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学位授与の題目	Geology, petrology and geochemistry of ultramafic and mafic rocks from the Isabela ophiolite, Philippines (フィリピン、イサベラオフィオライトの超苦鉄質岩および苦鉄質岩の地質学・岩石学・地球化学的研究)
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### 要約

The Isabela Ophiolite is a Cretaceous ophiolite exposed at the northeastern margin of north Luzon, in the Philippines. Petrological and geochemical characteristics of the peridotites suggest that it is made up of a continuous mantle section derived from a slow-spreading midocean ridge. The ophiolite is classified as transitional ophiolite subtype. Occurrence of plagioclase peridotite and discordant dunite in the Isabela ophiolite is attributed to extensive mantle rock and melt interaction in a fossil melt conduit through the fertile part of the mantle. Chromitite trains formed from peridotite-melt and pyroxenite-melt reactions shows a difference in associated mineral assemblage. Two basalt units with varying ages also showed variation in geochemistry. Occurrences of the discordant dunites and different basalt units have important implications in the tectonic history of the Isabela ophiolite.

### 学位論文要旨

The Isabela Ophiolite is a Cretaceous ophiolite exposed at the northeastern margin of north Luzon, in the Philippines. This study initially presents the overall petrological and geochemical characteristics of the Isabela ophiolite, with emphasis on the mantle section. The nature of plagioclase peridotites, discordant dunites and the pillow lavas are discussed in later sections.

Field investigation in three areas [Dinapigui (south), Palanan (central) and Divilacan (north)] of the Isabela ophiolite massif revealed both massive and layered peridotites. Lherzolite and clinopyroxene-rich harzburgite with primary porphyroclastic texture are generally the dominant rock-types, especially in the southern portion. Harzburgite, dunite and pyroxenite are also found in lesser amounts. In the northern portion, harzburgite (with secondary texture) becomes more dominant. The size and abundance of dunite and gabbroic veins also increase in the northern part. Chromitite deposits were also noted in both the southern and northern localities.

Compiled spinel compositions from dominant peridotites in the three areas show compositional similarity to abyssal peridotites. The samples encompass the entire field of abyssal peridotites defined by Dick & Bullen (1984) using spinel chromium (Cr#) and magnesium (Mg#) numbers. Samples from the south generally have the lowest spinel Cr# whereas northern samples have the highest Cr#. Clinopyroxene rare earth element (REE) compositions of representative samples all exhibit typical mid ocean ridge (MOR) peridotite REE patterns, with flat heavy to middle-REE followed by depletion in light-REE. Representative samples also encompass the entire field of abyssal peridotite clinopyroxene-REE compositions defined by Kelemen *et al.* (1995). This suggests that the southern part have more fertile peridotites compared to the central and northern areas.

Petrology and geochemistry of primary mantle minerals suggests that the Isabela ophiolite 1) is dominantly composed of fertile lherzolites and clinopyroxene-rich harzburgites, 2) is probably derived from a MOR environment, and 3) shows a continuous mantle section, with the southern part representing the lower and the northern part representing the upper part of the mantle column. Fertile lherzolites from Dinapigui could represent the deeper part of oceanic lithosphere that is usually absent in most ophiolites. Overall character suggests derivation from a slow-spreading ridge. A transitional ophiolite sub-type classification is proposed for this ophiolite unit.

Plagioclase lherzolite is not common in the Isabela ophiolite. One outcrop showed plagioclase segregations occurring in a sub-planar pattern cutting the foliation of the host lherzolite. Spinel along the plagioclase-rich zone show heterogeneity, suggesting interaction with melt and/or melt extraction. Primary clinopyroxenes also show evidence of reaction with melt. This plagioclase lherzolite occurrence represents the incipient stage of dunite-channel formation, where the lherzolite is just beginning to react to, or form melt extracts. On the other hand, the plagioclase-dunite float represents the final product of mantle rock and melt interaction. Here, pyroxenes are completely dissolved and olivine is re-crystallized, with plagioclase, clinopyroxene and amphibole crystallizing from stagnated interstitial melt left after olivine re-crystallization.

Abundance of discordant dunites with replacive nature is noted in one area in the Dinapigui. Clinopyroxene-rich harzburgite and harzburgite with very residual composition host the discordant dunites. Extensive wall rock and melt interaction could explain the occurrence of very residual peridotites in a fertile peridotite-dominated area. This area could represent a major melt conduit in one stage of the ophiolite evolution. Intrusion of these discordant dunites is one of the latest events that took place. Its replacive nature suggests that the peridotite was intruded at low pressure and not at mantle conditions. This has important implication in origin and timing of chromitite deposition. Chromitite trains that formed from the replacive reaction between melt and peridotite are usually associated with olivine. In comparison, chromitite that formed from the reaction between melt and pyroxenite has chromitite+olivine+clinopyroxene mineral assemblage. The reaction process between melt and pyroxenite is illustrated

here.

Comparison between two basalt units did not only show difference in age (as suggested by previous work) but also in composition. Both have nearly the same heavy REE composition but the younger Late Cretaceous basalts have enriched light REE compared to the older Early Cretaceous one. Although both show MOR characteristics, simple fractionation cannot explain this pattern, which may imply a change in magma source condition or tectonic setting.

## 学位論文審査結果の要旨

エリック・アンダル君の提出論文および、平成17年7月26日の口頭発表をもとに審査委員会を開催し、以下の結論を得た。アンダル君は、フィリピン、ルソン島北東部にあるイサベラ・オフィオライトを研究した。フィリピン諸島は変動の激しい島弧として知られており、数多くのオフィオライトが存在する。同オフィオライトは辺境の地にあり、情報のもっとも乏しいものであった。アンダル君は同オフィオライトが低速拡大軸で生成された海洋リソスフェア（主としてマントル部分）の断片であることを明らかにした。また、マントル中の上下方向の組成変化に由来するかんらん岩の性質（特に部分溶融度）の違いを見いだした。特筆すべきはオフィオライト最南部に露出する「極めて部分溶融度の低いかんらん岩」の発見であろう。これは現在の海洋底で得られるどのかんらん岩よりも部分溶融度が低く、現在の技術ではサンプリングできない、海洋リソスフェアの比較的深部を代表している物質の可能性がある。すなわち、海洋底研究におけるオフィオライトの利点を鮮やかに示すことに成功した。これ以外に、随伴する玄武岩、ダナイト、斜長石かんらん岩、クロミタイトなどの研究からオフィオライトの形成環境の多様性も示すことに成功している。アンダル君の成果は、海洋底のマグマ活動の解明やオフィオライトの成因問題などに対する寄与が極めて大きいと判断される。よって、本審査委員会は全員一致で、本論文がアンダル君に博士（学術）の学位を与えるのにふさわしいものと判断する。