論文内容の要旨

論文題目：

Petrological studies on boninitic, adakitic, calc-alkalic, tholeiitic and MORB-like volcanic rocks dredged from the Bonin (Ogasawara) Ridge forearc seamounts: Varied magmatic evolutions of an early stage island-arc

（小笠原海嶺前弧海域産ボニナイト質、アダカイト質、カルクアルカリ質、ソレアイト質及び中央海嶺玄武岩質火山岩の岩石学的研究：初期島弧火山活動のマグマの進化とそのメカニズム）

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The most representative volcanism of Paleo-Izu-Bonin-Mariana (IBM) are subduction-related boninitic, tholeiitic and calc-alkaline magmatism taken place from Eocene to early Oligocene in the west Pacific region. The boninitic rocks are recovered from a wide area along the Izu-Bonin-Mariana ridge forearc, and show the oldest ^{39}Ar-^{40}Ar age around 50-45 Ma among all reported IBM volcanic rocks. Petrologists generally supposed that the boninite occurred in the initial stage of Paleo-IBM subduction zone. The source mantle of boninite should be considerably more refractory than the source for MORB or typical island-arc tholeiitic basalts. The boninite could be produced by partial melting of a refractory peridotite, in which, the injected hydrous fluids / melts decreased the solidus temperature of refractory peridotite and caused the partial melting in a subduction environment characterized by very high temperatures (1150-1350℃) at shallow levels (<50 km depth) (Crawford et al., 1989; Pearce et al., 1992; Taylor et al., 1994). However, the mass balance estimation of the varied source mantle compositions and subduction-related fluid/melt components for producing the boninite and tholeiitic basalt, including the chemical compositions and the partial melting degrees of the source mantles, the chemical compositions and the total influx amounts of the fluids/melts generated by dehydration or partial melting of the subducted oceanic crust at different P-T conditions, are still unsettled. The tectonics mechanisms about how subduction was initiated, how the boninite magmatism transferred to tholeiitic magmatism, are also not clear.

During KH84-1-7, KH03-3, KT04-28 and KH05-1-5 cruises, varied volcanic rocks, including MORB-like basalts, Island arc type tholeiitic basalts and calc-alkali andesites-dacites, low Ca and high Ca boninites, adakitic high Mg andesites-dacites, calc-alkali high Mg andesites-hornblende dacites were collected from the Bonin Ridges forearc seamounts.

MORB-like basalts were firstly recovered from Bonin Ridge forearc seamounts. These basalts are very similar to the West Philippine Basin basement basalts (ODP Leg 195 Site 1201D) in petrographic and geochemical characteristics. By geochemical modeling calculation, the MORB-like basalts could be generated by 10 -12 wt % perfect fractional melting from original mantle of the West Philippine Sea Plate without any subduction component influx. It is the most potential that the MORB-like basalts are old residual segments of the West Philippine Sea Plate oceanic crust before the Paleo-IBM arc-related magmatism.

The high Ca and low Ca boninites dredged from the Bonin ridge forearc seamounts are very similar to the boninites sampled from the Chichijima Islands. By geochemical modeling calculations, the boninitic melt could be derived from partial melting of depleted source mantle with influx of slab melt. The depleted source mantle was a residual mantle which had been extracted 10-12 wt % MORB melt from original mantle of the West Philippine Sea Plate. The injected slab melt were generated by partial melting of subducted Oceanic crust at 4GPa and 1000℃ conditions in subduction zone. The total slab melt injected into depleted source mantle is ranging from 0.5 – 2.1 wt %. The low Ca boninite and high Ca boninite have similar depleted source mantle. However, the partial melting degrees of depleted source mantle for producing low Ca boninite magma are very high, ranging from 15 % to 30 %; on contrast, the partial melting degree for producing high Ca boninite magma are low, ranging from 5 % to 10 %.

Adakitic high Mg andesites and dacites were firstly recovered from Bonin Ridge forearc seamounts. Adakitic high Mg andesites contain extremely high Sr contents and low Y contents. In N-MORB normalized trace element patterns, adakitic high Mg andesites show strongly enriched in LREE respect to MREE, and much depleted in HREE like to typical adakitic rocks; however, the marked positive anomaly in Zr and Hf relative to Sm is similar to boninites. By geochemical modeling, the adakitic high Mg andesite also could be derived from partial melting of depleted mantle with influx of slab melt. The depleted source mantle for producing adakitic high Mg andesites is similar to source mantle producing the boninite, which is a residual peridotite undergone 10-12 wt % partial melting to extracted MORB melt from the original fertile mantle of the Philippine Sea Plate. After that, the depleted source mantle was injected by a greater quantity of slab melt than producing the boninitic magma (the total ratio of slab mass injected is close to 7 wt %). Then, the adakitic high Mg andesitic melt were generated by nearly 20 wt % partial melting of the depleted source mantle reacted with felsic slab melt. In adakitic high Mg andesites, olivine and chromian diopside xenocrysts present the geochemical characteristics of former residual peridotite. In the core of chromian diopside xenocrysts, bronzite and pargasite lamellae were crystallized accompanying with Si-rich glass inclusions. The Si-rich glass inclusions are characterized by adakitic-boninitic features in trace elements compositions, like to bulk rock. The bronzite and pargasite exsolution lamellae and glass inclusions in chromian diopside xenocrysts are the direct evidences of reaction between the slab-related adakitic melt and depleted mantle peridotite. The glass inclusions may be the primary melts derived from these reaction events.

The island-arc tholeiitic basalts dredged from the Bonin forearc seamounts are very similar to the tholeiitic basalts exposed on the Hahajima Island in geochemical compositions, but contain lower Sr contents than the Hahajima Island’s basalts. By geochemical modeling calculations, the low Sr tholeiitic basalts and high Sr tholeiitic basalts are resemble that these rocks could be generated by 15-20 wt % partial melting from original mantle of the West Philippine Sea Plate with injecting 1.2-3.0 wt % slab fluid derived at 6GPa, 800℃ dehydration condition in subduction zone. The high Sr tholeiitic basalts of Hahajima Island show younger ^{39}Ar-^{40}Ar age than the representative boninites in the Bonin Ridge. However, the massive low Sr tholeiitic basalts pillow lava present in the lowest section below the boninitic volcanic rocks units in Mariana forearc DSDP Leg 60 Site 458 core sections. The low Sr tholeiitic basalts of Site 458 resemble the low Sr tholeiitic basalts dredged from the Bonin ridge seamounts in geochemical features. Although there has not been any measured ^{39}Ar-^{40}Ar ages about the low Sr tholeiitic basalts, it is reasonable to suppose that the low Sr tholeiitic basalts may be older than boninites in all arc-related volcanic rocks of Paleo-IBM island-arc. The high Sr tholeiitic basalts and low Sr tholeiitic basalts show resemble P-T conditions of magma generation in subduction zone, but high Sr tholeiitic magmatism occurred after the boninite magmatism.

The calc-alkali high Mg andesite-hornblende dacite dredged from the Boninite seamount in the Bonin forearc region are very similar to the calc-alkali high Mg andesite-hornblende dacite collected from the Chichijima Island Mikazukiyama Formation in petrography and geochemical characteristics. The most interesting discovery about the distinctive mineral features of calc-alkali high Mg andesites-hornblende dacites is the co-existing of bronzite and hypersthene crystals, which contain different Mg compositions in cores. Bronzite crystals have high Mg contents (Mg# = 0.87) as same as the bronzite crystals in boninites, and presenting thin low-Mg rim. On the other hand, some hypersthene crystals exhibit very thin high-Mg rim. The hypersthene crystals (Mg# = 0.65) are very similar to the hypersthene which are the commonest mineral phase in the tholeiitic basalt and calc-alkali andesite-hornblende dacite of the Hahajima Island. The potential petrogenesis about the calc-alkali high Mg andesites-hornblende dacites is the magma mixing between the boninitic magma and the Hahajima Island type calc-alkali hypersthene andesitic-hornblende dacitic magma.

The most important result about petrological studies mentioned above is that the boninites and adakitic high Mg andesites could be produced by the partial meting from depleted source mantle of the Philippine Sea Plate, which had extracted MORB melt in former inter-ridge stage and then enriched with slab melt derived from a new subduction environment characterized by high temperature at shallow depth. According to the slab thermal structure (Iwamori, 2006) and the phase diagram of MORB + H_2O and peridotite + H_2O system (Maruyama and Okamoto, 2006), the slab melt only can be generated by the partial melting of subducted young oceanic crust (< 2 Ma). Although now that the tectonic evolution of the Western Pacific during the Eocene is not clear, the boninites and adakitic high Mg andesites are the best evidences to demonstrate the existence of an active ridge which was subducting beneath the West Philippine Sea Plate around 50-45 Ma. Because boninite magmatism and the abrupt change of the Pacific plate motion took place nearly at the same time (around 50 Ma) in the west Pacific, one possibility is to assume that the subduction of active ridge caused the abrupt change of the Pacific plate motion from NNW to NW. In this model, the low Sr tholeiitic basaltic magmatism were prior to the boninite magmatism, derived from a former old and cold slab subduction before the ridge approached the trench. When the ridge began to subduct and boninite magmatism occurred. After the boninite magmatism, younger high Sr tholeiitic magma was generated, because a low temperature slab subducted again. Another possibility can be assumed that the abrupt change of the Pacific plate motion caused the initiation of subduction along transform zone in a ridge-transform system. The boninite magmatism was occurred following the initial subduction (Casey and Dewey, 1984; Pearce et al. 1992). In this model, the boninite magmatism is the oldest volcanism in initial subduction zone. After the boninite magmatism, no slab melt was generated due to the low temperature of older slab that subducted. Then, the tholeiitic volcanism became dominant by partial melting of a fertile original mantle with injected slab fluid from the deep position of subduction zone.