

## **Climate history, lake evolution, and predicting organic richness of the Green River Formation, Piceance Creek Basin, Colorado**

J. Frederick Sarg, Kati Tanavsuu-Milkeviciene, JuFang Feng, Suriamin Huang  
*Colorado School of Mines, USA*

Lake deposits formed in the Green River Formation in the Piceance Creek Basin (PCB) during the early to middle Eocene are largely composed of kerogen-rich and kerogen-poor mudstones (clay and carbonate). Lake stages are defined as: S1 - Fresh Lake, S2 - Transitional Lake, S3 - Rapidly Fluctuating Lake, S4 - Rising Lake, S5 - High Lake, and S6 - Closing Lake. Lake stages correlate well with the long-term climate curve during the early to middle Eocene. Stage 1 appears to have formed during the warming phase of the climate optimum and represents the basin evolution from fresh to brackish lake conditions. The Piceance lake changed during the Stage 1 from an open lake to a closed lake basin that indicates a change from abundant rainfall and high runoff, to somewhat more seasonal and dryer climate. Increased seasonality, and flashy runoff began during Stage 2, indicating restricted lake conditions, and peaked during Stage 3, at the maximum of the Eocene climate optimum, when more arid conditions prevailed, and nahcolite and halite are abundant. The ensuing lake level rise (Stage 4) and high lake (Stage 5) occur during climatic cooling, accompanied by increased precipitation. Stages 4 and 5 contain widespread, thick profundal deposits and increasingly rich oil shale. Carbon and oxygen isotope, Total Organic Carbon (TOC), and elemental analyses record lake cycles of increased salinity and productivity that alternate with periods of increased freshening and oxidation, and that correlate with lake stages and the vertical variation in organic richness. During Stage 1, the fresh lake developed stratified conditions, high net productivity, and very rich oil shale ( $115 \times 10^9$  bbls). During transitional, Stage 2, stable lake conditions persisted, and lower net productivity resulted in moderately rich oil shale deposition (R2 -  $53 \times 10^9$  bbls, R3 -  $58 \times 10^9$  bbls). Highest salinity and stratification occurred in the highly fluctuating lake, Stage 3, resulting in the highest net productivity and very rich oil shale (R4 -  $108 \times 10^9$  bbls, R5 -  $179 \times 10^9$  bbls). During the rising lake Stage 4, moderate net productivity returned in a deepening lake, increasing net preservation, and forming rich oil shale (R6 -  $159 \times 10^9$  bbls). The Stage 5 high lake resulted in the highest net productivity and widespread, very rich oil shale (R7 -  $173 \times 10^9$  bbls).