

The Utility of the Stable Isotopic Composition of Severely Biodegraded Oils as Petroleum System Correlation Parameters

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Oil-source rock or oil-oil correlation is one of the most challenging steps in the analysis of complex petroleum systems. It is generally based on molecular fingerprints (biomarkers) and whole oil or oil fraction carbon isotopic composition. When biomarkers are unaltered by post expulsion processes, they can constitute a powerful tool for correlation but effects on biomarker concentrations in mixed oil charge scenarios and even destruction of biomarkers at severe biodegradation levels, may drastically affect the viability of the approach. Biodegradation is by far the most important process responsible for the variations in the composition and oil properties across the Alberta heavy oils and oil sands. In this study, continuous petroleum columns from the Alberta oil sands containing progressively biodegraded oil (from level 5PM to 8PM) are studied using molecular and isotopic analyses, with the purpose of evaluating the effect of biodegradation in the C, N, S and H isotopic compositions of bulk oil and fractions of different polarities to assess the viability of these proxies as oil correlation parameters. The results show that even though the total hydrocarbon fraction is highly depleted by biodegradation to different degrees, this process does not cause observable systematic carbon isotope changes in either the whole bitumen or in fractions of different polarities. $\delta^{15}\text{N}$ values in bulk bitumen also do not show any trend with biodegradation, as may have been expected from the observed destruction of carbazoles studied in the polar fractions of the oils, which change both concentration and distribution with biodegradation levels. Organic sulphur compounds in the aromatic hydrocarbon fraction are also progressively removed down the oil columns, yet $\delta^{34}\text{S}$ values of bulk oil remain essentially constant. Locally however, lower $\delta^{34}\text{S}$ values suggest secondary incorporation of ^{32}S -enriched sulfur. Finally, it is observed that S and N isotopic compositions of bitumen and heavy oils from the main studied pools in the basin differ consistently displaying what appears to be a regional trend. The lack of significant changes of the bulk isotopic composition of related oils with very different degrees of biodegradation suggests that the observed isotopic variations are source charge related. We conclude that S and N isotopic compositions can be used in biodegraded oils as stable source proxy signatures