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ASTRONOMICAL-FORCED PALEOSOL STACKING PATTERNS IN THE UPPER PALEOCENE TO LOWER EOCENE CLASSICAL FLUVIAL SUCCESSIONS OF THE BIGHORN BASIN (WYOMING, USA)

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The badlands of North America are famous for their scenic outcrops of continental successions showing a prominent color banding. The successions reveal a distinct rhythmicity, due to the repetitive intercalation of orange, red and purple colored fossil soils (paleosols). They often display clusters of 3-5 individual reddish paleosols with a thickness in the order of 8-10 meter, while larger-scale clusters consisting of 4-5 small-scale paleosol clusters can be recognized as well. Although considerable progress has been made on dating the classic fluvial succession of the Paleocene to lower Eocene formations in the Bighorn and Clark Fork basins (Wyoming, USA), no serious attempts thus far have been made to study the rhythmicity using a cyclostratigraphic approach.

Here we present the first results of a detailed cyclostratigraphic study carried out in the summer of 2005 on the fluvial successions in the Big Horn basin. The study focused on several sections in the Willwood Formation, which include Polecat Bench, Deer Creek (McCollough Peaks area) and Red Butte (Elk Creek area) sections. High-resolution color records were established both in the field and in the laboratory using a portable photospectrometer. Spectral analysis revealed the presence of significant spectral peaks with periods of around 2-3 and 7-9 meter. Subsequent bandpass filtering showed that the 7-9 meter cycles correspond to the paleosol clusters and the 2-3 meter cycles to the individual paleosol sequences.

Given the available time constraints, the 7-10 m clustering reflects astronomical climate forcing by the 21-kyr precession cycle. This would imply that the large-scale clusters observed in the field represent the short-term (100-kyr) eccentricity cycle. Finally the regular meter-scale sequences of individual paleosols may also reflect climate change, but in the sub-Milankovitch frequency band. Their thickness of ~2 m and the inclusion of 3-5 paleosols in the paleosol clusters points to a duration of 4-7 kyr for an individual paleosol. Cycles with approximately similar durations have been described from much younger lacustrine successions of early Pliocene age in Greece and from marine piston cores of late Pleistocene and late Pliocene age, although the exact origin of the associated climate changes remains enigmatic.

In view of the persistence of the hierarchically arranged stacking patterns, we consider astronomical climate forcing as a realistic working hypothesis for the origin of the paleosol rhythmicity. Our results are very encouraging indeed and argue strongly for a more elaborate and rigorous cyclostratigraphic study of the fluvial successions in the Willwood Formation. Such a study will allow determining the effect of astronomical climate forcing on fluvial sedimentation, paleosol formation and faunal and floral change in the Willwood Formation. Moreover, it will provide the necessary temporal resolution to assess the - potentially climate controlled - rates of mammal evolution and migration and provide tight constraints on age and duration of carbon isotope excursions associated with extreme global greenhouse events.