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Finding Ni-Mo – Disentangling ore genesis models for metalliferous black shales

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Organic matter rich black shales enriched in certain elements such as Ni, Mo, Co, V etc., are often referred to as hyper-enriched or metalliferous black shales. Causes of such enrichment may be attributed to a combination of processes such anoxic depositional setting, high biological productivity, hydrothermal activity etc. These processes may either aid in preservation of such metalliferous shales or be an additional source of metals. Two popular ore genesis models have been invoked for the formation of such types of metal enriched black shales – direct precipitation from seawater and hydrothermal origins. The sedimentary/seawater model suggests formation of such deposits initially occurred on the sea floor in a reducing environment where metals were sourced entirely from sea water and later concentrated during diagenesis. Some models invoke low-T hydrothermal fluids, where submarine springs may act as source of metals along with seawater, in the above-mentioned sedimentary models. Some research suggests high-T hydrothermal fluids possibly evolving from quartz-sulphide stockwork, may have been key along with seawater. While seawater and hydrothermal fluids remain popular fluid source types, ground water seeps, hydrocarbon seeps (petroleum discharge) have also been proposed.

The present contribution investigated the black shales from the Nuititang Formation in China and Nick prospect in Yukon, Canada. The study proposes an oil source model for such deposits based on current observations. We advocate a model that is essentially a nuanced seawater model that advocates for oil as the source of metals and trigger for various chemical transformations that may have resulted in concentrating the metals to higher grades. Given it is difficult to explain high grades of enrichment solely due to seawater, we prefer oil discharge (into the water column/sediments or both) as a key step in the mineralization upgrade process. The presentation will discuss characteristic texture of the sulphides derived using reflected light microscopy and Scanning Electron Microscopy (SEM) in support of the model. Geochemical analyses (via Electron Microprobe Analyses or EPMA) along with speciation analyses (for Ni, Mo) using the synchrotron facility (Advanced Photon Source) at the Argonne National Laboratory will also be presented in support of the proposed model.