論文の内容の要旨

Mid-Cretaceous marine osmium isotopic record

(白亜紀中期海洋オスミウム同位体記録)

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Mid-Cretaceous (~120 to 90 Ma) experienced several dramatic environmental perturbations (e.g., oceanic anoxic events (OAEs), biotic crises, and extremely high temperatures). Although they are considered linked to the massive submarine volcanism forming large igneous provinces (LIPs), reliable evidence supporting their linkages has been limited so far. Marine Os isotope ratio ($^{187}Os/^{188}Os$) reflects the balance between the unradiogenic Os input ($^{187}Os/^{188}Os$~0.12) from the mantle and extraterrestrial materials, and radiogenic Os input ($^{187}Os/^{188}Os$~1–1.5) through continental weathering. Therefore, paleo-marine Os isotopic information recorded in the sedimentary sequence has the potential as a tracer of the mantle-derived LIPs volcanic activity. In this dissertation, I reconstructed a continuous high-resolution paleo-marine osmium isotopic record ($^{187}Os/^{188}Os$) throughout the mid-Cretaceous and tried to constrain the exact timing of massive volcanic events, and explored their relationship to the mid-Cretaceous environmental perturbations.

In Chapter I, I reviewed the previous studies on the temperature, pCO_2, and hydrothermal activity during the mid-Cretaceous and verify the conventional mid-Cretaceous image of "*the greenhouse world supported by high pCO_2 released from the intensive hydrothermal activity associated oceanic crustal production*". Subsequently, I summarized the major environmental perturbations during the mid-Cretaceous (i.e., OAEs and LIPs volcanism), the osmium isotopic records in the sedimentary sequence, and the scope of this study.

In Chapter II, I reconstructed a continuous marine Os isotopic record from upper Aptian to lower Albian (~118–110 Ma) encompassing oceanic anoxic event (OAE) 1b using Tethyan and Pacific sedimentary records. Os isotopic record showed several unradiogenic shifts during the lower part of OAE1b, which could represent massive submarine volcanic events at the Kerguelen Plateau. Since these unradiogenic shifts correspond to the biotic crises of planktonic foraminifera, massive volcanic events could have triggered severe biotic crises through ocean acidification. Besides, Os isotopic ratio showed radiogenic shifts during the upper part of OAE1b implying the enhanced continental weathering caused by intensive global warming.

In chapter III, I conducted continuous high-resolution Os and carbon isotopic measurements using Tethyan sedimentary record covering the entire Aptian (~120–113 Ma). From the paleontological information and carbon isotopic ratios of carbonate ($\delta^{13}C_{carb}$), I identified the previously undescribed black shale horizons in the early Aptian (*Leupoldina cabri* planktonic foraminiferal Zone and Ap7 of carbon isotopic segment) and named it as the "Wezel Level". Os isotopic ratio showed unradiogenic shifts at two black shale horizons of Wezel and Fallot Levels during the early to mid-Aptian. The sedimentary ages of these events roughly correspond to the formation ages of Ontong Java, Manihiki, and Hikurangi Plateaus, which once formed a single large oceanic Plateau called "Ontong Java Nui". Thus, I concluded that the deposition of black shale horizons during Aptian is related to the enhanced submarine volcanic events at the OJN. This result implies that the massive volcanic events at the OJN could have continued for about 5 million years.

In chapter IV, I reconstructed the Os isotopic record of the pelagic deep-sea sedimentary record of Goshikinohama bedded chert. Goshikinohama bedded chert provides a rare opportunity to examine the redox condition at the deep-sea Pacific basin during Aptian OAE1a. However, the exact stratigraphic interval of OAE1a has not been precisely constrained because of the lack of reliable stratigraphic indicators. The new Os isotopic data showed characteristic unradiogenic shifts at two purple chert horizons. These Os isotopic variations could represent the massive input of mantle-derived unradiogenic Os through the volcanic activity at the OJN, which can be correlated to the OAE1a interval. Since most of the OAE1a sequence is composed of red chert rich in hematite, oxic conditions prevailed at the deep-sea Pacific basin even during the OAE1a. However, the two purple beds with the especially unradiogenic Os isotopic values are slightly enriched in redox-sensitive elements (V, Cr, and U). These facts imply that the two especially intensive phases of the OJN volcanism caused especially strongly reducing conditions, which could have extended to the deep-sea Pacific Basin.

In chapter V, I reconstructed continuous marine Os isotopic record during the Hauterivian to Barremian encompassing the first mid-Cretaceous OAE, called Faraoni Level. As the result, Os isotopic ratio showed cyclic radiogenic shifts from 0.7 to 0.9 paced by the 400 kyr eccentricity, which represents the cyclic enhancement of continental weathering. Combining clay mineral composition in the Tethyan sedimentary sequence, I concluded that eccentricity-paced intensification of monsoonal activity caused the cyclic increase in continental weathering. Since Faraoni Level is not accompanied by the unradiogenic shifts, I concluded that this event is unrelated to the massive volcanic events.

In chapter VI, I measured Os isotopic ratios of Albian to Turonian sedimentary rocks samples deposited in pelagic Tethys and Indian Oceans. Combining these data with previous chapters, I reconstructed a continuous long-term Os isotopic record across the mid-Cretaceous. The compiled Os isotopic record suggests that hydrothermal activity was enhanced during Aptian, late Albian, and latest Cenomanian, which likely represent the enhanced hydrothermal activity associated with submarine LIPs volcanism. Besides, mid-Cretaceous OAE can be classified into two types: (1) OAEs accompanied by unradiogenic Os isotopic shifts (OAE1a, Wezel and Fallot Events, and OAE2) and (2) OAEs which is not accompanied by unradiogenic shifts (OAE1c and OAE1d). The former OAEs were global events and caused by the increase in the primary productivity triggered by the massive LIPs volcanism. On the other hand, latter OAEs have been mainly reported from the Tethyan region and were caused by the ocean stratification induced by the enhancement of monsoonal activity. The warmest interval during the mid-Cretaceous does not correspond to the enhanced hydrothermal activity but corresponds to the interval of the subaerial LIPs volcanism and circum-Pacific volcanic episodes. These data suggest that subaerial eruptions and following outgassing may have played an important role in the regulation of the mid-Cretaceous climate.

In Chapter VII, I summarized the doctoral dissertation. Subsequently, I compiled the Os isotopic variations during the Phanerozoic massive volcanic events and discussed the relationship between the location of LIPs volcanism and marine osmium isotopic variations. Finally, I described the problems and future perspectives of osmium isotopic studies using the sedimentary sequence.