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Experimental study on the solubility of zircon in boron-bearing granitic melts

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Granitic rocks associated with zircon deposits often contain notable boron, suggesting a potentially crucial role of boron in zircon mineralization. However, the influence of boron on the solubility of zircon in granitic magma remains unclear. In this study, the solubility of zircon in three granitic melts (peralkaline, metaluminous, and peraluminous) with ~6 wt% H_2O (i.e., water-saturated) and up to 7.7 wt% B_2O_3 was investigated at 800 °C and 2 kbar using a cold-seal vessel. As melt B_2O_3 content increased from 0 to 1 wt%, the ZrO_2 content increased consistently, from 2.10 to 2.60 wt% in the peralkaline melt (ASI = 0.63), from 0.20 to 0.26 wt% in the metaluminous melt (ASI = 0.98), and from 0.02 to 0.03 wt% in the peraluminous melt (ASI = 1.20). However, with a further increase of B_2O_3 to 8 wt%, the ZrO_2 content in all of the three granitic melts steadily decreased to approximately one-eighth of the maximum value. Raman and nuclear magnetic resonance spectroscopic measurements suggest that the shift in zircon solubility behavior is related to the structural of boron and oxygen. The turning point at B_2O_3 =1 wt% marks a transition from predominantly three-coordinated boron in low-boron melts, producing non-bridging oxygen favorable to Zr incorporation, to the prevalence of four-coordinated boron in high-boron melts, giving rise to bridging oxygen. The experimental results imply that the mechanism and behavior of zircon saturation can be different in magmas of different degree of evolution. In less evolved granitic magma with < 1 wt% B_2O_3, the increase of zircon solubility with increasing boron content withholds zircon precipitation until boron is removed form the melt by vapor saturation or crystallization of boron-bearing minerals. While in highly evolved magma (such as pegmatite) with > 1 wt% B_2O_3, an increase in boron content will lead to continuous crystallization of zircon and loss of zirconium from the melt. This difference could explain the observation that zirconium deposits are mainly associated with granite rather than pegmatites.