Origin of chert layer in lacustrine deposits (Green River Fm.) in NW America: Implication for lake productivity change during the Early Eocene Climatic Optimum

*Ryusei Kuma[1], Hitoshi Hasegawa[2], Koshi Yamamoto[1], Masayuki Ikeda[3], J. Whiteside[4]

1. Nagoya University, 2. Kochi University, 3. Shizuoka University, 4. Southampton University

Paleoclimatic reconstructions of extremely warm periods are important in understanding the dynamics of Earth’ s climate system under an exceptionally warm mode. Proxy records demonstrated that the Early Eocene Climatic Optimum (EECO: 53–49 Ma) is characterized by the warmest interval through the Cenozoic era with elevated (ca. 1125 ppm) atmospheric CO_2 levels (e.g., Lowenstein and Demicco, 2006; Zachos et al., 2008). Deconto et al. (2012) demonstrated that orbitally triggered decomposition of soil organic carbon in permafrost of high latitude environments, caused subsequent warming of the hyperthermals during the EECO. To reconstruct paleoclimatic change in the mid-latitude terrestrial environment at the EECO interval, the present study targeted on the lacustrine sediments of the Green River Formation distributed widely in Northwest America.

The Green River Formation is known as one of the largest petroleum resources, and many previous studies were conducted to determine the chronology and to reconstruct paleoenvironmental setting (Smith et al., 2008; Whiteside and Keuren, 2009). We have conducted field survey in the Indian Canyon section in northern Utah since 2016 summer. In order to reconstruct the quantitative terrestrial paleoenvironmental and paleoclimatic changes during the EECO, we performed sedimentological facies analysis and analyzed major element composition of rock samples taken from the outcrops of the formation (every ca. 1 m interval, totally 192 samples) to extract the paleoclimatic proxies. Especially, we focused on chert layers intercalated within the lacustrine strata of the Green River Formation (Bradley and Eugster, 1969), and interpreted the formation mechanism of chert layer to elucidate the usefulness for a paleoclimatic proxy.

Based on the lithofacies changes of the lacustrine deposits, we identified the Depth Ranks for reconstructing lake-level changes. We then compared the Depth Ranks and obtained major element composition. The results reveal that the similarity between Depth Ranks and CaO/Al_2O_3, which is thought to be reflecting lake level changes. TiO_2/Al_2O_3 does not show marked change through the section, therefore the provenance of clastic sediments in the studied interval are relatively stable. The relationship between SiO_2 and Al_2O_3 shows positive correlation (corresponding the line of terrigenous materials) with excess enrichment of silica in most of samples. Some samples showing very high SiO_2/Al_2O_3 values appear to be corresponding to the chert layers. On the basis of fluorescent microscopic observation and SEM-EDS analysis, silica enrichment (high value of SiO_2/Al_2O_3) is considered to be formed by replacement of originally algal organic matter.

Previous studies (e.g., Bradley and Eugster, 1969) also reported the occurrence of chert layers or chert nodules in the Green River Formation strata, however, most of the previous studies stated these chert layers as Magadii-type chert, which are thought to be precipitated inorganically in shallow lake environment like playa lake. Hay (1968) and Eugster (1969) interpreted that the Magadi-type chert was inorganically precipitated in highly alkaline and/or saline lake (e.g., Magadi Lake in Kenya) during near surface alteration by dilute ground water. On the other hand, some recent studies proposed that the formation of the Magadi-type chert was influenced by pH changes by algal activity (e.g., Krainer and Spotl,

1998; Behr and Rohricht, 2000). As mentioned above, we also interpreted that excess silica enrichment and formation of chert can be influenced by replacement of originally algal organic matter. Thus, we proposed that excess silica enrichment can be used for the proxy of lake productivity at the time of the Early Eocene.

We further examined the possible cause of the lake level and productivity changes, based on the comparison with the orbital-scale insolation change at the time of the Early Eocene. The changes in excess silica enrichment show periodicities of approximately 100 kyr and 400 kyr cycle, that appear to be corresponding to eccentricity cycles. The reconstructed 400 kyr amplitude modulation of the lake productivity changes (recorded as excess silica enrichment) in the Green River Formation seem to be synchronized with the 400 kyr and 2.4 Myr long eccentricity cycles of insolation change at the Early Eocene (Lasker et al., 2004). To understand more detail paleoclimatic changes and their controlling factors, high-resolution analyses of the major and minor element composition obtained from drilling core samples of the Green River Formation by using μXRF core scanner (COX, Itrax) are now ongoing.

Keywords: lake sediments, Eocene, climate change, Green River Formation, chert, replacement

