



A gallery of oil components, their metals and Re-Os signatures

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Most sediment-hosted metallic ore deposits are one degree of freedom from hydrocarbon. That is, sulfide fluid inclusions may contain vestiges of travel in tandem with hydrocarbon-bearing fluids. For metallic ore deposits of stated metamorphic and magmatic origin, the degrees of freedom are several times more or, in some cases, no relationship exists. Still, the fetish for stereotyping and classifying ore types into hardline ore deposit models (or hybrid models when the data are wildly uncooperative) impedes our ability to move toward a better understanding of source rock. Fluids in the deeper earth, fluids in the crust, and the extraterrestrial rain of metals provide the Re-Os template for oil. So, too, this combination ultimately drives the composition of many metallic ore deposits.

The world of crude oil and its complex history of maturation, migration, mixing, metal-rich asphaltene precipitation, and subsequent mobility of lighter and metal-poor components, is an untapped resource for students of ore geology. In the same way that Mississippi Valley-type lead and zinc deposits are described as the outcome of two converging and mixing fluids (metal-bearing and sulfur-bearing fluids), asphaltene precipitation can be an outcome of a lighter oil meeting and mixing with a heavier one. In the petroleum industry, this can spell economic disaster if the pore-space becomes clogged with a non-producible heavy oil or solid bitumen. In ore geology, sulfide precipitation on loss of permeability may create a Pb-Zn deposit.

Petroleum systems provide a gallery of successive time-integrated Re-Os results. Heavy or biodegraded oils, if intersected by lighter oil or gas, can generate asphaltite or tar mats, and release a reservoir of still lighter oil (or gas). During this process there are opportunities for separation of metal-enriched aqueous fluids that may retain an imprint of their earlier hydrocarbon history, ultimately trapped in fluid inclusions. Salinity, temperature and pH are part of the equation controlling composition of metal-bearing aqueous fluids siphoned from residual hydrocarbons. The Re-Os isotopic behavior of oil components is generally specific to location and may differ within a single oil field, or even within discrete fractions of a single sample of oil [1]. Different fractions in a crude oil, for example maltenes and asphaltenes, can preserve signatures of unique sources. This should not be surprising, since economic geologists have long called upon meeting and mixing of metal-bearing with sulfur-bearing fluids from different sources.

A time-integrated geologic history can also be derived from bitumen veins, with the Re-Os age of the metal source cached in these veins. Preservation of early metal and hydrocarbon history, and intact Re-Os systematics preserved in younger-formed systems have enormous potential for the resource industry. Several examples will be presented.

[1] Georgiev, S.V., Stein, H.J., Hannah, J.L., Galimberti, R., Nali, M., Yang, G., and Zimmerman, A. (returned post revision, 11 Jan 2016) Re-Os dating of maltenes and asphaltenes within single samples of crude oils: *Geochimica et Cosmochimica Acta*.

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