Trace Element Chemistry in Green River Formation Oils Shales from The Piceance and Uinta Basins: Implications for Interpretation of Redox Conditions in Lacustrine Systems

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ABSTRACT

The Eocene Green River Formation represents one of the largest accumulations of sedimentary organic matter in the world. The most recent U.S. Geological Survey assessment of oil shale resources in the Piceance and Uinta Basins indicates that rocks with yields of at least 15 gallons per ton represent over one trillion barrels of oil in place in Colorado and Utah. During deposition in Eocene Lake Uinta, low oxygen conditions in the bottom waters of the stratified lake have been proposed as a key factor in preserving the massive accumulation of organic material. In marine environments, bottom-water anoxia generally leads to accumulation of redox-sensitive trace metals, like molybdenum (Mo), vanadium (V), and nickel (Ni). Trace metal ratios calculated based on the concentrations of these metals and other elements in marine black shales have been correlated to particular depositional conditions, including ranges of dissolved oxygen concentrations and the presence of dissolved hydrogen sulfide. Examination of trace element concentrations in Green River oil shales reveals that parameters based on redox-sensitive metals do not consistently indicate anoxic conditions for core samples from the Piceance and Uinta Basins. Despite the high concentrations of hydrogen-rich, Type I kerogen present in much of the Green River oil shale, the ratios of Ni/Co and V/Cr indicate oxic and oxic-to-dysoxic conditions, respectively. The concentration of Mo is generally expected to correlate with organic carbon content, but in the Green River cores the relationship between Mo and total organic carbon content is much weaker than what is typically observed in marine shale deposits. One commonly reported parameter, V/(V+Ni), places the Green River oil shales in an anoxic depositional environment and also indicates euxinic conditions in some samples, which is consistent with expectations. The closed-nature of Lake Uinta along with the high alkalinity and pH, may explain the failure of various trace element ratios to indicate anoxia. These results show that trace element parameters used to interpret depositional conditions in marine systems may not necessarily be applicable to understanding the sedimentological origins of lacustrine mudrocks. Therefore, the application of these ratios to interpret lacustrine source rock data collected in chemostratigraphic surveys should be done cautiously.