南部マダガスカル，アンバトメナに産出するマグマ起源サフィリン

有馬眞[1]、木本健太[1]、R. RAKOTONDRAZAFY[2]，N. O. T. RAKOTONANDRASANA[1]，M. A. RANAIVOSON[1]，山下浩之[3]
[1]横浜国立大学,[2]アンタナナリボ大学,[3]神奈川生命の星地球博物館

Igneous sapphirine in Ambatomena, southern Madagascar

M. Arima[1], K. Kimoto[1], R. Rakotondrazafy[2], N. O. T. Rakotonandrasana[1], M. A. Ranaivoson[1], H. Yamashita
[1] Yokohama National Univ., [2] Univ. of Antananarivo, [2] Kanagawa Prefectural Museum of Natural History

Sapphirine is commonly thought to be metamorphic, and igneous sapphirine is rare. We examined the Ambatomena sapphirine-bearing intrusion of early Paleozoic age (~487 Ma [1]) in Ambatomena, southern Madagascar. The intrusion is located within the Beraketa shear zone, which is a hundreds kilometer long by tens kilometer wide mega shear zone and interpreted as a vertical lithospheric shear network probably rooted into the upper mantle [2]. The intrusion was emplaced into highly deformed leptynitic gneisses metamorphosed during the Pan-African orogeny. It is composed of coarse-grained undeformed heterogeneous rocks including high-Al-Mg rock, anorthosite, charnockite, phlogopitite, and pegmatite. The high-Al-Mg rock consists of sapphirine (spr), spinel (spl), orthopyroxene (opx), cordierite (crd) and subordinate amounts of plagioclase (pl), K-feldspar (Kfs), corundum (cor), rutile (rut), and/or phlogopite (phl). In places, the high-Al-Mg rock exhibits the interlocking texture. The subhedral corundum grains show melt-reaction coronas of spl and spr. The rocks contain abundant spr-opx symplectites and in some places crd-opx symplectites were developed. Sapphirine grains in contact with cor and spl are more aluminous than the 7:9:3 composition (up to 68 wt% Al_2O_3, #Mg=0.90-0.96). The spr-spl geothermometry [3] suggests equilibrium temperatures for the spr-spl paragenesis around 930~1060°C at 5 kb.

The Ambatomena high-Al-Mg rocks have a wide range of SiO_2 (30.1~53.2 wt%) and are characterized by high #Mg (0.81~0.92), Al_2O_3 (16.0~40.3 wt%) and MgO (19.8~24.3 wt%), and low CaO, Na_2O, and K_2O. The corundum-bearing anorthosite contains relatively low MgO (4.85 wt%) and high CaO (19 wt%). Although alkali-Mg-metasomatic processes have been proposed for the formation of Ambatomena rocks [4, 5], we proposes an alternative genetic model, suggesting that the sapphirine and associated minerals crystallized from aluminous silica undersaturated melts at high temperatures. Petrographic features indicate the following crystallization sequence; (1) crystallization of corundum from melt, (2) subsequent peritectic reaction of corundum with melt to produce spinel and sapphirine coronas, (3) reaction of spinel with melt to form orthopyroxene and sapphirine, and (4) crystallization of cordierite, plagioclase, K-feldspar, and phlogopite from residual melts. A part of this sequence [from (1) to (3)] is broadly comparable to the liquidus phase relations in the MgO-Al_2O_3-SiO_2 system reported by Taylor [6] and those in the forsterite-diopside-anorthite-silica system by Liu & Presnall [7, 8].

Liu & O,Neill [8] found a suprasolidus assemblage of spr, spl, opx, sanidine, anorthosite and melt at 1230°C and 11 kb in the experiment product of the CMASK system. Bose & Arima [10] conducted melting experiments of a natural kondalite composition and obtained melts in equilibrium with spr, spl, opx, pl, and Kfs at 950°C and 8 kb. Employing MELTS program, Sutherland et al., [11] tested the feasibility of crystallization of corundum form low-volume initial melting of amphibolite assemblages and reported that corundum appears in equilibrium with melt at 720-880°C and 7-11 kb. These data suggest that the liquidus stability fields of sapphirine and other relevant minerals (spl, opx, cor) in the AMS and CAMS systems shift toward lower temperatures and pressures by the additions of such other components as FeO, Na_2O, K_2O, TiO_2 and H_2O.

More than 90 % of major oxide contents of the high-Mg-Al rocks can be approximated by the AMS system and the rock compositions desplay a linear array in the AMS plots. When the normative compositions of the high-Al-Mg rocks are projected from the normative corundum apex onto the pl-ol-Q base of the CAMS tetrahedra, the corundum-bearing anorthosite occupies the corundum liquidus field and the high-Al-Mg rocks exhibit a linear array parallel to the ol-Q join, suggesting that the Ambatomena high-Mg-Al rocks represent cumulates involving spinel, sapphirine, corundum, orthopyroxene and cordierite derived from aluminous silica undersaturated melts. The Ambatomena intrusion was emplaced probably at middle crustal depths < 7 kb along the Beraketa shear zone.

References

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