Re-Os Elemental and Isotopic Systematics in Petroleum:

A Potentially Powerful Tracer

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The recent discovery that residues of migrated hydrocarbons can yield Re-Os oil generation ages requires fundamental information regarding the nature of Re and Os in oil to be established. Re and Os abundances in whole oil are found to correlate positively with asphaltene content, and a significant enrichment in Re and Os abundance in asphaltene, relative to the whole oil, is observed for all samples that contain measurable asphaltene. Relative to the whole oil, > 83 % Re and Os are present in the asphaltene fraction, with most samples being > 90%. The Re and Os abundances in the maltene fraction are very low, being ≤ 2 ppb Re and 20 ppt Os. The enrichment of Re and Os in the asphaltene fraction relative to the maltene fraction is similar to other trace metals such as Ni, V and Mo. Given the abundance of Re and Os in the asphaltene component and that heteroatomic ligands are concentrated in the asphaltene, this may suggest these elements are bound predominantly by such ligands.

The $^{187}Re/^{188}Os$, $^{187}Os/^{188}Os$, and $^{187}Os/^{188}Os$ values calculated at the estimated time of oil generation from asphaltene are similar to those of the whole oil, as expected from the elemental results. This suggests that the asphaltene fraction can be used to approximate the Re-Os isotopic compositions of the whole oil. In addition, to first order, the Os isotopic composition in oils today reflects source rock age. For example, Ordovician sourced oils show the highest $^{187}Os/^{188}Os$ (~ 5.5) and Cretaceous sourced oils have low $^{187}Os/^{188}Os$ (~ 2). This relationship is also seen for Alberta Oil Sands ($^{187}Os/^{188}Os$ = 2.2-4.4), which are likely sourced from the Devonian Exshaw Formation ($^{187}Os/^{188}Os$ = 2.4 – 4), and for oil ($^{187}Os/^{188}Os$ = 2.5) sourced from the Jurassic Nordegg Formation ($^{187}Os/^{188}Os$ = 2 – 6). However, one Devonian sourced oil with very low $^{187}Os/^{188}Os$ (~ 1.4) has been analyzed. However, the Os isotopic composition of the whole oil and asphaltene fraction is similar to the identified source rock (Duvernay Formation, 1.6 – 1.7) – this source rock is characterized by unusually low $^{187}Re/^{188}Os$ ratios (~ 220) and Re and Os abundances. Such a relationship between $^{187}Os/^{188}Os$ compositions in oil and the age of the source rock must result from the Os isotopes in oil reflecting those of the source rather than, for example, putative interaction between oil and reservoir or pathway rocks. This demonstrates that Re-Os isotopes in petroleum are potentially powerful tracers.