Isotopic variations along the Southwest Indian Ridge, 30-50°E

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Isotopic studies of MORB (Mid-Ocean Ridge Basalt) have established the existence of a vast domain in the Indian Ocean where $^{206}Pb/^{204}Pb$, and $^{143}Nd/^{144}Nd$ ratios are lower, but $^{208}Pb/^{204}Pb$, $^{207}Pb/^{204}Pb$, and $^{87}Sr/^{86}Sr$ ratios are higher, than those of the Pacific and Atlantic Oceans (north of 25°S). In this domain, the Southwest Indian Ridge records a gradual, but irregular isotopic transition in the MORB source mantle from typical Indian-ocean type composition to the east and Atlantic like ones to the west of 26°E. Here, we present double spike high precision Pb-isotope and Sr-Nd-Hf isotope data for both basaltic glasses and basalts, dredged along the Southwest Indian Ridge (SWIR) between 30° and 50°E during the SWIFT cruise.

All samples from this ~2000 km section of the SWIR possess Nd-Pb-Sr isotopic signatures typical of Indian MORB. New analyses for lavas from the 39-41°E section, identified previously as exhibiting the most extreme DUPAL signature extend the previous range in $^{206}Pb/^{204}Pb$ (16.585-18.426) and $^{176}Hf/^{177}Hf$ (0.282880-0.283191) to some of the lowest values yet found among spreading centres worldwide. Modelling shows that the low $^{206}Pb/^{204}Pb$ and $^{176}Hf/^{177}Hf$ ratios from 39-41°E section cannot be accounted for by contamination of the upper mantle through recycled oceanic components (crust+sediment). The linear array defined by these lavas in ^{207}Pb-^{204}Pb-^{206}Pb-^{204}Pb intercepts the Pb crustal evolution curve at ~1.2 Ga similar to the mid-Proterozoic age of the lithosphere of southern Madagascar. The combined isotopic systematics suggest binary mixing between depleted mantle and a component of ultimate origin in the continental crust or mantle lithosphere. This component may have been thermally eroded by Marion plume when it lay beneath Madagascar some 90 m.y. ago.

The extreme isotopic compositions exhibited by lavas from the 39-41°E segment of the SWIR represent a local mantle heterogeneity with a localized explanation, and are separated from understanding the ocean-wide isotopic character of the Indian Ocean mantle.

Direct observation of immiscible fluids using X-ray radiography

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Revolutionary New Technique

The new method for the direct observations of immiscible fluids has been developed using X-ray radiography technique (Kanzaki et al., 1987) together with Kawai-type multi-anvil high pressure apparatus (SPEED-1500) installed at BL04B1, SPring-8, Japan. Hydrous Sr-plagioclase and hydrous CFMAS-basalt systems are used as starting materials. We developed a new sample container, which is comprised of a metal (Pt or AuPd) tube and a pair of single crystal diamond lids put on both ends of metal tube. The sample, which is put inside of the container, can directly be observed through the diamond lids and an aperture of the metal tube. The experimental conditions are at pressures of 3 to 6 GPa and at temperatures up to about 1400°C. Pressure is applied first, and then temperature is increased slowly.

Results

At around 800-900°C and 3 GPa in both systems, we observed some light-gray spherical bubbles moving upward in the dark-gray matrix. The light-gray spherules that absorbed less X-ray are considered to be aqueous fluid phase, whereas the dark-gray matrix is silicate melt. At least up to 1400°C in hydrous Sr-plagioclase system and 1200°C in hydrous system, immiscible two phases (i.e., both aqueous fluid and silicate melt) were observed at 3 GPa. One preliminary experimental result at 6 GPa in hydrous basalt system showed that there appeared no bubbles up to 1000°C.

Conclusion

Our new technique could be applied to the direct observations of various kinds of 2-fluids coexisting under deep mantle conditions.

References

Kanzaki, M., K. Kurita, T. Fujii, T. Kato, O. Shimomura, and S. Akimoto, (1987), In High Pressure Res. In Mineral Phys., AGU, 195-200.