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Evidence for Milankovic cycles on the Early Earth? A cyclostratigraphic study of Precambrian iron formation

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During the past 25 years, the evolution of signal treatment methods and their coupling with stratigraphy have enabled reconstruction of the orbital parameters of the Earth (Milanković cycles) from increasingly ancient sediments. Cyclostratigraphy is based on the extraction of the frequency content of rhythmic sedimentary records, enabling the identification of major orbital components and providing for very high resolution relative geochronology. Precambrian iron formations (IF) are amongst the most remarkable ancient rythmites on Earth. However, controls on their deposition and rythmicity remain poorly constrained. In this study, luminosity variations of lithological origin in the type section core of the ~140 m-thick Dales Gorge Member (DGM; 2.48 Ga) of the Brockman IF (Hamersley basin, Western Australia) have been examined using cyclostratigraphic methods, in order to identify signatures of ancient Earth orbital dynamics and provide new constraints on Earth orbital parameters for the Precambrian [1].

Photographs of the DGM type section composite core were evaluated for the best proxy representing colour-related lithological variations. We then analysed the luminosity dataset using multi-taper spectral analysis [2] coupled with a red-noise confidence model [3]. Paradoxically, laminae for which these deposits are most known (banding thinner than 20cm) do not seem to show a regular cyclicity. Rather, strong cyclical signatures are expressed at higher scales (thicker than a metre). The observed frequencies show a coherent response to multiple orbital forcings along the whole 140m of the deposit, confirming a strong climatic control on the deposition of the Dales Gorge Member. Furthermore, if our spectral analyses are correct, precession and obliquity seem to have not changed by more than 10% from present day values since deposition of the Dales Gorge Member. As precession and obliquity are directly linked to the Earth-Moon distance, these values allow us to compute from our data possible values for the Earth-Moon distance at 2.48 Ga. Our estimates are in disagreement with most popular numerical models for the evolution of the Earth-Moon distance throughout Earth history, as they indicate a Moon only 0.5% closer to the Earth than today. If these results are correct, it would imply that the origin of modern lunar recession rates as observed by Lunar Laser Ranging is to be found in most recent (1 Ga) history of the Earth.

References:

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