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Experimental observations of TiO_2 activity in rutile-undersaturated melts

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Abstract

An estimate of TiO_2 activity ($a_{TiO_2}^{melt\text{-}sat}$) is necessary for the application of trace-element thermobarometry of magmatic systems where melts are typically undersaturated with respect to rutile/anatase. Experiments were performed in the system SiO_2-Na_2O-TiO_2 to develop two independent methods of estimating $a_{TiO_2}^{melt\text{-}sat}$—one based on the commonly applied rutile-saturation technique and another utilizing a novel Ti-in-tridymite thermometer. It is demonstrated that the rutile-saturation model can lead to an overestimate of $a_{TiO_2}^{melt\text{-}sat}$ relative to TiO_2 activity calculated using the solubility of Ti in tridymite (SiO_2) coexisting with rutile. Overestimation via the rutile-saturation technique is due to variations in the solubility mechanisms of Ti in the melt phase as a function of Ti content. In natural systems, overestimates of $a_{TiO_2}^{melt\text{-}sat}$ will lead to an underestimation of crystallization temperatures by Ti-based trace-element thermobarometers. Although this study is not directly applicable to natural systems, it lays the groundwork for future research on natural composition magmas to constrain TiO_2 activity in melts.

Keywords: Thermobarometry, experimental petrology, Raman, Ti activity