Geophysical Research Abstracts
Vol. 12, EGU2010-2447, 2010
EGU General Assembly 2010

Evaluation of reservoir alteration processes using compound-specific carbon and hydrogen isotope ratios

Andrea Vieth, Raingard M. Haberer, Heinz Wilkes, and Brian Horsfield
GeoForschungsZentrum Potsdam, Organic Geochemistry, Potsdam, Germany (vieth@gfz-potsdam.de)

Biodegradation of hydrocarbons in shallow prospects is one of the main processes occurring at the petroleum reservoir scale which may lead to a significant reduction of volumes of oil in place as well as compositional changes which are the basis of quality deterioration in particular during the early stages of alteration. The majority of the global petroleum reserves are more or less significantly biodegraded (Head et al., 2003).

In the past decade, compound-specific isotope analysis has become a powerful tool in environmental and petroleum geochemistry to evaluate the biodegradation of hydrocarbons in laboratory and field studies (Meckenstock et al., 2004; Vieth and Wilkes, 2010). In petroleum reservoirs the enrichment in ^{13}C of selected petroleum hydrocarbons has been used as a qualitative indicator of biodegradation but can also be used to quantify biodegradation of selected light hydrocarbons (Vieth and Wilkes, 2006). The complex situation within petroleum reservoirs will also limit the application of stable carbon and hydrogen isotopic compositions as indicators of biodegradation processes if oil samples with origin from different source rocks, thermal maturities as well as charging and mixing histories are evaluated. It is known that the application of stable isotopes for the assessment of biodegradation of individual hydrocarbons becomes increasingly insensitive with increasing chain length of the target compounds as a result of the dilution of the isotope effect occurring at the reactive site over the whole molecule. Assuming that for field studies at least a change in δ^{13}C of 2‰ for an individual compound would be required for a reliable assessment of biodegradation the isotope method will be limited to compounds with a maximum number of approximately 10 carbon atoms. Comparable limitations are expected to occur for the effects of biodegradation on the hydrogen isotopic compositions of individual hydrocarbons (Wilkes et al., 2008).

It was the aim of the project “BioPetSFlux” to evaluate alteration processes at the reservoir scale using different approaches (e.g. compound-specific isotopy, NSO compounds, molecular modelling). Based on the conceptual assumptions mentioned before, the stable carbon and hydrogen isotopic compositions of light hydrocarbons, n-alkanes, pristane and phytane of 19 oil samples from a petroleum reservoir have been evaluated and several new isotope parameters have been developed to assess and differentiate primary and secondary processes that occurred and influenced the molecular and isotopic composition of the oils on the reservoir scale. In our field study, we observed good correlations between concentrations and δ^{13}C values of $i\mathrm{C}_5$, $n\mathrm{C}_5$ and $n\mathrm{C}_6$ that fit to the Rayleigh equation and indicate that biodegradation occurs. As the isotope ratios of larger n-alkanes, as well as pristane and phytane will remain unchanged during this secondary alteration process and will reveal information about primary charging processes, we have been able to establish a regional scheme for this petroleum system mapping the charging and alteration effects leading to compositional heterogeneity within this oil field. Our results are in accordance with the basic organic geochemical characterisation and lead to a more precise assessment of the reservoir alteration processes.

References:

Head, I.M., Jones, D.M., Larter, S.R., 2003. Nature 426, 344-352.

Meckenstock, R.U., Morasch, B., Griebler, C., Richnow, H.H., 2004. Journal of Contaminant Hydrology 75, 215-255.

Vieth, A., Wilkes, H., 2006. Geochimica et Cosmochimica Acta 70, 651-665.

Vieth, A., Wilkes, H., 2010. In: Timmis, K.N. (Ed.), Handbook of Hydrocarbon and Lipid Microbiology. Springer, Berlin, pp. 99-111.

Wilkes, H., Vieth, A., Elias, R., 2008. Organic Geochemistry 39, 1215-1221.