

Scandium silicates from the Baveno and Cuasso al Monte NYF-granites, Southern Alps (Italy): Mineralogy and genetic inferences

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ABSTRACT

A chemical and paragenetic study has been performed on Sc silicates and Sc-bearing beryl occurring in Hercynian NYF-miarolitic pink granite and granophyric leucogranite at Baveno and Cuasso al Monte, Western Southern-Alps, Italy. In the Baveno and Cuasso al Monte plutons, detailed field work allowed the discovery of a significant number of crystals of bazzite, thortveitite, scandiobabingtonite, cascandite, and jervisite representative of all the known morphological and color varieties of these minerals in the two localities. Other studied samples belong to the historic collections of the Natural History Museum of Milan.

Except for beryl, which crystallizes relatively early in aplitic granophyre, all the other Sc minerals crystallize as late-stage phases in cavities associated with fluorite. Chemical analyses reveal moderate Sc enrichment at the rim of beryl crystals. Bazzite displays a relatively large chemical variation, from “primitive” compositions enriched in Fe₂O₃ and Al₂O₃, to “highly evolved” compositions with values of Sc₂O₃ up to 17.54 wt%. Scandiobabingtonite shows a perfect inverse correlation between Fe³⁺ and Sc concentrations, suggesting complete solid solution between babingtonite and its Sc analogues. A wide variety of compositions have been determined for cascandite, significantly extending the compositional range of this mineral. In particular, the MnO content ranges from 0.37 to 4.87 wt%. The jervisite crystals analyzed in this work have rather homogeneous compositions much closer to the end-member if compared with the holotype analysis reported in literature. Thortveitite shows a wide range of compositions with variation in Sc₂O₃, Y₂O₃, HREE, and Fe₂O₃. Significant fluctuations of the Sc/Yb ratios are in agreement with similar complex variations in the ratios between REE (e.g., Y/Dy) reported in the literature for crystals of gadolinite-group minerals from the same localities.

Two different genetic models are discussed to explain the precipitation of Sc silicates as late stage phases in cavities. (1) during the latest stages of magma crystallization, HFSE and Sc were extracted from the silicate liquid and partitioned into fluids due to the complexing effect of F. Indeed, in view of the NYF geochemistry of the granite and the significant abundance of the associated F-bearing minerals, fluorides (but not other complexing agents such as carbonates and phosphates) played the major role in concentrating HFSE and Sc. In cavities, such elements resulted in a series of rare accessory phases when F was extracted from fluids because of the precipitation of zinnwaldite and fluorite. (2) HFSE, Sc, and Y+REE were mainly incorporated by gadolinite-(Y) and siderophyllite crystallizing from residual magma. Many of the accessory phases crystallized in cavities because of the aggressive effect of subcritical hydrous, F-rich fluids on the previously formed gadolinite-(Y) (liberating REE, Y, B, Be, Fe, Ca), siderophyllite (liberating Fe, Ti, and possibly Nb-Ta, Sc, etc.), and feldspars (liberating Ca, P, Cs, Ba). This second model is consistent with the widespread hydrothermal alteration of the Baveno and Cuasso al Monte granites and granophyres.