American Mineralogist, Volume 94, pages 1520–1534, 2009

Chemical substitutions, paragenetic relations, and physical conditions of formation of högbomite in the Sittampundi layered anorthosite complex, South India

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Abstract

Layered anorthosite, chromiferous pyroxenite, and spatially associated mafic and felsic rocks of the 2.9 Ga Sittampundi layered complex (SLC), South India, underwent high-grade metamorphism at ca. 2.5 Ga and were subjected to amphibolite-facies metamorphism accompanied by intrusion of granitoid plutons during late-Neoproterozoic tectonothermal activity (0.72–0.45 Ga). During the latter event, anorthosite developed millimeter- to centimeter-thick compositional layers rich in clinopyroxene+amphibole+clinozoisite+chlorite±chromite and corundum+spinel+chlorite. Tiny grains of högbomite replaced only the grains of corundum and spinel and are in textural equilibrium with chlorite. The studied högbomite contains appreciable TiO_2 (>4.4 wt%) but insignificant NiO and ZnO. Cr_2O_3 content reaches up to 0.35 wt% only in chromite-bearing samples. Systematic partitioning of Fe and Mg between högbomite and associated Fe-Mg minerals demonstrate attainment of chemical equilibrium among these phases. Integrating textural relations and algebraic analyses of the phase compositions, several reactions were constructed involving the associated oxide phases (spinel, corundum, högbomite), calcite, and silicates (amphibole, chlorite, anorthite, clinozoisite). Interpretation of the reaction reveals that (1) Mg^{2+} and Ti^{4+} were mobile for more than 2 cm during the formation of högbomite and chlorite, and (2) chloritization of amphibole in the clinopyroxene+amphibole-bearing layers released Ti that was transported to the spinel+corundum-bearing layers to develop högbomite. Stability fields of some critical mineral assemblages in P-X_{CO_2} and T-X_{CO_2} space combined with geothermobarometry in the associated rocks tightly constrain the growth of högbomite in the presence of aqueous fluids ($X_{CO_2} < 0.15$) to the P-T range of 7 ± 1 kbar, 650 ± 50 °C. These aqueous fluids, presumably derived from the Pan-African granitoid batholiths, chloritized amphibole grains, and transported the released Ti^{4+} to the spinel+corundum-bearing layers to develop högbomite. Topological relations in isothermal-isobaric fugacity diagrams (log f_{O_2}-log f_{S_2} and log f_{O_2}-log f_{H_2O}) in the system FeO-Al_2O_3-TiO_2-O_2-S_2-H_2O-CO_2 (+MgO, Cr_2O_3) indicate that the stability and compositional characteristics of natural högbomite are strongly influenced by f_{O_2}, f_{S_2}, f_{H_2O}, and concentrations of other soluble species (Ti, Mg, Cr, etc.) in the metamorphic fluids.

Keywords: Högbomite, corundum, spinel, anorthosite, Ti-mobility, Sittampundi, South India