Zircon solubility in supercritical fluids and zirconium mobilization in subduction zones

WEI CHEN, XIAOLIN XIONG*, EIICHI TAKAHASHI, XINGCHENG LIU

Guangzhou Institute of Geochemistry, Chinese Academy of Sciences, Wushan, China
(*correspondence: xiongxl@gig.ac.cn)

Supercritical fluids may serve as effective agents for the transfer of Zr and other high field strength elements (HFSE) in subduction zone, yet zircon solubility investigation in such solute-rich fluids is rare. Here, zircon solubility (ZrO_2 content at zircon saturation) in solute-rich supercritical fluids in $KAlSi_3O_8$ (± K_2O ± Al_2O_3) – H_2O systems was investigated at 2.0-6.0 GPa and 800-1000°C, close to the top-slab conditions at sub-arc depths. All the supercritical fluids were quenched to hydrous glasses and thus can be analyzed using electron probe.

ZrO_2 content in the supercritical fluids increases with temperature and solute content and alkalinity (molar K/Al ratio) but decreases with pressure. At 2.0 GPa, ZrO_2 content in $KAlSi_3O_8$ – H_2O fluids (K/Al = 1.0) increases from < 100 ppm at 800-900°C and solute content < 50 wt% to 500-700 ppm at 1000°C and solute content >70 wt%. At 2.0 GPa and 1000 °C, addition of K_2O to the $KAlSi_3O_8$ – H_2O system strongly enhances ZrO_2 content to ~10000 ppm at K/Al of 1.67. Therefore, solute content and alkalinity exert primary controls on zircon solubility. At 4.0 and 6.0 GPa, the crystallization of muscovite and kyanite results in K/Al higher than 1.0 in the $KAlSi_3O_8$ – H_2O fluids and the negative effect of pressure on zircon solubility was offset and even reversed due to the enrichment of K_2O. Comparison with literature data shows that zircon solubility in solute-rich supercritical fluids is at least 10 times higher than in dilute aqueous fluids. During subduction, the fluid released from slab will become higher in solute and alkali/Al due to increasing *P-T* and formation of Al-rich residual phases. Zircon solubility and element carrying capacity of supercritical fluid thus increase with subduction depth. The experimental results not only explain zircon dissolution-redeposition in metamorphic rocks, but also zircon presence in wedge peridotites and Zr enrichment of primitive arc basalts relative to ocean-ridge basalts.