Trace-element variation associated with diagenetic phosphate and sedimentary organic matter in organicrich mudstone beds, Green River Formation, eastern Uinta Basin, Utah, USA

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The Green River Formation is a >2 km-thick succession of fine-grained strata variably rich in organic material that accumulated in several lacustrine basins during the Eocene. In the Uinta and Piceance Creek basins of Utah and Colorado, the Green River Formation hosts the world's largest oil shale resource. This resource is concentrated in 8 organic-rich mudstone (ORM) intervals (up-section from R1 to R8), the richest being R7, also known as the Mahogany Oil Shale Zone (MOSZ) which marks the base of the informal upper member of the Green River Formation. Ongoing studies relate to several beds of oil shale sampled from the lower R8 zone, ~60 to 130 m above the base MOSZ, both from core and outcrop. Microscale variations in trace-element geochemistry have been identified in ORM using ICP-MS, indicating values obtained from bulk analyses might obscure the details of trace-element compositional variation in the stratigraphic record. While attributed to abiogenic processes this variability might have been biogenically mediated, or influenced by the nature, accumulation, and abundance of sedimentary organic material. Organic material content is similarly variable, occurring as thin, laminar, non-particulate, C-dominated layers of matter in ORM — interpreted as kerogen agglomerations formed from the degradation of algal and bacterial oozes. SEM analyses indicate the presence of disseminated heavy metal accumulation within both matrix and non-particulate organic material in the study samples. Analyses have indicated some relationship between organic material and trace-element variability, with systematic enrichment patterns of lanthanides, actinides, and toxic heavy metals occurring in phosphatic intervals of these ORM. The relationship between trace-element geochemistry and organic material is examined using a combination of inorganic geochemical data and organic geochemical indices to highlight compositional variations related to the nature and type of organic material, source rock maturity trends and organic richness in the Green River Formation. As a consequence of deposition in lowenergy lacustrine environments, shallow burial, and the general immaturity of Green River Formation source rocks, some sub-millimetre scale sedimentary structures and features have been preserved and might enable further insight into any relationships between the elements of this study. While the influence of microbial communities and organic material on pore-water chemistry is not precisely understood, some contribution to the variance in traceelement chemistry might perhaps be observed in this study due to the relationships between trace-element abundance and sub-millimetre scale sedimentary features.

Atlantic Geology, 2017, Volume 53
Atlantic Geoscience Society Abstracts – 43rd Colloquium & Annual General Meeting 2017
doi: 10.4138/atlgeol.2017.006