Why Re-Os Geochronology Works for Oils – Experimental Evidence

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ABSTRACT

When did source rocks reach maturity? When were hydrocarbons expelled? When, and for how long, did oil migrate? When did interactions with formation waters or other oils take place? When did the reservoir fill? These are key questions for comprehensive modeling of petroleum systems. For the past decade, the Re-Os isotopic system has advanced from dating source rocks to tracking and directly dating oils. Given the Re-Os isotopic composition of a crude oil and its maltene and asphaltene fractions, we can determine both the age and initial 187Os/188Os, an isotopic tracer [1]. But what do the acquired Re-Os ages and initial 187Os/188Os actually signify? To address this, we have carried out experiments to determine where Re and Os reside within the complex molecular mix in oils. Further, we have measured the distribution of Re and Os between oils and water through controlled experiments. And finally, we are empirically probing the impact of asphaltene precipitation on Re-Os chemistry through analyses from a well-understood oil field. Together, these studies reveal the behavior of Re and Os through the full evolution of a petroleum system. We show that Re and Os are both sequestered in the most polar fractions of oils. Resins hold most of the Re and Os within heptane-soluble maltenes; for asphaltenes, concentrations increase systematically with polarity. The dependencies are not identical, however; Re/Os ratios vary among the oil fractions. Precipitation of asphaltene will therefore alter the Re-Os isotopic systematics of the impacted oil. Intriguingly, radiogenic 187Os correlates better with total Os than its parent 187Re, indicating that newly generated 187Os seeks an Os site. That is, while Re and Os both favor more polar fractions, they do not appear to occupy identical sites. Oil-water reactions at elevated temperatures show Os is rapidly sequestered in the oil, and Os isotopic exchange is swift. Transfer of Re, in contrast, is sluggish. Although the 187Os/188Os ratio of the oil will shift toward that of the water, the age is preserved. Thus, we have confidence that interaction of oil with formation waters will not, by itself, disturb the Re-Os age of the oil. More work is underway to build on these promising results.
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