Milankovitch paleoclimatic, tectonic, and sedimentary signals in late Permian-Early Triassic fluvial-lacustrine records, Bogda Mountains, NW China

Wentao Zhang and Wan Yang, Missouri University of Science and Technology*

ABSTRACT

The stratigraphic sections in the Bogda Mountains, Xinjiang, NW China, provide detailed records of the terrestrial paleoenvironments during the late Permian to Early Triassic time at the paleo-mid-latitude of NE Pangea. The South Taodonggou (STDG), Central Taodonggou (CTDG), South Tarlong (STRL) and North Tarlong (NTRL) sections are located in the Tarlong-Taodonggou half graben at the southern foothills of Bogda Mountains (Yang et al., 2010, 2021; Guan, 2011; Peng, 2016; Obrist-Farner and Yang, 2017; Fredericks, 2017; Zheng and Yang, 2020). Lake expansion and contraction, and fluvial peneplanation and deposition, occurred repetitively in the basin (Yang et al., 2007, 2010, 2021).

This study carried out gamma analysis, gamma and astronomical tuning, and spectral analysis of the lithofacies and environmental series. The thicknesses of the STDG, CTDG, STRL, and NTRL sections are 282.9 m, 539.7 m, 872.2 m, and 826.1 m, respectively. The major lithofacies are conglomerate, sandstone, mudrock, carbonate rock, and paleosols (Yang et al., 2010, 2021).

Gamma analysis generates facies-dependent thickness-time conversion factors (gamma values) to construct gamma-tuned time series (Kominz and Bond, 1990; Bond et al., 1991; Kominz et al., 1991), which are more realistic than the untuned thickness series. Positive and stable gamma values suggest that the assumption of a unique sedimentation rate for each facies is not violated. The sedimentation rates of individual facies ranged from 0.18 to 1.53 m/kyr in the STDG section, 0.13 to 2.43 m/kyr in the CTDG section, 0.29 to 1.03 m/kyr in the STRL section, and 0.3 to 1.09 m/kyr in the NTRL section with average rates of 0.33 m/kyr, 0.3 m/kyr, 0.44 m/kyr and 0.46 m/kyr, respectively. The average sedimentation rates of the STRL and NTRL sections are 1.5 times greater than those of the STDG and CTDG sections. This difference can be attributed to the accommodation space, with the STRL and NTRL sections situated on the axial subsidence and depositional center of the half graben, while the STDG and CTDG sections are on the ramp margin. The stratigraphic completeness of the four sections ranges from 32% to 57% as the ratio between depositional and total durations. Astronomical tuning mitigated the long-term impact of variable sedimentation rates.

The gamma and astronomical tuning enhance the spectral resolution of the environmental series. Spectral analysis of the astronomical-gamma-tuned series of STDG, CTDG, STRL and NTRL sections reveal significant peaks ranging from 14.2 to 405 kyr, corresponding to Milankovitch cycles (Figure 1). The evolutive spectrograms of the STDG, CTDG, STRL and NTRL sections contain many peaks with varying magnitude and frequency persistency throughout the entire section, with notable differences between the lower and upper parts (Figure 1). Most fluvial and lacustrine high-order cycles (HCs) have durations less than 14 kyr, while some have durations same as obliquity and precession index cycle periods. The high-frequency signals, representing these HCs, in the sub-Milankovitch bands in the spectra are interpreted as combination tones of the eccentricity and precession index cycles. These results suggest that the cyclic sedimentation of the fluvial-lacustrine cycles was predominantly controlled by Milankovitch paleoclimatic forcing with variable strength evident across the entire sections.

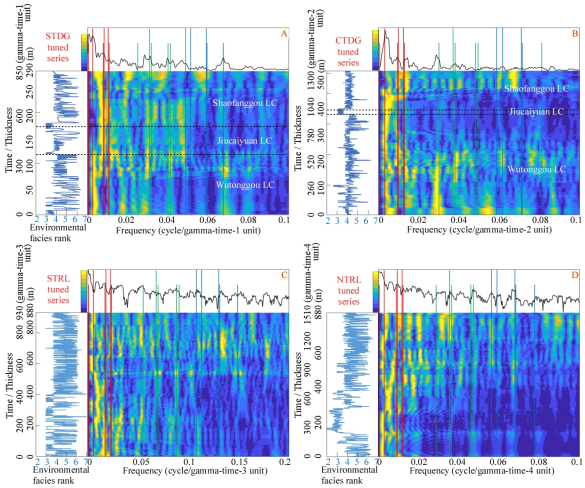

Figure 1: Evolutive FFT spectra of the astronomical-gamma-tuned series (light blue curves on the left) of the STDG (A), CTDG (B), STRL (C), and NTRL (D) sections. On the top of each evolutive spectrum is the 2pi-MTM spectrum (black curves). Base of the stratigraphic section is at the bottom. The line spectrum of Milankovitch climatic cycles is the best match with each curve. Red lines are eccentricity, green lines are obliquity, blue lines are precession index.

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