Late Cambrian astronomically forced climate change

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Compelling evidence of orbital cycles across an 8.7 Myr interval of the late Cambrian is provided in core scanning X-ray fluorescence data of two cores from the Alum Shale Formation (Scandinavia). We provide robust evidence for precession, obliquity, short- and long-eccentricity cycles in pyrite-bound elements (S, Fe) and elements bound to clay minerals (Al, Ti, K, Si) in black shales that exhibit no visible sign of cyclicity. The obtained record enables the establishment of a floating astronomical time scale for the Miaolingian – Furongian interval from which the durations of trilobite biozones and the carbon isotope 'SPICE' event are precisely determined. Reconstructed sedimentation rates are consistent between the two cores and correlate negatively to the eustatic sea level curve. We also provide a key empirical constraint on the duration of the obliquity period at ~493 Ma of 31.4 ± 1.2 kyr. This constraint is used to calculate the Earth-Moon distance and Cambrian day length to 368.9 ± 2.3*103 km and 21.78 ± 0.29 hr, respectively. These numbers constrain the recession of the Moon and tests models for the long-term dynamic evolution of the Earth-Moon system. Finally, we discuss plausible drivers for the cyclic sedimentation of pyrite and clay minerals in the Alum Shale Formation with implications for paleoclimate models of an ice-free Early Paleozoic world.

Keywords : Late Cambrian, Furongian, Alum Shale, SPICE event, cyclostratigraphy, Earth-Moon distance

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