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モンゴル白亜系湖成層に記録される湖水位および湖生物生産のオービタルスケール変動: OAE1a-1b 期の陸域気候変動復元に向けて
Orbital-scale lake-level and productivity changes in the mid-Cretaceous lacustrine deposits in southeast Mongolia

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The mid-Cretaceous period is characterized by an extremely warm greenhouse climate with elevated atmospheric CO2 levels, and repeated occurrences of Ocean Anoxic Events (OAEs). However, detailed processes and causal mechanisms of these marked events, particularly the response of the terrestrial climate system, are only poorly understood. To evaluate interactions between the land and the ocean during an OAE interval, we examined the terrestrial climatic record from Aptian lacustrine deposits (Shinekhudag Formation) in southeast Mongolia.

The Shinekhudag Formation is widely distributed in southeastern Mongolia, and is well exposed in the Shine Khudag locality. The formation is composed of alternating beds of dark greyish paper shale, greyish calcareous shale, light greyish dolomitic marl, and whitish to yellowish dolomite. Strata are continuously exposed up to 250 m in thickness. The shale and dolomite successions are rhythmically alternated (decimeter-, meter-, tens of meter-scale), probably controlled by orbital-cycles. Shales and dolomitic marls show micrometer-scale lamination (alternation of organic- and detritus-rich layers), most likely reflecting seasonal cyclicity. The sedimentation rate is estimated as ca. 4-8 cm/kyr based on varve-counting of thin-sections.

In order to clarify the depositional environments and the controlling factors for the rhythmically alternating lithofacies change in the Shinekhudag lacustrine deposits, we conducted X-ray diffraction analysis to reconstruct changes in the sediment mineralogy, and we also performed elemental analysis (C, N, S), Rock-Eval pyrolysis, and a quantitative study of palynofacies to evaluate the organic matter composition in the shale and dolomite couplets. Both, the sediment mineralogy and organic matter composition of lacustrine deposits are controlled largely by hydrological factors that are highly dependent upon climatic fluctuations. The results revealed that the cyclic alternations (ca. 1-1.5 m cycles) of the dolomite abundant layer and detritus minerals and calcite rich layer, corresponding to the rhythmically alternating dolomite and shale layers of field observation. C/N values were significantly low (4-10) in the dolomite layers, while higher values (15-30) occur in the shale samples. Rock-Eval pyrolysis revealed that all the samples are composed of Type I-II organic matter. Palynofacies analysis further indicated dominance of Botryococcus colonies in the dolomite layers, whereas the shale layers show abundant amorphous organic matters, algal cysts, and terrestrial palynomorphs.

These lines of evidences indicate that the rhythmically alternating lithofacies changes recorded in the Shinekhudag lacustrine deposits were mainly controlled by orbital-scale lake-level changes as well as by lake productivity changes. Namely, the dolomite layers were formed during low lake level by microbially mediated precipitation in highly alkaline lake waters. Botryococcus colonies were abundant under such oligotrophic and euryhaline conditions. On the other hand, the shale layers were deposited during high lake levels, which were characterized by higher algal productivity and increased inputs of detrital minerals. Spectral analysis of the lithofacies change in the Shinekhudag Formation shows the cycles involving approximately 1.28 m, 2.27 m, 5.88 m, and 22.4-25.6 m cycles, corresponding to periodicities of approximately 21 kyr, 38 kyr, 98 kyr, and 373-427 kyr, respectively, based on a varve-tuned average sedimentation rate of 6 cm/kyr. These values are in accordance with orbital precession, obliquity, and eccentricity cycles, respectively. Therefore, the Aptian lacustrine deposits in southeast Mongolia are interpreted to record the orbital-scale paleo-hydrologic changes during the OAE1a-1b interval.

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