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**TITLE:** Geophysical and topographic expression of early Mesozoic grand cycles of the Milankovitch band (*Invited*)

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**ABSTRACT BODY:** Grand cycles are orbitally controlled insolation cycles that have frequencies significantly lower than the precession-related  $\sim 1/100\text{ky}$  “eccentricity” cycles (1). We have previously shown that variations in sedimentary facies and  $\delta^{13}\text{C}$  interpreted in terms of lake level changes in Triassic-Jurassic cores of the Newark Basin Coring Project (NBCP) of eastern North America track predicted orbital cycles related to precession (2,3). In addition to the usual  $\sim 1/20\text{ky}$  and “spilt”  $\sim 1/100\text{ky}$  cycles, Grand Cycles with frequencies of  $1/405\text{ky}$  (g2-g5) are very prominent and cycles with much lower frequency of  $\sim 1/1.8\text{m.y.}$  representing the g4-g3 frequency are present. The latter differs from the present frequency of  $\sim 1/2.4\text{m.y.}$  because of the chaotic diffusion of planetary orbits (4).

Wavelet analysis of borehole geophysical logs from the NBCP show the same basic frequencies as do sedimentary facies. The high-frequency precession-related cycles as seen in natural gamma and sonic velocity logs are strikingly complimentary to visually identified sedimentary facies patterns because the former tend to show the most striking cyclicity where the sedimentary facies pattern are the most muted. The  $1/405\text{ky}$  cycles are also very prominent; but other grand cycles, while detectable, are distorted by the necessary detrending of each of the seven borehole records that comprise the NBCP composite (cf. 5,6). Simple detrending procedures leave a low-frequency residue and more complex models prejudice the low frequencies we are trying to detect. This emphasizes the importance of the facies interpretations that requires no detrending, and clear understanding of the meaning of the geophysical environmental proxies.

As might be expected from the seismic velocity logs, synthetic seismic traces generated from the borehole data of the NBCP show the grand cycles. When tied to very long industry exploratory borehole records from the Newark basin, themselves tied to seismic lies, both the  $1/405\text{ky}$  (g2-g5) and  $\sim 1/1.8\text{m.y.}$  (g4-g3) cycles can be clearly seen as the most coherent components of the seismic profiles across the basin (6).

The topographic expression of the deeply eroded tilted strata of the Newark basin section also reveals the grand cycles which can be seen from space, with ridges reflecting time intervals of high- and valleys low-precessional variability that can be directly tied to the stratigraphy, much as bundles of plausibly obliquity-related rhythms can be seen in crater walls on Mars (7).

All of these ways of observing the grand cycles of the Milankovitch band reflect their importance as major features of the sedimentary record and are complementary means to detect and empirically map the chaotic evolution of the solar system.

References: 1) Olsen PE, 2008, GSA Abst. Prog. 40(6):282. 2) Olsen PE, Kent DV, 1996, PPP

122:1. 3) Whiteside JH et al. 2011, PPP 301:1; 4) Olsen PE, Kent DV, 1999, Phil. Trans. Roy. Soc. Lond. (A), 357:1761. 5) Goldberg DS, 2003, in LeTorneau PM & Olsen PE, Columbia Univ. Press., pp 104-117. 6) Reynolds DJ, 1993, Ph.D. thesis Columbia Univ., NY. 7) Lewis K. et al. 2008, Science 322:1532.

**KEYWORDS:** [4946] PALEOCEANOGRAPHY / Milankovitch theory, [9612] INFORMATION RELATED TO GEOLOGIC TIME / Triassic, [0915] EXPLORATION GEOPHYSICS / Downhole methods, [1199] GEOCHRONOLOGY / General or miscellaneous.

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