学位報告４

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主　論　文　の　要　旨

論文題目　Petrological and geochronological study of high-temperature Mogok metamorphic rocks, central Myanmar
(ミャンマーに産する Mogok 高温変成岩類の岩石学的，地質年代学的研究)

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論　文　内　容　の　要　旨

The Mogok metamorphic belt is one of the important regional metamorphic belts of Southeast Asia, belonging to the great Sundaland, which forms the present Southeast Asia landmass. The Mogok metamorphic belt has been documented mainly in terms of its structural geology and geochronology, but the results of petrological studies have been published infrequently. Therefore, the author has tried to provide additional petrological data for the study of the Mogok metamorphic belt.

The author studied the Sagaing ridge, which is west of Mandalay in central Myanmar, and the Minwun ridge for comparison. The main purposes of the study are as follows:

(1) Conduct studies on the petrological and mineralogical characteristics of the Mogok and related metamorphic rocks;

(2) Estimate pressure/temperature (P/T) conditions of metamorphic rocks in the Sagaing and Minwun ridges and compare them; and

(3) Estimate the metamorphic age of the Mogok rocks using the chemical Th–U–Pb isochron dating method (CHIME) to determine the metamorphic P/T trajectory and time at which metamorphism occurred.

Myanmar (Burma) is geologically divided into western and eastern provinces, which are bordered by the 1200 km long north–south trending, right-lateral, strike-slip Sagaing fault. The western province is also called the Burma microplate and is bordered by the Andaman subduction zone on its western margin (Mitchell et al., 2007). The eastern province is a part of the Sibumasu block of the Asian plate. In the Sagaing area of the Mandalay region, gneissose rocks occur on the eastern side of the Sagaing fault, whereas schistose rocks occur on its western side.

The Sagaing ridge, which is 2–3 km in width and 40 km in length, is situated on the eastern side of the Sagaing fault. This ridge belongs to the Mogok metamorphic belt, and its eastern side is unconformably covered by Late Neogene sedimentary lithology in the form of conglomerate, sandstone, and mudstone. The main rock types of the Mogok metamorphic belt of this ridge are gneiss, marble, calc-silicate rock, schist, and amphibolite. The garnet–biotite–plagioclase–sillimanite–quartz assemblage and its partial system suggest equilibrium P/T conditions of 0.65–1.1 GPa/780–950 °C for the peak metamorphic stage and 0.3–0.5 GPa/600–680 °C for the exhumation and hydration stage. Biotite grains in the Sagaing pelitic gneisses coexist with rutile and/or ilmenite, contain high TiO_2 content up to 6.2 wt% [0.34 per formula unit (pfu) for O = 11], and show high temperature conditions up to 700–800 °C, based on the calibrations proposed by Henry et al. (2005). The zirconium contents of the rutile grains vary depending on their (1) grain size, (2) mode of occurrences, such as isolated grains and/or intergrowths with ilmenite, and (3) the minerals (biotite or feldspar/quartz) that host the rutile. Zirconium contents of the rutile reach 3600 ppm, and a Zr-in-rutile geothermometer calibrated by Tomkins et al. (2007) gives temperature conditions of 700–900 °C, assuming P = 0.8 GPa for isolated rutile grains hosted by aggregates of feldspar and quartz. The intergrowth rutile grains hosted by feldspar and quartz also give higher temperatures up to 870 °C. Fine-grained isolated or intergrowth rutile grains, which mostly occur as inclusions in biotite, have relatively lower temperature conditions of 600–770 °C. These P/T conditions, estimated by conventional geothermobarometers and empirical geothermometers, suggest extensive distribution of upper amphibolite and granulite facies in the metamorphic rocks in the Mogok metamorphic belt of central Myanmar. Pseudosection analyses of garnet-bearing pelitic gneisses also imply high temperature equilibrium under the upper amphibolite and granulite facies conditions. The Zr-poor fine-grained rutile in biotite is considered to be exsolved during the exhumation phase.

Some rutile grains show strong a zonal structure, having Nb_2O_5-rich cores up to 3.7 wt%. Such Nb-rich parts also contain trivalent cations and suggest a coupled substitution of (Nb, Ta)(Al, Cr, V, Fe)Ti_{-2}. Some rutile grains included by ilmenite are in a solid/solid solution of $Fe^{3+}_{4}\square_{-1}Ti_{-3}$, where $\square$ represents a vacant site.

The Minwun ridge, a narrow 7 km long and 0.4 km wide zone, is situated on the western side of the Sagaing fault and is covered by Miocene sedimentary lithologies on its western side. Although major lithologies of the Minwun ridge are garnet-mica schist, and talc-chlorite schist the metamorphic grade gradually increases from south to north, and amphibolite occurs at the northern end of the ridge. Garnet–biotite–muscovite–plagioclase–quartz assemblage yields equilibrium P/T conditions of 0.41–0.68 GPa/570–640 °C. The metamorphic rocks in the Minwun ridge are distinctly lower in grade than the Mogok metamorphic rocks.

Monazite grains in the Mogok metamorphic rocks show complex compositional zoning consisting of three segments—I, II, and III, according to three stages of recrystallization. Most of the monazite grains include segments II and III, and segment I is rarely observed in some grains. Segment I is characteristically higher in Y than the other segments, which implies that segment I might have formed in a garnet-absent assemblage. On the other hand, segment II is depleted in Y and probably recrystallized in a garnet-stable environment. Segment II is probably the product of the main crystallization stages and might have replaced the monazite grains forming during the segment I stage. Segment III is a fluid-aided alteration product of segment II during the latest retrograde stage, during which garnet was unstable. The calculated monazite age data (using 284 spot analyses from CHIME) indicate relatively diverse ages of four age components, suggesting mixed records for multiple growths of monazite grains. These ages were calculated as: 49.9 ± 7.9 Ma, 49.3 ± 2.6 Ma, 38.1 ± 1.7 Ma, 37.8 ± 1.0 Ma, 28.8 ± 1.6 Ma, 28.0 ± 0.8 Ma, and 23.7 ± 1.3 Ma (at the 2σ level). The Late Eocene epoch has been suggested as the peak metamorphic stage of the upper amphibolite and/or granulite facies and the Late Oligocene epoch has been suggested as the subsequent hydration stage.