Terrestrial paleoenvironments during the mid-Cretaceous reconstructed from the continuous lacustrine strata in Southeast Mongolia

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To elucidate the causal relationship between environments of land and ocean during the mid-Cretaceous Oceanic Anoxic Events intervals, we have investigated terrestrial paleoenvironmental records of Cretaceous lacustrine strata in the intra-continental Gobi Basin, southeast Mongolia. This study has been conducted as the Japan-Mongolia-China joint researches since 2009 (Ando et al., 2011).

The Shinekhudag Formation, its below (Tsagantsav Fm.) and above (Khuhuteg Fm.) exposed in the Shine Khudag area, Shaazangiin Gobi region are studied to cover the majority of terrestrial sequences for constructing a composite section (Jerzykiewicz, and Russell, 1991; Hasegawa et al., 2012). The lacustrine Shinekhudag Fm. is composed of alternating beds of dark greyish paper shale (oil shale), greyish calcareous shale, light greyish dolomitic marl, and yellowish to brownish dolomite. The strata are continuously exposed up to 400 m in thickness. The shale and dolomite successions are rhythmically alternated (decimeter-, meter-, tens of meter-scale), possibly controlled by orbital cycles. Paper shale contains micrometer-scale laminations, which are most likely varve origin. The estimated sedimentation rate is ca. 6-7 cm/k.y. by the varve-counting methods on thin sections. The age of the Shinekhudag Fm. is currently assigned to be Aptian or Barremian-Aptian based on the ostracodes, concostracans, floral and molluscan evidence (Jerzykiewicz and Russell, 1991; Yuan and Chen, 2005), and $^{40}Ar/^{39}Ar$ dating of basaltic rocks in the uppermost part of the underlying Tsagantsav Fm. (ca. 121-125 Ma: Graham et al., 2001).

In order to clarify the depositional environments and the controlling factors for the rhythmically alternating lithofacies changes, we conducted XRD analysis, elemental analysis (C, N, S), Rock-Eval pyrolysis, and a quantitative study of palynofacies to evaluate the organic matter (OM) composition. The mineral composition results confirmed the cyclic alternations (ca. 1.5 m cycle) of dolomite abundant layers and detritus minerals and calcite rich layers. C/N values are significantly low (< 10) in the dolomite samples, while higher (> 15) in shale samples. Rock-Eval analysis shows significantly high hydrogen index (> 650 mg/g) with relatively high T-max values (430–440°C), and all the samples are composed of Type I–II OM. Palynofacies analysis further indicated the dominance of *Botryococcus* colonies in dolomite layers, whereas shale layers are abundant in amorphous OM, algal cysts, and terrestrial palynomorphs.

These lines of evidence indicate that the rhythmically alternating lithofacies changes in the Shinekhudag lacustrine deposits were mainly controlled by orbitally driven changes in lake level and lake productivity during the OAE1a–1b interval. Namely, the dolomite layers were formed during low lake levels 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.

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