wireline tools. Under most conditions, LWD logs tend to give measurements which are more representative of the actual formation parameters due to the very fact that data acquisition is being done right after drilling through the formation before extensive invasion by mud fluids has taken place. In highly deviated development wells, LWD logs are preferred over conventional to wireline logs which most probably will have to be run on drill pipe, incurring additional rig time and cost. The use of LWD logs has

also resulted in substantial cost saving compared to wireline logs, since wiper trips are no longer required. In the particular case of the Dulang Field, where reservoir sands are at relatively shallow depths and are of unconsolidated nature, drilling of while drilling gives logs with better quality than the conventional logs, either wireline or pipe conveyed, since the latter is run usually after severe washouts have occurred. Furthermore, LWD logs being acquired almost instantaneously after drilling and transmitted up-hole in real time, decisions on revised well trajectories if required, well completion strategy etc. can be made very quickly with inherent cost savings.

Further improvement in formation evaluation is achieved by taking an integrated approach whereby all available information such as mud logs, drill cutting descriptions, formation tester results, core description and analysis data, well test data, etc. are taken into account when petrophysical evaluation of a well or a field is carried out. Based on core description and core analysis data, a comprehensive mineralogical model is constructed as an input to formation evaluation. Core data such as permeability, capillary pressure data whenever available are used to verify and calibrate the evaluated results thus leading to a more robust interpretation.