High-Resolution Geochemistry While Drilling (HRGWD): Application in Greater Campos Basin, Offshore Brazil

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Introduction

Almost on-line geochemical data provides valuable information during drilling operations that is complimentary to conventional logging techniques and which can be gleaned no other way. Typical results include the prediction of oil properties (e.g. origin, oil type, thermal evolution, oil quality (e.g. gravity and biodegradation)), and the calculation of oil saturation. The analysis can be quickly performed in cuttings and core samples in time to enable successful exploration evaluations and to help operation managers make precise on-site decisions.

To enhance the accuracy of the results, fast analysis of produced oils from a particular field near the drilling area allows the construction of calibration curves based on measured oil properties versus biomarker ratios. Once suitable calibration curves have been constructed, oil properties can be indirectly determined throughout an entire well via gravimetric, carbon isotope, GC, GC-MS or GC-MS-MS analysis of core or cutting extracts. Also, we can apply Isotech tubes and perform carbon isotopes in all gases collected through the Mud Line. The use of calibration curves is not fundamental for the application of HRGWD as support to exploration and production drilling operations, but when applied it is able to enhance even more the quality of achieved results.

Where conventional logging techniques do not provide a definitive identification of oil-water contacts and oil quality, geochemical logging can be used. By calibrating GC fingerprints of cutting and core extracts to zones of known oil legs, water legs, and gas legs, they were able to apply these diagnostic fingerprints to determine oil-water and gas-oil contacts in wells where the contacts could not be located by other means.

Not only is geochemical logging an important method for the determination of oil properties, for reservoir continuity studies and for recognition of oil-water contacts, geochemical logging can be used to define pay zones and rank the oil quality. Along with providing distinctive geochemical fingerprints, each extract also carries information concerning the amount of oil contained within a particular unit, i.e. the oil saturation. This is done by quantitative analysis of ubiquitous molecular species found in petroleum and also on the basis of the richness of the color of the extract. Where hopane concentrations are high and extract color is dark, the oil saturation is high. However, high oil saturation does not necessarily mean that the oil will be producible. These data must be combined with other oil characteristics from the HRGWD log, such as gravity, and porosity and permeability derived from conventional well logging.

An example of HRGWD technique is shown in figures 1 and 2, which presents the HRGWD evaluation during two well drilling in the Greater Campos basin, Brazil.
Results

In well illustrated in Fig. 1, the presence of hydrocarbons in the organic extracts of the cuttings samples was readily revealed by the colour analyses. Oil is present in the section from 3130 to 3300 m. The distribution of the oil in the interval follows an almost perfect gaussian distribution peaking between 3180 to 3240m.

The percentage of saturate hydrocarbons and the distribution of hydrocarbons revealed by whole oil gas chromatography suggest that the oil present in the section has a low API gravity of between 12° and 14°. Furthermore, detailed biomarker analysis (by GC-MS and selected GC-MS-MS) shows that the oil is of uniform quality through the reservoir interval and shows no discontinuities chemical characteristics. Also, the results confirm the low API gravity of the oils.

Figure 1- Oil saturation and GC data from cutting samples while drilling showing oil zones.

The cuttings samples gas chromatography (GC), carbon isotopes and gas chromatography/mass spectrometry (GC-MS) saturate data show a very good correlation among the terpanes between the samples analysed. The steranes show a high degree of biodegradation. Using both the terpane data and selected GC-MS-MS sterane data, it was possible to deduce that the oil present in the reservoir interval originated from a lacustrine saline source rock derived from the upper part of the Lagoa Feia formation, had been under peak generation thermal stress and have undergone severe biodegradation process.
In the example from figure 2, it could be observed the variation in the crude oil origin with depth and TOC content. In the upper part of the well, the biomarker data suggest the presence of oils derived from marine carbonate source rocks (e.g. C_{29} Hopanes >> C_{30} Hopanes) typical of Albian/ Cenomanian sections in the area. Also, the sterane data showed that thermal equilibrium has not been reached and the section, therefore still immature. On the other hand, the lower part of the well, around 5000m, the biomarker data suggest the presence of oils derived from marine siliciclastic source rocks (e.g. C_{29} Hopanes << C_{30} Hopanes) typical of organic-rich black shale from Albian/ Cenomanian sections in the area. Also, in those depths the hopane and sterane data showed that the samples were expelled just close peak generation stage of thermal evolution.

Figure 3. Plot of TOC data together with Biomarkers showing oil type and quality

Figure 3. Plot de biomarker versus diamondoids of the oil shows indicating the presence of mixed oil with the cracked one originating from a deep reservoir accumulations in the well.