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Solubility and stability of beryl in granitic melts

JOSEPH M. EVENSEN,[1,2,*] DAVID LONDON,[1] AND RICHARD F. WENDLANDT[2]

[1]School of Geology and Geophysics, University of Oklahoma, 100 East Boyd Street, Norman, Oklahoma 73019, U.S.A.
[2]Department of Geology and Geological Engineering, Colorado School of Mines, 1516 Illinois Street, Golden, Colorado 80401, U.S.A.

ABSTRACT

Beryllium contents of granitic melts at saturation in beryl (± chrysoberyl, phenakite, or quartz) have been determined by forward- and reverse-direction experiments at 650–850 °C and 200 MPa using natural beryl or the compositionally equivalent mixture of phenakite + alumina + quartz added to metaluminous haplogranite, peraluminous haplogranite, and macusanite (a peraluminous Li, B, F, and P enriched rhyolite obsidian from Macusani, Peru). Chrysoberyl coexists with beryl ± quartz in moderately to strongly peraluminous systems (ASI approximately ≥1.05); the assemblage phenakite + beryl + chrysoberyl is stable in silica-undersaturated bulk compositions. The BeO content of the melts, which ranged between 0.03–0.40 wt%, varies principally with temperature (the solubility of beryl falls with decreasing T) and with the activity product of beryl, $(a_{BeO})^3(a_{Al_2O_3})(a_{SiO_2})^6$. Beryllia contents are lowest in strongly peraluminous and quartz-saturated haplogranite melts; however, the highest BeO content measured in glass products occurs for the strongly peraluminous macusanite at 850 °C (4016 ppm); we infer that the greater solubility of beryl in macusanite melt results from melt speciation reactions involving Li, F, B, and P. For all bulk compositions studied, the BeO content of melt projects to a narrow range of similar values at low T, near the solidus of haplogranite. Thus, metaluminous to peraluminous granitic magmas with and without common volatile and fluxing components will, if cooled to subsolidus temperatures, have similarly low BeO requirements for beryl saturation. The small BeO content of melt near the solidus of haplogranite results in a minor (10 °C) depression of the freezing point. Compared to Be-free haplogranite melt, the mean melt composition at the beryl-saturated granite minimum shifts slightly toward quartz. Beryl is common in peraluminous granitic rocks in part because lower BeO contents are required to saturate these melts in beryl, and possibly because these melts acquire higher BeO contents by mica melting reactions at their sources. Beryl is also a common constituent of border-facies assemblages in granitic pegmatite dikes, regardless of their ASI values. This early crystallization of beryl results from the low BeO content required to saturate *any* granitic melt in beryl at the low-T environments in which pegmatite dikes solidify.