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Depositional environments of the mid-Cretaceous lacustrine deposits in southeast Mongolia: Implication for terrestrial environmental changes at the OAE interval

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The mid-Cretaceous period is characterized by an extremely warm “greenhouse” climate, 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 terrestrial climate system, have been poorly understood. Possible causal mechanisms of OAEs in the mid-Cretaceous greenhouse climatic conditions include following mechanism; (1) increased terrestrial humidity and terrigenous input into the oceans, (2) enhanced ocean surface productivity, and (3) the excess of organic burial in the oceans. Increased terrestrial humidity and chemical weathering may have increased terrigenous input into the oceans (so called “Weathering Hypothesis”; e.g., Weissert et al., 1998; Hasegawa, T., 2003). To evaluate interaction between the land and the ocean during the mid-Cretaceous OAE interval, we investigated terrestrial paleoenvironmental changes using the mid-Cretaceous lacustrine deposits at intra-continental sites in central Asia (Gobi basin, southeastern Mongolia).

The mid-Cretaceous lacustrine deposits (Shinekhudag Formation) are widely distributed in southeastern Mongolia. The Shinekhudag Formation, well exposed in the Shine Khudag locality in the Shaazangiin Gobi area, is composed of dark grey paper shale (oil shale), light grey silty claystone, and whitish to yellowish calcareous claystone. Strata are continuously exposed up to 400 m in thickness. The shale and calcareous clay successions are rhythmically alternated (decimeter-, meter-, tens of meter-scale) in Shine Khudag locality, which can be controlled by orbital cycles. Paper shale deposits include micrometer-scale laminations, which are most likely varve origin. The estimated sedimentation rate is ca. 3-5 cm/k.y. by the varve-counting methods on thin sections. The age of the Shinekhudag Formation is assigned as Aptian or Barremian-Aptian based on the floral and molluscan evidence (Krassilov, 1982; Jerzykiewicz and Russell, 1991), and K-Ar dating of basaltic rocks in the uppermost part of the underlying Tsagantsav Formation (ca. 126 Ma: Graham et al., 2001).

In order to clarify the depositional environments and their controlling factors of the rhythmically alternated lithological change in the Shinekhudag lacustrine deposits, elemental analysis (C, N, S) and Rock-Eval pyrolysis were performed on the shale and calcareous clay samples. C/N values are significantly low (< 10) in the calcareous clay samples, while relatively higher (> 13) in the shale samples. Rock-Eval analysis shows significantly high hydrogen index (> 650 mg/g) in the calcareous clay samples, while slightly lower value (< 610 mg/g) in the shale samples. The most samples showed relatively high T-max values (430–440 ˚C). These results indicate that the organic matter of the Shinekhudag lacustrine deposits were mainly of algal origin (dominant in calcareous clay layer) but with relative higher contribution of other materials including terrestrial plants and/or cyanobacteria (relatively high in shale layer). These lines of evidence suggest that the rhythmically alternated shale and calcareous clay succession was formed by fluctuations in the lake-levels and associated changes in surface primary producers, which could be controlled by orbital-scale (probably also millennial-scale) precipitation changes during the mid-Cretaceous time.