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# A Zr-Hf geothermometer for magmatic zircon: New experiments and formulation

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## Abstract

We present new experimental data on $ZrO_2$ and $HfO_2$ concentration in aluminosilicate melts of wide compositional range [$M = (Na + K + 2Ca)/(Al \cdot Si)$, cation ratio, from 0.66 to 2.77] equilibrated, respectively, with zircon (Zrn) or hafnon (Hfn) at temperature 900–1473 °C. The experiments indicate nearly identical dependence of Zrn and Hfn solubility on the melt composition. A geothermometer equation: $T\ (\pm 36) = 2449/(\ln K_d + 1.704)$, where $K_d = (Zr/Hf)^{Zrn}/(Zr/Hf)^m$ is the Zr and Hf distribution coefficient between Zrn and melt ($m$), symbols of elements denote their concentration (in ppm) in zircon and melt, and $T$ is temperature in Kelvin, is derived by thermodynamic processing of the experimental data. In calculations with this equation, we accepted a constant Zr concentration in Zrn of 490 000 ppm. The commonly observed increase in Hf concentration from the cores to margins of magmatic zircon crystals may be related to fractional crystallization of zircon. For differentiated magmatic series, the initial crystallization temperature of zircon in the least silicic varieties should be evaluated using the cores of zircon grains with the highest Zr/Hf ratio. Application of the geothermometer for mafic and intermediate rocks may be hampered due to simultaneous crystallization of Zrn with other ore and/or mafic minerals relatively enriched in Zr and Hf. The newly derived geothermometer has some advantages over other indicators of the crystallization temperature of magmatic zircon based on the zircon saturation and on the Ti concentration in this mineral, as it does not depend on the major-oxide melt composition and on the accuracy of the estimated $SiO_2$ and $TiO_2$ activities in the melts. Calculations of Zr and Hf fractionation trends in the course of zircon crystallization in granitoid melts allow evaluation of the temperature at which more evolved melt portions were segregated.

**Keywords:** Zircon, hafnon, aluminosilicate melts, geothermometry, magmatic fractionation