RECONSTRUCTION OF TERRESTRIAL PALEO-HYDROLOGIC CHANGE DURING THE MID-CRETACEOUS "SUPERGREENHOUSE" PERIOD: INSIGHTS FROM THE LACUSTRINE RECORDS (SHINEKHUDAG FM.) IN SOUTHEAST MONGOLIA

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The mid-Cretaceous period is characterized by an extremely warm "greenhouse" climate, elevated atmospheric CO_2 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 and Erba, 2004; Emeis and Weissert, 2009). 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 the eastern Gobi basin, southeast Mongolia (Ando et al., 2011).

The mid-Cretaceous lacustrine deposits (Shinekhudag Formation) are widely distributed in southeastern Mongolia (Jerzykiewicz, and Russell, 1991; Hasegawa et al., 2012). 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 calcareous shale, and whitish to yellowish dolomite. Strata are continuously exposed up to 400 m in thickness. The shale and dolomite successions are rhythmically alternated (decimeter-, meter-, tens of meter-scale) in Shine Khudag locality, which can be 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 Formation is assigned as Aptian or Barremian-Aptian based on the ostracode, concostracans, floral and molluscan evidences (Krassilov, 1982; Jerzykiewicz and Russell, 1991; Yuan and Chen, 2005), and Ar^{40}/Ar^{39} dating of basaltic rocks in the uppermost part of the underlying Tsagantsav Formation (ca. 125 Ma; Graham et al., 2001).

In order to clarify the depositional environments and the controlling factors for the rhythmically alternating lithofacies change, we conducted X-ray diffraction (XRD) analysis to reconstruct changes in the mineral composition. We also performed elemental analysis (C, N, S), Rock-Eval pyrolysis, and quantitative study of palynofacies to evaluate the organic matter (OM) composition in the shale and dolomite couplets. The mineral composition results revealed that the cyclic alternations (ca. 1.5 m cycle) of the dolomite abundant layer and detritus minerals and calcite rich layer. C/N values are significantly low in the dolomite samples, while higher in the 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 dominance of *Botryococcus* colonies in the dolomite layers, whereas the shale layers show abundant 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 (Figure 1A).

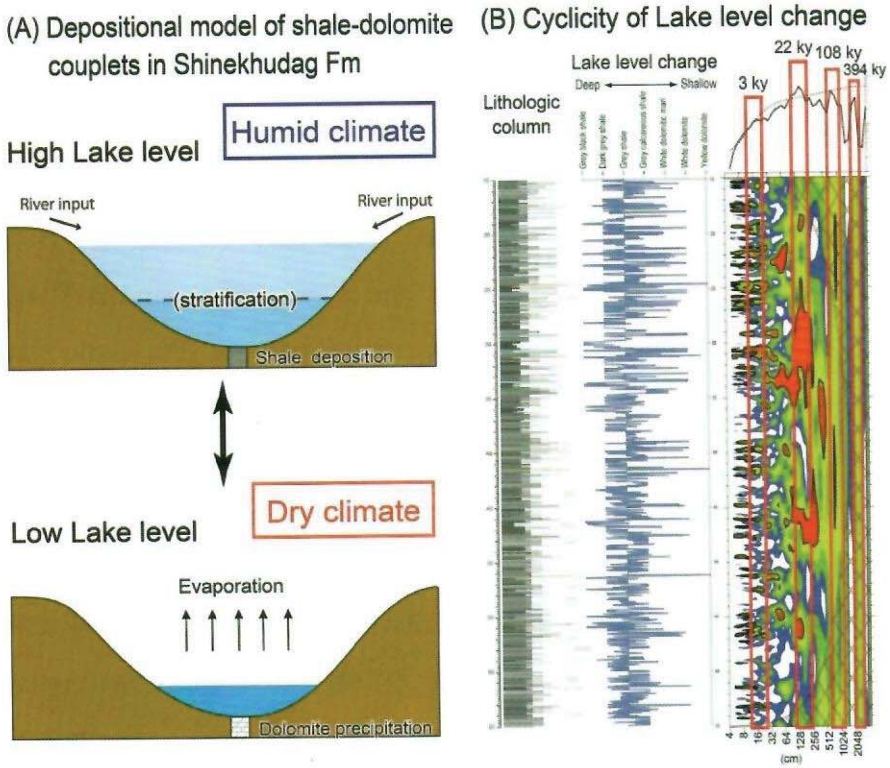

Fig.1 (A) Depositional model of shale-dolomite couplets in Shinekhudag Formation. (B) Lithologic column, reconstructed lake level changes, and dominant cyclicities of the lake level changes of the Aptian lacustrine deposits (Shinekhudag Formation) in southeast Mongolia.

Namely, the dolomite layers were formed during low lake level by microbially mediated precipitation in highly alkaline lake waters (e.g., Last, 1990; Dupraz et al., 2009). *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 cyclicities involving ca. 1.5 m, 7 m, and 26 m cycles, corresponding to periodicities of ca. 22 kyr, 108 kyr, and 394 kyr, respectively, based on a varve-tuned average sedimentation rate of 6.5 cm/kyr (Figure 1B).

These values are in accordance with orbital precession (18–23 kyr cycle) and eccentricity cycles (100 and 400 kyr cycles). 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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