Use of Laser Ablation ICP-MS and SEM for Possible Correlation, and Identification of Microbially Influenced Diagenetic Phases, in Lake Mudstone of the Green River Formation, Utah, USA

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ABSTRACT

Many distinct beds of lacustrine organic-rich mudrock (oil shale) are present in the 'R8' zone above the Mahogany Oil Shale Zone of the upper Green River Formation in the eastern Uinta Basin of Utah. Several of these beds have been found to contain anomalously high phosphate and toxic trace-metal components that are now being tracked across outcrop and core to test their potential as a correlation tool in the fine-grained basin-centre stratigraphic succession.

Scanning Electron Microscopy (SEM) records algal mats, phosphatized vermiform (coprolitic?) and globular (fossilized coccoid microbe?) structures, and planktonic shell debris. These features are all associated with extensive bedded intervals, and localized concretions, of microcrystalline and blocky carbonate fluorapatite (CFA) cement. Mercury is encountered in one such interval, trapped in the blocky CFA cement; elsewhere tin and tungsten anomalies associate with the globular structures of microcrystalline CFA. An SEM interpretation ofthe diagenetic succession suggests rhombic, variably ferroan dolomite was followed by pyrite, euhedral to blocky calcite cement and CFA, all of which formed early in the shallow substrate.

Laser Ablation-Inductively Coupled Plasma-Mass Spectrometry (LA-ICP-MS) permits non-destructive chemostratigraphic study of stratified rock at the sub-lamina scale including measurement of elemental abundances across 9 orders of magnitude, including detection limits as low as 20 ppb for heavy elements; and the analysis of some low-atomic weight elements. In the present study, core and outcrop sample analysis of over 50 elements at -50 micron spacing indicates a complex zonation of lanthanide and actinide enrichment is also present across the em-scale margins of porous microcrystalline CFA intervals. Closest to the outer margin there is an order of magnitude increase in the light rare earth elements (REEs). Internally, progressively heavier REEs show peak abundances at two orders of magnitude above background. Thorium and uranium anomalies correlate with the heavy REEs. Collectively these lanthanide and actinide anomalies are likely the result of variable diffusion of dissolved ions from reducing porewaters into the gradually occluding micropores, and their selective substitution of Ca in the growing, early diagenetic CFA lattice.