Geochemical Evaluation of Sediments in Areas of Deep Water Oil Exploration Drilling – Campos Basin, Brasil


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Introduction

The amount of drilling and exploration of oil wells in shallow and deep waters off the Brazilian coast has grown considerably over recent decades. New drilling concepts are technically demanding and require very high performance drilling fluids with capacities that exceed those presented by water-based fluids (WBFs), which has led to the development of non-aqueous fluids (NAFs) made of emulsions, whose continuous phase is basically composed of highly processed synthetic hydrocarbons. The use of WBFs or NAFs, or even both, depends on the drilling conditions and both have been used extensively by the oil industry. The impacts caused by drilling activities when both types of fluids are used result from the generation of waste fluids and drill cuttings, a constant concern of government environmental agencies. In order to monitor environmental changes caused by oil well drilling using WBFs and NAFs, chemical analyses were made before and after drilling. Analysis of organic compounds obtained from recent sediments. This analysis of the organic compounds included analysis of the aliphatic hydrocarbons (linear and unresolved complex mixture), polyaromatic hydrocarbons - PAH (16 prioritized by the Environmental Protection Agency), ketones, alcohols and sterols.

Methodology

The exploration well examined in the present study was drilled in the Campos Basin whose depth at the wellhead was 902 m. The sampling sites were located within a 300 meters radius (150 and 300 m) of the well, as shown in Figure 1.

Three sampling cruises were performed: before drilling, one month after drilling and twelve month after drilling. The first cruise aimed to characterize the site background. Sediment samples were extracted with dichloromethane in a soxhlet apparatus. The resulting extract was fractionated by adsorption chromatography followed by gas chromatography analysis with mass selective detector (GC/MSD). The same analytical procedure was applied to the drilling fluid.

Results and Discussion

The lipid fraction analysis from the three cruises indicated the presence of n-alkanes, n-alkane-2-ones, n-alcohols and sterols in all sediment samples.

The aliphatic hydrocarbon fraction analysis of the first cruise samples showed a bimodal distribution with predominance of odd over even n-alkanes in the range C_{14} to C_{35} (Fig. 3) with a maximum concentration in C_{29} or C_{31}, suggesting a contribution of algae organic material (low n-alkanes) and terrestrial plants (high n-alkanes). Analysis
of the same fraction from the second and third cruise showed changes in hydrocarbons profile in samples from sites 3, 4 and 9, located in the direction of the predominant ocean currents (Figs. 1 and 2). Ocean currents direction data (Freitas et al., 2003) are varied, with a slight predominance for the north-northeast direction from 713 m to 873 m (Fig. 2) becoming almost zero at 900 m depth. Very similar values are reported by Xavier et al., (1993). Comparing the profile of these samples (Fig. 4) with the aliphatic fraction of the analyzed WBFs and NAFs drilling fluids (Fig. 5), it is possible to conclude that the change occurred due to the drilling fluid presence, since there was a hydrocarbon increase in the range C\textsubscript{15} to C\textsubscript{18}. This profile remained unchanged after one year of drilling activities, but it must be pointed out that there was no change in the total petroleum hydrocarbon average (TPH) in the investigated site from the first to the third cruise. Furthermore the TPH value was extremely low (Fig. 6).

The \textit{n}-alkane-2-ones presented a bimodal distribution with predominance of odd over even hydrocarbons and maximum concentration in C\textsubscript{31} and C\textsubscript{33}, a profile that did not change in all samples collected during the three cruises. The \textit{n}-alcohols profile revealed the presence of alcohols between C\textsubscript{16} and C\textsubscript{32} with predominance of even over odds and a maximum concentration in C\textsubscript{16} and C\textsubscript{18} and C\textsubscript{28} and C\textsubscript{30} for most of the samples. This is characteristic of algae and terrestrial plants contribution, and no significant changes were detected during the three sampling periods.

Sterols analysis showed the presence of sterols C\textsubscript{27}, C\textsubscript{28} and C\textsubscript{29} in all samples, indicating a phytoplankton and terrestrial plants contribution since there was predominance of the sterols cholesta-5-en-3\textbeta-ol (cholesterol) and 4\alpha-23,24-trimethyl-5\alpha-cholest-22-en-3\textbeta-ol (dinosterol). This profile remained unchanged during the three cruises.

The 16 PAH analysis is presented in Table 1. It can be seen that the 16 PAH sum reached a maximum of 186.56 µg.kg\textsuperscript{-1} (ppb) on the three cruises. It was observed that, there is no homogeneous distribution of these compounds throughout the three cruises, which may be related to natural sample variations. Another important observation is that there was no increase in these compounds due to the presence of drilling fluids, as observed in samples from sites 3, 4 and 9.

Conclusions

Lipid fraction analysis showed that the extractable organic matter presented in the site is constituted by the contribution of algae and organic matter of terrestrial origin. The drilling fluid used for drilling an oil well at 900 m deep present no significant environmental changes in the studied site.

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References


**Figure 1.** Sediment sampling sites around the drilling well.

**Figure 2.** Ocean currents in the studied site, with north-northeast predominance for 713 m, 793 m and 873 m depth.

**Figure 3.** Example of aliphatic fraction profile from samples of the first cruise.

**Figure 4.** $n$-alkanes fraction profile from sediments collected in site 3 (A), site 4 (B) and site 9 (C) during cruises 1, 2 and 3.

**Figure 5.** Example of the aliphatic hydrocarbon profile (number of carbons in the chain) versus the concentration in mg.kg$^{-1}$ for water based (WBF) and synthetic based fluids (SBF).

**Figure 6.** Temporal development of TPH in mg.kg$^{-1}$ for the three sampling cruises. Mean concentrations considering all sites ($n = 8$ for cruise 1, $n = 9$ for cruises 2 and 3); the first mean (in month zero) refers to the first cruise, the second (month 1) to the second cruise and the third (month 12) to the third.

**Table 1:** Average values for the sums of polyaromatic hydrocarbons (16 PAH) in µg.kg$^{-1}$ (ppb), for the three sampling cruises, NS = no sampling.