Formation of two oceanic large igneous provinces in the western Pacific Ocean

*Takashi Sano[1]

1. National Museum of Nature and Science

Oceanic plateaus are mostly submarine large igneous provinces (LIPs), representing an immense transfer of magma from mantle to crust. Many of the oceanic plateaus were formed during Cretaceous periods, suggesting these eruptions were part of an episodic magmatic outbreak related to mantle convection. LIPs therefore provide windows into those regions of the mantle which do not generate normal mid-ocean ridge basalt.

With their large volumes, oceanic plateaus seem simply explained by a massive thermal plume and consistent with the emergence of a plume head, a large volume of buoyant hot material formed by the detachment of a nascent plume from a thermal boundary layer. This boundary layer is usually assumed to be the core-mantle boundary, where the thermal contrast could cause a large volume of material to detach from the boundary layer and rise through the mantle over a period of millions of years. When this plume head arrived at the base of lithosphere, spread our and underwent adiabatic melting, the LIPs would be formed. This hypothesis makes some important predictions: the plume head should emplace a large volume of volcanic material in a short period of time (~1-2 Mys), the buoyant plume head should cause significant (~1-3 km) initial uplift, the magma source temperature should be distinctly higher than at spreading ridges, the rising plume should carry primitive lower mantle material to the surface.

In order to examine the plume head model, two oceanic LIPs, Ontong Java Plateau (OJP) and Shatsky Rise, were drilled in the first decade of the 21st century. Coring data from the two LIPs show that basement rocks are characterized by massive sheet flows, similar to flows on continental flood basalts. ^{40}Ar-^{39}Ar data of the cored basements show that durations of magmatic activity of the two LIPs are longer than the prediction of the plume model; minor episodes ranging from 90 to 44 Ma are present for the OJP volcanism, although the major episode occurred at ~122 Ma, and a long hiatus of ~10 Myr separates the final massive flows for Shatsky Rise. Petrological data estimate that the temperature of the magma source (i.e., potential temperature) is ~300 °C higher than ambient mantle for the OJP and ~150-200 °C higher for the Shatsky Rise, but these temperatures are lower than those predicted based on the plume model (>400 °C). Geochemical data show that lavas from the two LIPs are variably enriched, implying the plume origins for their magma source. However, obvious plume signatures (e.g., lower mantle signature with high $^{3}He/^{4}He$) are not confirmed for volcanic products from both LIPs. Likewise, some lava compositions suggest the involvement of subducted slab materials in their magmatic source. Furthermore, subsidence after the emplacement of the two LIPs is lower than that predicted by a thermal plume model. Recent investigations therefore show that a simple thermal plume model cannot explain the magma genesis of the two LIPs, and more complex (e.g., thermochemical) models should be introduced. Recent ocean drilling investigations have improved our understanding, but further work is required to constrain the underlying nature and source of LIP volcanism.

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