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Paleoenvironments and ecosystems in the mid-Cretaceous Oceanic Anoxic Event 1a and 1b in Vocontian Basin, SE France

Kazuki Okano[1], Ken Sawada[1*], Hiroshi Nishi[1], Reishi Takashima[1]

[1]Faculty of Science, Hokkaido University

Black shales were occasionally discovered in the mid-Cretaceous formations, and depositions of these sediments are closely associated with the expansion of oxygen-poor water in the ocean, called the oceanic anoxic events (OAEs). In this study, the biomarker analyses of the black shales corresponding to the OAE1a (the Goguel level) and OAE1b (the Jacob, Kilian, Paquier, and Leeenhardt levels) from the Vocontian Basin of SE France are curried out in order to reconstruct the changes of environmental systems and marine ecosystems, and to elucidate the mechanism for expansion of anoxic waters during these OAEs.
The 2-methylhopane (2-MHP) is identified in the Goguel level. The relative abundances of 2-methylhopane (2-MHP indices) tend to increase toward upper layers within the Goguel level, which indicates that cyanobacterial communities were predominant in surface water with expansion of anoxic condition. In the present-day, cyanobacteria are abundant in the tropic and subtropical oligotrophic waters. From this thing, the increase of cyanobacterial biomass in the upper layers of the Goguel level suggests expansion of oligotrophic and warm waters in sea surface layers. The concentrations of steranes and dinosteranes, which originated from all marine phytoplankton and dinoflagellate, respectively, are consistently low. These results support that expansion of oligotrophic waters throughout the Goguel level. Two events of high productivity are recognized by the highest concentrations of steranes and dinosteranes in this level. In these layers, the 2-MHP indices decreased relative to adjacent layers, indicating that there is inverse correlation between cyanobacterial and the other algal production. These results coincide with predominance of cyanobacteria under oligotrophic condition. Above the Goguel level, marine primary production gradually increased and cyanobacterial biomass decreased.
In the OAE1b samples, the terrestrial higher plant biomarkers such as the retene and the dibenzofuran are abundantly identified. The concentrations of these biomarkers are relatively low in the Jacob level, but high in the middle part of the Paquier level. Moreover, the concentrations of marine algal biomarkers such as steranes and dinosteranes are high in the Kilian and Paquier levels, while these are low in the Jacob and Leenhardt levels. These trends are similar to those of terrestrial biomarker concentrations, which indicate that the nutrient was transported from land to ocean. During the Jacob and Leenhardt levels, terrestrial input presumably decreased in the ocean. Therefore, the structure of clear lamination and prominent variation of carbon isotope ratios are not recognized in the Jacob and Leenhardt levels. In the Kilian and Paquier levels, the archaeal biomarkers such as 2,6,15,19- tetramethylicosane (TMI) and 2,6,10,15,19-pentamethylicosane (PMI) are detected, but are not detected in the Jacob and Leenhardt levels. Carbon isotope ratios of TMI and PMI range -35 to -20 permil, suggesting that these biomarkers are originated from methanogenic archaea. Thus, these expansions of methanogenic archaea during the Kilian and Paquier levels were possibly related to the intensification of anoxic condition. As mentioned above, the deposition of black shales are strongly related to terrestrial input. The same mechanisms are observed in modern tropical ocean areas such as the Bismarck Sea (Papuwa New Guinea), where is characterized by strong stratification and supply of a large amount of terrigenous materials by riverine flow system of the Sepik River, and productivity of marine phytoplankton is high in the

stratified surface water, resulting in deposition of sediment rich in organic matter. In this study, it is suggested that the Bismarck Sea is typical ocean model for the paleo-Tethys Sea during OAE1 b, called 'Bismarck Sea-type OAE'.

Keywords: Oceanic Anoxic Event (OAE), paleo-ecosystem, biomarker, Cretaceous,
supply of terrigenous material, 'Bismarck Sea-type OAE'