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Grand Cycles of the Milankovitch Band

*** Olsen, P E**

polsen@ldeo.columbia.edu

Lamont-Doherty Earth Observatory, Rt 9W, Palisades, NY 10964 United States

Celestial mechanical theory predicts not just the familiar set of Milankovitch cycles of about 21, 41, and 100 ky, the climatic significance of which was established 25 years ago by Hays, Imbrie, and Shackleton (1); but also longer period cycles "grand cycles" with present day periods of about 400 ky, and 1.25, 2.35 and 4.6 my. The effects of these longer period cycles are only potentially discernable, convincingly, in very long climate records spanning several to tens of millions of years. However, long term chaotic drift in the fundamental frequencies of the planets makes the actual value of all - except the 400 ky - grand cycles, unpredictable for records older than about 50 Ma (2). Added uncertainty exists because of the poorly understood evolution of the Earth-Moon system, which makes calibration by the high frequency precession and obliquity cycles unreliable for distant times. The 400 ky cycle provides a reliable tuning target for long ancient records because it is caused by the gravitational interaction of Jupiter and Venus, the former of which has an extremely stable orbit. One of the longest paleoclimate records available is that resulting from the Newark Basin Coring Project (NBCP), with 6700 m of Triassic-Jurassic lacustrine strata, spanning about 30 my years. Based on evolutive thickness-frequency spectrograms, the major higher-frequency precession-related cycles are all present, with an especially strong 400 ky signal. Tuning to the 400 ky cycle reveals significant low-frequency cycles of 1.75 and 3.5 my (3). The former is homologous to the present day 2.35 my grand cycle, which modulates climatic precession, and is caused by the gravitational interaction of Earth (g3) and Mars (g4); the observed difference is well within the predicted chaotic region (4) of the fundamental frequencies (g4-g3). The latter 3.5 million year cycle is a homologue of the present day 4.6 my grand cycle. This cycle is a consequence of the secular resonance, theta (2(g4-g3) - (s4-s3)) (2,4). Identification of these long period cycles is essential, because what may appear to be unique climatic transitions could actually be nodes of the grand cycles superimposed on a longer climatic trend. Also, because the NBCP record has virtually no expression of high frequency obliquity cycles (as expected by its tropical position), the presence of the 3.5 my cycle suggests some large-scale climate system telecommunication between the Triassic continental tropics and regions sensitive to obliquity, perhaps through weathering-modulated atmospheric CO2. In addition, the presence of the 1.75 and 3.5 my grand cycles suggests that the mode of the secular resonance in the Triassic was not different to that of today, as is theoretically possible (2). Finally, the long period cycles should be globally synchronous, and hence they offer a new low-frequency means of cyclostratigraphic correlation. References: (1) Hays, J. D., Imbrie, J. and Shackleton, N. J. 1976. Science 194:1121. (2) Laskar, J. 1999. Phil. Trans. Roy. Soc. Lond. A, 357:1735. (3) Olsen, P. E. and Kent, D. V. 1999. Phil. Trans. Roy. Soc. Lond. A, 357:1761. (4) Laskar, J. 1990. Icarus 88:266.

http://www.ldeo.columbia.edu/~polsen/nbcp/nbcp.html

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