

Zircon solubility in $\text{KAlSi}_3\text{O}_8\text{-H}_2\text{O}$ supercritical fluids

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High field strength elements (HFSEs), such as Zr, Hf, Ti, Nb, and Ta, are traditionally considered to be immobile in shallow geological processes. However, the ubiquitous presence of zircon (the major host of Zr) in high-pressure metamorphic veins and orogenic peridotites provides compelling evidence that HFSEs are transportable in subduction zones. Zircon solubility in aqueous fluids, hydrous melts, and supercritical fluids is important for understanding the HFSEs chemical transport in subduction zones. Although zircon solubility was extensively studied in aqueous fluids and hydrous silicate melts, its solubility in solute-rich fluids or supercritical fluids is poorly known. Here we experimentally determined zircon solubility in KAlSi_3O_8 ($\pm\text{K}_2\text{O} \pm \text{Al}_2\text{O}_3$) – H_2O supercritical fluids at 2–6 GPa and 800°C–1000°C, close to the slab-top conditions at sub-arc depths. The results show that zircon solubility (expressed as ZrO_2 content at zircon saturation) ranges from 65 to 6,400 ppm ZrO_2 , 10–100 times higher than that in dilute aqueous fluids; it increases with temperature, solute content, and solute alkalinity (molar K/Al ratio) but decreases with pressure. The experiments at 2 GPa show that solute alkalinity in addition to temperature and solute content exerts a primary control on zircon solubility, while the experiments at 4–6 GPa show that the negative effect of pressure on zircon solubility is offset by the increase in solute alkalinity due to the crystallization of Al-rich phases kyanite and muscovite. We suggest that high-alkali supercritical fluids during deep subduction could be significant transfer agents for Zr from the slab to the mantle wedge.