Cyclicity and hydrologic controls of organic matter sources in oil shale of the Green River Formation, Wyoming, Colorado, and Utah

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The Green River Formation preserves the largest body of oil shale resources in North America. It occupies three large intermontane structural basins; two located in southwestern Wyoming, and another in northeastern Utah/northwestern Colorado. This cyclical lacustrine formation spans ≥15 million years (53-38 Ma), and lacks significant diagenetic alteration. The long time span and low thermal maturity allowed us to perform geochemical analysis of molecular fossils such as leaf waxes and microbial membranes over orbital time scales. We measured carbon isotopic values of bulk organic material as well as leaf wax hydrocarbons from samples of two Green River Formation rock cores from the Uinta basin. To investigate the lake ecology during times of high organic matter burial, we surveyed the range of archaeal and bacterial biomarkers present in the hydrocarbon-rich Mahogany zone using gas chromatograph mass spectrometry. Frequency analysis of the multi-million year carbon isotope record combined with published Fischer assay data reveals that the hydrocarbon rich sequences through the Green River Formation vary with changes in the Earth's orbit. The ~21,000 year cycle of precession dominates the variation in oil richness, while short and long eccentricity (~100,000 and ~400,000 years, respectively) modulate the precession cycle. While levels of thermal degradation were too high to preserve the lipid membranes of Archaea, we observed biomarkers indicating the presence of cyanobacteria, dinoflagellates, and potentially green sulfur bacteria. This suite of organisms points to fluctuating oxic and anoxic conditions in the lake.