Aptian-Albian Radiolarian Faunal Transition and Productivity in the Equatorial Pacific Ocean : Implications for Paleoenvironmental Changes

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論 文 内 容 要 旨

The Aptian and Albian radiolarian faunal changes in the western Tethys are reflected in paleoceanographic conditions, such as the oxygen level and nutrient supply during oceanic anoxic events (OAEs; OAE1a in early Aptian, OAE1b in latest Aptian to early Albian, and OAE1c in late Albian) and long-term climatic changes during Aptian and Albian. The oceanic anoxic events in the western Tethys are associated with the extinction of a high percentage of radiolarians in OAE1a (41%) and the Urbino event of OAE1b (42%), and the origin of a high percentage of radiolarians during OAE1c (56%). The diversity of radiolarians in the western Tethys increased twice in late Albian. By contrast, previous studies of Pacific radiolarians have not focused on OAEs and long-term climatic changes.

This study clarifies the stratigraphic distributions of radiolarian species during Aptian and Albian using rock samples from Deep Sea Drilling Project (DSDP) Site 463 and Ocean Drilling Program (ODP) Sites 1207, 1213, and 1214, which were located in the equatorial Pacific during the Aptian and Albian. From Aptian to the Albian, the OAEs had less of an impact on equatorial Pacific radiolarians than on Tethyan radiolarians. During the OAE1a, 8.8% of the equatorial Pacific species went extinct; in the OAE1b, 0, 4.2, and 5.3% went extinct during the Jacob or 113, Paquier, and Urbino events, respectively, while 0% went extinct with 0% of species originating during OAE1c. The extinction rates in OAE1a (3-8% of species in each 0.5-m.y. interval) and 1b (0-9% of species in each 0.5-m.y. interval) are much higher than the background extinction rates (0-5% of species in each 0.5-m.y. interval). The radiolarian assemblage in Albian in the equatorial Pacific was unusually stable, with very low extinction and speciation rates. In Aptian and Albian, equatorial Pacific radiolarians showed different patterns to that in the western Tethys, reflecting the low impact of OAEs and the unusually stable assemblages in the Albian. These findings suggest that the paleoceanographic conditions in the equatorial Pacific differed from those in the western Tethys during the OAEs and Albian time. The relatively low extinction and speciation rates during the OAEs, with higher diversity in the equatorial Pacific than that in the western Tethys, suggest that paleoceanographic conditions were probably more oxygenated than they were in the western Tethys.

I examined the paleoceanographic conditions in the equatorial Pacific using radiolarian productivity in shallow and deep water. Although radiolarian productivity has been used to study post-Cretaceous paleoceanographic changes, indicating the influences of water masses, previous studies of Cretaceous radiolarians have not considered radiolarian productivity because fragile radiolarian tests are affected by dissolution during diagenesis. To avoid the dissolution problem, I established a new method to use dissolution resistant species, which reflects changes in the productivity of shallow- and deep-dwelling radiolarians in the equatorial Pacific from Aptian to Albian. The high radiolarian productivity of shallow-dwelling strong-shell species during Aptian immigrated to high productivity in deep-dwelling species during Albian. The unusually stable assemblages in Albian were explained by the dominance of deep-dwelling radiolarians. This drastic transition is probably connected to warming from icehouse to greenhouse conditions during the Aptian-Albian transition and an increase in surface-water calcareous planktons.

In summary, equatorial Pacific radiolarian faunas were influenced by both OAEs and long-term paleoceanographic changes associated with the transition from icehouse to greenhouse climates. However, OAEs had a weaker impact on equatorial Pacific radiolarians than on Tethyan radiolarians, suggesting higher dissolved oxygen conditions in the Pacific than in the Tethys.

論文審査の結果の要旨

申請者の鹿納晴尚は前期白亜紀アプチアン期からアルビアン期における赤道太平洋地域の放散虫群集の変遷を明らかにした。当時は温暖化が強まる時代であり，アプチアン期からアルビアン期にかけて極域の氷床がなくなることが知られている。さらに，この時代には複数の海洋無酸素事変（OAEs；OAE1a,1b,1c）が報告されている。これらの環境変動による放散虫群集への影響として，テチス域でOAE1a,1bにおいて大規模な絶滅イベント，OAE1cでは出現イベントが知られていたが，太平洋域では未解決であった。彼は当時赤道太平洋に位置していた海洋底コアを用いて連続的に放散虫化石群集の詳細な検討を行ない，OAE1a，1bにおいて，小規模な放散虫絶滅イベントがあることを初めて示した。OAE1cでは群集の変動は見られなかった。これらは赤道太平洋域においてOAEsの影響がテチス海より小さかったことを示している。また，テチス海と異なり，赤道太平洋では安定した（種構成の変化が少ない）群集がアルビアン期に持続したことを初めて示した。

彼はテチス域と赤道太平洋域では海洋環境が異なると考え，放散虫の生産量に着目し海洋構造の変遷を考察した。以前の白亜紀放散虫の研究では，殻が脆弱な種の溶解のため，生産量による古海洋変動の議論はされてこなかった。彼は高耐性種に着目し，クラスタ解析と既知の数種の水深分布から主要種の水深分布を特定し，それらの生産量の変動を初めて明らかにした。その結果，アプチアン期前期のOAE1aではプルームの火成活動により海洋表層種の生産量が増加したことを示した。アプチアン期-アルビアン期境界頃に表層種の生産量減少，深層種の生産量増加があり，その後安定したことを示した。この時期には極域の氷床が消滅したため，海洋表層と深層の混合が弱まり，Si, P, Nといった生物制限元素が表層で減少したため，表層種の生産量が減少，深層種の生産量が増加したと解釈した。アルビアン期の安定した放散虫群集は深層種が優勢であるためと結論付けた。

以上の研究成果は，自立して研究活動をおこなうに必要な高度の研究能力と学識を有することを示している。したがって，鹿納晴尚提出の博士論文は，博士（理学）の学位論文として合格と認める。