博士論文

フィリピン海南部パレスベラ海盆ゴジラメガムリオンに産する斑れい岩類の岩石学的研究

Petrogenesis of the gabbroic rocks from the Godzilla Megamullion, an oceanic core complex in the Parece Vela Basin, Philippine Sea

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Abstract

The aims of this study are to describe the petrographic, mineralogical, and geochemical characteristics of gabbroic rocks occurring in the Godzilla Megamullion located in the Parece Vela back-arc basin in the southern Philippine Sea, to discuss the petrogenesis of these gabbros, and to describe the tectonic and magmatic evolution of the Godzilla Megamullion.

An oceanic core complex (OCC), also called a megamullion, is a unique bathymetric feature characterized by an elevated dome-like structure developed at a ridge-transform intersection of an extinct slow-spreading ridge system. It is considered that OCC was formed by development of detachment faults rooted to upper mantle and OCC has attracted high attention from petrologists since lower crustal and mantle rocks are widely exposed at seabed of OCC regions. OCCs have been identified at various slow-spreading ridges and are thought to be an important feature for understanding the plate tectonic evolution of Earth's ocean floor. Recently, many OCCs have been found at the Mid Atlantic Ridge (MAR) and the Southwest Indian Ridge (SWIR). Several OCCs have also been discovered in the Parece Vela back arc basin in the southern Philippine Sea (Ohara *et al*., 2001). In this basin, the Godzilla Megamullion, the largest OCC in the world, is located at a ridge-transform intersection of a slow-spreading ridge at 15–16.5° N, 138.5–139.5° E. It extends for 55 km along the spreading ridge and is 125 km wide perpendicular to the ridge.

This study examines the petrological and geochemical characteristics of gabbroic rocks recovered from six dredge sites during cruises KR03-01 (*R/V Kairei*; sites D06, D09, and D10) and KH07-02 (*R/V Hakuho-maru*; sites D14, D18, and D25), three ROV dive sites during cruise YK09-05 (*R/V Yokosuka* and the submersible *Shinkai 6500*; dives 6K#1140, 6K#1141, and 6K#1147), and five dive sites of cruise YK11-08 (*R/V Yokosuka*, the submersible *Shinkai 6500*, and ROV survey; dives 6K#1270, 6K#1275, 6K#1276, YKDT#115, and YKDT#116).

Compared with petrological data of rocks reported from other OCC's, such as the Kane Megamullion, the Atlantis Massif in MAR, and the Atlantis II Fracture Zone in SWIR,

the gabbroic rocks of the Godzilla Megamullion are characterized by higher abundances of amphibole and iron oxide minerals and lower modal compositions of olivine.

The studied rocks show extensive variation in whole rock composition. Low modal abundance of olivine and high abundances of amphibole and iron oxide minerals are characteristic features of the majority of the gabbroic rocks recovered during the cruises. The studied gabbroic rocks are classified into troctolite, olivine gabbro, gabbro, hornblende pyroxene gabbro, pyroxene hornblende gabbro, hornblende gabbro on the basis of the classification by Streckeisen (1976). The chemical compositions of mineral constituents in the rocks show systematic variations that are indicative of magmatic differentiation. Anorthite content in plagioclase, #Mg (Mg/ (Mg + Fe) value in olivine and clinopyroxene decrease from less differentiated to highly siliceous evolved rocks. The whole rock compositions indicate that troctolite is the most primitive variety and that trondhjemite is the most differentiated variety in the Godzilla Megamullion.

Based on the geochemical and petrological characteristics of the gabbroic rocks, the rocks were classified into five types. Type-1 is cumulate rock characterized by highly depleted large ion lithophile (LIL) and high field strength (HFS) elements. This type includes troctolites, olivine gabbros and gabbros, and hornblende pyroxene gabbros and pyroxene hornblende gabbros. Type 2 is gabbro characterized by relatively high contents of LIL elements and SiO_2 higher than 52 wt. %. It includes pyroxene hornblende gabbros and hornblende gabbros. Type 3 is characterized by high concentrations of LIL elements and Ti and SiO_2 less than 52 wt. %. The rocks of this type are enriched in iron oxide minerals. Type 3 includes hornblende pyroxene gabbros, pyroxene hornblende gabbros, and hornblende gabbros. Type 4 rocks are characterized by relatively enriched LIL elements. They show flat MORB normalized trace elements patterns similar to those of basalt recovered from the Godzilla Megamullion. This type is fine-grained gabbroic rock, which is interpreted as a less differentiated variety and probably represents the most primitive basaltic magma composition in the studied region. Type 5 is trondhjemite.

Troctolite, olivine gabbro and gabbro were recovered only from the distal parts (WLR and ELR) of the Godzilla Megamullion. An age of ~13 Ma has been reported from this region. On the other hand, trondhjemite was recovered from the medial (WHR) and proximal (WAR) parts of the megamullion, from which ages of 11 and 8.7 Ma, respectively, have been reported. Gabbroic rocks with relatively primitive composition were recovered from the Neck Peak region, where a younger age of 8.4 Ma has been reported

The spatial and temporal distribution of gabbroic rocks in the Godzilla Megamullion suggests a higher degree of partial melting for the early stage magmatic activity at its distal part and a lower degree of partial melting for the later stage magmas developed at its proximal part.

The differentiation processes of the studied rocks were evaluated with the "MELTS" program. The processes were also tested with mass-balance calculations by employing whole rock compositions, modal mineral abundances, and chemical compositions of mineral constituents of the studied rocks. In the MELT modeling, a basaltic glass composition (YK11-08 6K#1275R07) was employed as the starting composition. The physical conditions used in the modeling were the following: fO_2 was defined by the quartz-fayalite-magnetite (QFM) buffer, pressure was 1500 bars, and temperature ranged from 1220 to 900 °C. The modeling was carried out with the starting composition and various amounts of water (0.00 to 2.0 wt. % H_2O). Mineral compositions obtained from the "MELTS" modeling were comparable to those observed in the studied gabbroic rocks.

The "MELTS" modeling suggested that the whole rock compositional variations in the gabbroic rocks are well represented by fractional crystallization processes of a primary magma comparable in composition to the olivine basalt recovered from the Godzilla Megamullion. The results suggest that the type 1 gabbros could have been generated by crystal accumulation in a primary magma with 0.02 wt. % H_2O added at a temperature of 1210 ~ 1120 °C. Residual melts derived from a primary magma with 0.5 wt. % H_2O added could have produced the type 2 gabbros at temperatures ranging up to 1140 °C. The type 3 gabbros could have been generated from residual melts derived from a primary magma with 0.02 wt. % H_2O added at temperatures ranging up to 1180 °C. The mass balance calculations suggest that the type 5 trondhjemite was generated by anatexis of a gabbroic source composition comparable to the hornblende pyroxene gabbro or pyroxene hornblende gabbro.

The modeling suggests that early stage (~13 Ma) troctolites and olivine gabbros in the WLR and ELR were formed by accumulation of early-crystallized minerals at relatively higher temperatures. It also suggests that the type 3 deformed gabbros were crystallized from residual gabbroic melts formed by crystal fractionation of a basaltic primary magma. The data indicate that the type-1 and type-3 rocks represent a large volume of basaltic magma formed by a higher degree of partial melting of source mantle. The data also suggest that the gabbroic rocks in the WHR represent early stage (11 Ma) magmatic products of the WLR and ELR. The majority of these WHR gabbros show deformed texture. The modeling also suggests that

the gabbroic rocks were derived from melts generated by a relatively lower degree of partial melting of mantle source. The gabbroic rocks with an age of ~8.7 Ma in the WAR have highly differentiated mineral assemblages and bulk compositions. The hornblende pyroxene gabbros in the WSR contain plagioclase crystals with relatively high anorthite content, indicative of less fractionated magmatic activity, and represent the latest magmatic activity (~8.4 Ma) in the Godzilla Megamullion.

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