Japan Geoscience Union Meeting 2010
(May 23-28 2010 at Makuhari, Chiba, Japan)

BPO021-05 Room: 301B Time: May 25 10:00-10:15

Long-period Milankovitch cycles from the Jurassic bedded chert; implications for chaotic behavior of the Solar System

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Long-term orbital motion of the planets in the Solar System is chaotic (e.g. Sussman and Wisdom, 1988), and Milankovitch cycles recorded in sedimentary rhythms provide a clue to understand dynamics of the Solar System. Bedded cherts consist of rhythmical alternations of chert and shale beds and Milankovitch cycle origin of middle Triassic bedded chert was demonstrated based on the hierarchy of cyclicities in chert bed thickness variation that is nearly identical to that of periodicities of Milankovitch cycles (Ikeda, in submitted). Cyclostratigraphic studies of middle Triassic bedded chert sequence in Japan and late Triassic lacustrine sequence in eastern USA suggest that Earth-Mars secular resonance during Triassic was 1800-kyr cycle in a librational state different from that observed at present (Olsen and Kent, 1999; Ikeda, in submitted). On the other hand, cyclostratigraphic studies of upper Jurassic limestone-shale sequence in England suggest that Earth-Mars secular resonance during late Jurassic was ca. 2400-kyr cycle in another librational state similar to the present. If correct, the chaotic transition of Earth-Mars secular resonance should have occurred sometime in Jurassic. To examine the timing and the mode of the chaotic transition of Earth-Mars secular resonance, we extended bedded chert cyclostratigraphy to the lower Jurassic using the bedded chert exposed in Inuyama area, central Japan. We estimated the average duration of a chert-shale couplet in the lower Jurassic bedded chert as 20-kyr, confirming the possibility of its precession cycle origin. Spectral analysis of bed number series of chert bed thickness variation was conducted assuming one chert-shale couplet as representing a 2 0-kyr precession cycle. The result revealed approximately 100, 20, and 5 beds cycles, which correspond to approximately 2000-, 400-, and 100-kyr periodicities, respectively. By further assuming approximately 20 beds cycle as representing 405-kyr eccentricity cycle of constant and stable periodicity, we converted the bed number series to the time series. Spectral analysis of the time series revealed distinct periodicities of 2460-, and 105-kyr in addition to 405-kyr. The 2460-, and 105-kyr periodicities agree well with 2400-, and 100-kyr periodicities for eccentricity cycles. Moreover, we detected the amplitude modulation of approximately 405-kyr cycle of chert bed thickness variation with 2400-kyr periodicity, which would correspond to the amplitude modulation of climatic precession cycle with 400-kyr periodicity by 2400-kyr eccentricity cycle. 24 00-kyr cycle is correlated to the periodicity of the present librational state of Earth-Mars secular resonance. Our results suggest that the chaotic transition of Earth-Mars secular resonance from 1 800-kyr to 2400-kyr should have occurred near the Triassic/Jurassic boundary. Exact timing and mode of transition will be discussed.

Keywords: Chert, Milankovitch, Chaos, Mars, secular resonance, Eccentricity