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Compositional changes of organic matter and carbon isotope stratigraphy through the mid-Cretaceous lacustrine deposits

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Cretaceous oceanic anoxic events (OAEs) are well known perturbation events of carbon circulation over the earth surface. Oceanic environments during the events are well documented from marine sequences based on paleontological and geochemical characterization. On the other hand, lack of tools for precise inter-regional correlation between marine and non-marine sequences prevents us from discussion of dynamic environmental changes involving causal relationship between terrestrial and oceanic phenomena.

This study focuses on mid-Cretaceous Aptian-Albian terrestrial sequences from southeastern Mongolia that have been located deep inside of the Eurasian continent since Cretaceous and presumably record the climatic responses on the continent to OAE1a and OAE1b. The Shinekhudag Fm., and formations below (Tsagantsav Fm.) and above (Khuhuteg Fm.) exposed in the Shine Khudag location, Shaazangiin Gobi area are studied to cover majority of the sequence to construct a composite section. The Shinekhudag Fm., the main part of the studied section, is composed of alternating beds of dark greyish paper shale, greyish calcareous shale, light greyish dolomitic marl, and whitish to yellowish dolomite. Total range examined here is 490 m in thickness including sampling gap derived from bad outcrop conditions.

Carbon isotope value (d13C) of total organic matter trough the composite section exhibits general trend of gradual drop between 200 m and 330m (lower half of the Shinekhudag Fm.). However, some adjacent samples shows considerable difference as large as 6 permil suggesting that the d13C fluctuation does not only reflect secular variation of 13C/12C of ocean-atmospheric carbon reservoir but also changes in mixing rate of organic matter derived from different primary producers. It is also suggested from scattered stratigraphic distribution of C/N ratio ranging 3 to 38. Rock-Eval pyrolysis on selected 15 samples including that with C/N ratio over 20 shows high hydrogen index values over 400 mgHC/gTOC for all samples. This fact indicates contribution of terrestrial plant fragments in the sediments is not significant in the Shinekhudag Fm.

Cross-plot diagram of d13C and C/N ratio exhibits clear negative correlation for all sample sets from the Tsagantsav and Shinekhudag formations. It indicates that both parameters are controlled by a same factor in these formations. It is mixing rate of two types of organic matter produced by contrasting organisms. One of them is represented by normal lacustrine algae that has C/N ratio around 6 and the other is by unknown producer that has hydrogen index as high as algae, C/N ratio around 30 and d13C values 3 permil more negative relative to algae. The regression lines of the sample sets show parallel distribution and 4 permil of gradual negative sliding within the Shinekhudag Fm. Carbon isotopic shifts of two end components with same magnitude reflecting change in 13C/12C ratio of atmospheric CO2 is the most plausible explanation for this gradual sliding of the regression line. Applying this d13C fluctuation to chronostratigraphy, it is correlated to the long-term negative shift through the early Aptian after OAE1a.

Although carbon isotope stratigraphy is a powerful tool for international chronostratigraphic correlation (Ogg et al., 2008), its application to terrestrial sequences has been limited because of the difficulty of source evaluation of organic matter. Evaluation using C/N-d13C regression line in a cross-plot diagram can give clue to application of d13C chronostratigraphy to lacustrine sedimentary rocks.

Keywords: Cretaceous, lacustrine, carbon isotope, organic carbon, oceanic anoxic event