Changes of Nutrient Levels in the Northwestern Pacific and Eastern Indian Oceans during the Past 15 Myr Based on Calcareous Nannofossil Assemblages

Doctor Thesis

博士論文

Changes of Nutrient Levels in the Northwestern Pacific and Eastern Indian Oceans during the Past 15 Myr Based on Calcareous Nannofossil Assemblages

（石灰質ナンノ化石群集変化に基づく北西太平洋と東インド洋の過去 1500 万年間の海洋環境復元）

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I use three cores and three well cuttings sample drilled in the northwestern Pacific and eastern Indian oceans for this reconstruction of global paleoceanographic changes. Moreover, cuttings sample from three wells drilled in the Okinawa-jima along NW–SE transect, which can establish more regional scale environmental changes during the Shimajiri Group deposition.

In Chapter I, to reconstruct the Cenozoic paleoceanographic evolution, in particular, temporal changes in nutrient levels, studied calcareous nannofossil assemblages from Ocean Drilling Program holes 1210A, located in the northwestern Pacific Ocean, and 762B, situated in the eastern Indian Ocean. At each site I focused on the relationships among the nannofossil accumulation rate (NAR), relative abundance of *Discoaster*, and coccolith size of the genus *Reticulofenestra*. The co-occurrence of a low NAR, high *Discoaster* abundance and presence of large *Reticulofenestra* suggest a deep thermocline and nutricline, typical of oligotrophic conditions. Conversely, the co-occurrence of a high NAR, low *Discoaster* abundance and presence of small *Reticulofenestra* indicate a shallow thermocline and nutricline, typical of eutrophic conditions. The combination of these three parameters suggests that the gradual eutrophication and collapse of sea surface stratification occurred in the northwestern Pacific Ocean at 7.9, 6.4, and 5.0 Ma. In contrast, abrupt eutrophication is indicated at 8.8 Ma in the eastern Indian Ocean. Although the timing of eutrophication differs between the Pacific and Indian Ocean sites, it roughly coincides with tectonic and/or climatic events around the two oceans. This finding suggests that tectonic and climatic events are capable of causing an increase in the terrestrial input and/or coastal upwelling of nutrients that subsequently leads to the eutrophication of sea surface waters.

In Chapter II, the Cenozoic sedimentary succession in Okinawa-jima, including the upper Miocene to Pleistocene siliciclastic deposits (Shimajiri Group) and the Pleistocene reef to shelf deposits (Ryukyu Group), suggests a drastic paleoceanographic change from a ‘mud sea’ to a ‘coral sea.’ To delineate the paleoceanographic evolution of the mud sea, I quantified the stratigraphic distribution of the calcareous nannofossil assemblages from the Shimajiri Group in a 2119.49 m-deep well (Nanjo R1 Exploratory Well) drilled in southern Okinawa-jima (Ryukyu Islands, southwestern Japan). Four late Miocene and Pliocene datum planes were found in the studied interval: the first occurrence of *Amaurolithus* spp. (7.42 Ma), the last occurrence of *Discoaster quinqueramus* (5.59 Ma), the first occurrence of *Ceratolithus rugosus* (5.12 Ma), and

the last occurrence of *Reticulofenestra pseudoumbilicus* (3.70 Ma). The calcareous nannofossil assemblages from the Tomigusuku Formation and the lower part of the Yonabaru Formation are characterized by a lower total number of coccoliths and abundant *Sphenolithus abies* that is associated, at times, with common *Discoaster* spp. Overall, these suggest the existence of oligotrophic conditions between 5.3 and >8.3 Ma. The total number of coccoliths increased and small *Reticulofenestra* spp. became more common in the middle part of the Yonabaru Formation, suggesting that eutrophic conditions were present between 3.5 and 5.3 Ma. The rare occurrence of calcareous nannofossils in the upper part of the Yonabaru Formation indicates a return to oligotrophic conditions at 3.5 Ma. Micropaleontological evidence suggests that these oceanographic changes were likely caused by local tectonic movement (shallowing of the sedimentary basin in which the Shimajiri Group was deposited).

In Chapter III, I investigated the calcareous nannofossil biostratigraphy and paleoceanography of the Shimajiri Group in two exploratory wells (depths, 1243 and 1800 m) drilled on southern Okinawajima, Ryukyu Islands, southwestern Japan. Three late Miocene to Pliocene datum planes were identified: the first occurrence of *Amaurolithus* spp. (7.42 Ma), the last occurrence of *Discoaster quinqueramus* (5.59 Ma), and the first occurrence of *Ceratolithus rugosus* (5.12 Ma). These datum planes were also identified in two other deep wells on southern Okinawa-jima. Nutrient levels (reconstructed from the total numbers of coccoliths, the relative abundances of small *Reticulofenestra* spp., and the relative abundances of *Discoaster* spp. plus *Sphenolithus abies*) suggest that deposition of the Shimajiri Group (>8.29–3.50 Ma) occurred under conditions of eutrophication. The eutrophication was likely caused by shallowing of the sedimentary basin, and was associated with an abrupt eutrophication event that occurred in the northwestern Pacific Ocean at 5 Ma.

Thus, the comparison among NAR, relative abundance of *Discoaster* and modal variation in *Reticulofenestra* coccolith size can reconstruct global and regional changing of sea surface condition especially nutrient level. The long-term variation in nannofossil assemblages show a gradual eutrophic trend since the late Miocene which induced by tectonic and/or climate evolution.