American Mineralogist, Volume 101, pages 1252–1267, 2016

SPECIAL COLLECTION: MECHANISMS, RATES, AND TIMESCALES OF GEOCHEMICAL TRANSPORT PROCESSES IN THE CRUST AND MANTLE

Zircon saturation and Zr diffusion in rhyolitic melts, and zircon growth geospeedometer

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ABSTRACT

Zircon is a ubiquitous accessory mineral in silicic igneous rocks. We have carried out new zircon dissolution experiments to refine our understanding of Zr diffusion and zircon solubility in several rhyolitic melts. Zr diffusivity depends strongly on temperature and H_2O content, and weakly on pressure and anhydrous melt composition. The diffusion data for each individual melt follows the Arrhenius relation. The dependence of Zr diffusivity on temperature, pressure, and melt composition (including H_2O content) is modeled for different rhyolitic melts in this study and for the combined literature and our data. Our data on Zr concentration at zircon saturation in silicic melts show strong dependence on temperature and weak dependence on pressure and melt composition, and are somewhat off the trend based on existing zircon solubility models. The dissolution or growth rate of a freely falling zircon crystal in a specific hydrous rhyolitic melt is modeled. The controlling factors are mostly the temperature and Zr concentration in the melt. Typical zircon growth rate in wet rhyolitic melt is 0.01 to 1.0 μm/yr. The size of zircon crystals can be used to place limit on the cooling rate of its hosting magma. The presence of large indigenous zircon crystals in Bishop Tuff requires slow cooling of the Bishop Tuff magma chamber.

Keywords: Zirconium diffusion, Zr diffusivity, zircon solubility, zircon growth, zircon geospeedometer, cooling rate, Bishop Tuff, Invited Centennial article