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総　説

巨大海台をつくる基盤溶岩の掘削成果

Results of Basement Drilling on Oceanic LIPs

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Abstract

In the first decade of the 21st century, two oceanic large igneous provinces (LIPs), the Ontong Java Plateau (OJP) and the Shatsky Rise, were drilled to recover basement lavas. Coring data show that basement rocks comprise massive sheet flows, similar to continental flood basalts. The high effusion rate to generate the massive sheet flows cannot be explained by normal plate tectonic processes. Because the two LIPs are considered to have formed at plate boundaries, previous workers have suggested that thermal plume heads underlie plate boundaries, generating voluminous magmas. ^{40}Ar–^{39}Ar data show that the duration of LIP magmatism exceeds that of the predictive model for plumes. Minor volcanic episodes between 90 and 44 Ma occurred in the OJP, with the major event occurring at ~122 Ma. For the Shatsky Rise, a ~10 Myr hiatus separates the final massive flows from main volcanism. Petrological data suggest the temperature of the magma source (potential temperature) was ~300°C, higher than the ambient mantle of the OJP, ~150–200°C higher than the Shatsky Rise, and lower than that of the plume model (>400°C). Geochemical data show that lavas from the two LIPs are variably enriched relative to normal upper mantle, suggesting they were derived from a plume source. However, unequivocal plume signatures (e.g., lower-mantle geochemical signatures with high $^{3}He/^{4}He$) have not been identified in the volcanic products of the LIPs. Similarly, some lava compositions suggest the contribution of subducted slab materials to their magmatic source. Furthermore, the amount of subsidence following emplacement of the LIPs is less than that predicted by the thermal plume model. Thus, our study shows that a simple thermal plume model does not account for the genesis of the LIPs, indicating that more complex (e.g., thermochemical) models should be developed. Recent oceanic crust drilling programs have improved our understanding of LIP magmatism, but further work is required to constrain its characteristics and source.

Keywords: Large Igneous Provinces, Oceanic Plateau, Ontong Java Plateau, Shatsky Rise, Ocean Drilling Program, Integrated Ocean Drilling Program, Plume, Magma genesis

はじめに

1968年から開始された海洋掘削科学は，深海掘削計画（DSDP：Deep Sea Drilling Project）から国際深海掘削計画（ODP：Ocean Drilling Program）へと引き継がれ，2003年からは日本が建設したライザー掘削装置を装着する地球深部探査船「ちきゅう」が参加し，統合国際深海掘削計画（IODP：Integrated Ocean Drilling Program）が開始した．そして現在は国際深海科学掘削計画（IODP：The International Ocean Discovery Program）へと移行し，海洋掘削科学は48年目を迎えた．

「ちきゅう」の深海掘削への参加は21世紀の開始時期であったため，今世紀の地球科学を担う船として大いに期待されてきた．1997年に東京で開催されたCONCORD（Conference on Cooperative Ocean Riser Drilling）は，ライザー掘削によってのみ実現可能な科学目標を設定し，技術問題を検討する作業であった．このCONCORDで設定された目標の1つとして「巨大海台の成因と地球環境への影響の解明」が挙げられた．

巨大海台は海洋底に存在する大規模火成区（LIPs：Large Igneous Provinces）である（Coffin and Eldholm, 1994; 佐野, 1999; 佐野ほか, 2004; Ernst, 2014）．これに対し，大陸に形成したLIPsは大陸洪水玄武岩として知られている．LIPsの定義に関しては，次章で解説するとして，これはマ