# Decadal- to orbital-scale paleoclimatic changes in the mid-Cretaceous “supergreenhouse” evidenced from Mongolian lacustrine records

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Understanding the global climate system during extremely warm “supergreenhouse” periods, such as the mid-Cretaceous, is one of the major aims of paleoclimatology. Hasegawa et al. (2012) suggested the drastic shrinkage of the Hadley circulation and enhanced mid-latitude hydrological cycle with wavier westerly jet stream during the mid-Cretaceous, based on the spatio-temporal reconstruction of desert distribution and paleo-wind pattern. However, the mechanism of such a drastic change in atmospheric circulation system have been poorly constrained, due to the lack of appropriate datasets. Here we present results of our ongoing research project targeting on annual- to orbital-scale paleoclimatic reconstruction based on a mid-Cretaceous lacustrine record in Mongolia.
The Aptian lacustrine deposits (Shinekhudag Formation) are widely distributed in southeastern Mongolia. In the type locality Shine Khudag area, the formation is about 250 m thick and composed alternating beds of dark gray shale, light gray dolomitic marl and yellowish dolomite. The shale and dolomite successions are rhythmically alternated (decimeter-, meter-, tens of meter-scale), which are thought to be formed primarily by lake level changes reflecting precipitation changes. Dark gray shale bed is well-laminated, consisting of micrometer-scale couplets of algal organic matter and detrital minerals. To obtain the continuous paleoclimatic record of this unique lacustrine deposit, we have drilled two scientific research cores (CSH01, 02) in Shine Khudag area in 2013 and 2014 summer.
Based on the radiometric age dating and detail chronostratigraphic study, the Shinekhudag Formation is considered to be deposited between ca. 123–119 Ma, and the calculated sedimentation rate is ca. 6.3–12.5 cm/kyr (Hasegawa et al., in revision). Given the average thickness of micro-lamination and calculated sedimentation rate, micrometer-scale laminations (couplets of organic matter and detrital minerals) in shale and dolomitic marl beds are most likely varves, reflecting seasonal cyclicity. Lacustrine varve record is a powerful tool to reconstruct detail climatic and chronological record (e.g., Wolff et al., 2011; Nakagawa et al., 2012). Thus, the Shinekhudag Formation have a potential to record the annual-scale climatic change and seasonal changes in mid-latitude Asia during the Aptian time.
In order to obtain the paleoclimatic signals and their controlling factors from the Shinekhudag lacustrine record, we performed XRF and ICP-MS analysis for major and minor element compositions of the bulk samples. Based on the factor analysis of major and minor element compositions, several climatic signals (e.g., precipitation, redox condition of lake bottom) were obtained. Spectral analysis of each factor scores reveals that cycles involving approximately 2, 6, 20, 40, and 100 kyr, based on the average sedimentation rate of 10 cm/kyr. The later values are in accordance with orbital precession, obliquity, and eccentricity cycles, respectively. Therefore, Shinekhudag

 

lacustrine deposits are interpreted to record the millennial- to orbital-scale paleoclimatic changes during the mid-Cretaceous “supergreenhouse” period.
Furthermore, although precipitation proxy (e.g., Si/Al, Ca/Al) shows a strong precession and eccentricity cycles, proxy for redox condition of lake bottom (e.g., P/Al, U/Al, Mo/Al) shows a clear obliquity cycles, suggesting different responses to the orbital insolation. Both the sediment mineralogy and palynofacies assemblages correspond also to the precession and eccentricity-paced precipitation (lake level) changes, except for the calcite contents and algal cysts abundance. Lake surface productivity signal is thought to be more sensitive to orbital insolation forcing. Thus, to verify the variation and cyclicity of lake surface productivity signal and its relationship to other climatic signals, elemental analysis (TOC, TN, TS) are now conducting.

Keywords: lake, greenhouse, varve, precipitation, productivity, orbital forcing

 