IN SITU MEASUREMENTS OF THE COMPRESSIBILITY OF PURE AND TRACE ELEMENT DOPED SYNTHETIC ZIRCON

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The ability of zircon to incorporate and retain trace elements and isotopic information makes it an indispensable tool for geochemists and geochronologists. In recent years, it has become apparent that trace element uptake is often limited mainly by mineral structure and compressibility (e.g. Blundy and Wood, Nature 1994). Understanding the uptake of trace elements into zircon therefore requires accurate knowledge of crystal-structural changes as a function of pressure, temperature, and trace element doping levels (e.g. Finch et al., Am Min 2001).

We have determined the room temperature compressibility of pure, synthetic zircon (ZrSiO$_4$) and zircon doped with around 10 wt% of (REE + P) impurities. Samples were grown from a Li-Mo flux (Hanchar et al., Am Min 2001). Room temperature unit cell volumes of powdered samples were measured in situ in a diamond anvil cell at pressures up to 30 GPa, using angle-dispersive synchrotron X-ray diffraction techniques at CHESS.

A third order Birch-Murnagahan equation of state was fitted to our data. The best fit room temperature bulk modulus for pure zircon $K = 201 \pm 1$ GPa, with $K' = 4.0 \pm 0.2$ and room pressure unit cell volume $V_0 = 260.76 \pm 0.04 \AA^3$. This bulk modulus is over 11% lower than suggested by earlier studies on natural (Hf-bearing) zircon samples (e.g. Hazen and Finger, Am Min 1979), which only covered pressures up to 4.8 GPa. In addition, we observe the start of the transformation of zircon to reidite.
(scheelite-structured ZrSiO₄) at a pressure of 19.7 GPa, over 3 GPa lower than previously measured for natural (impure) zircon (Knittle and Williams, Am Min 1993).

Results for trace element doped zircon are significantly different, with $K = 184 \pm 1$ GPa, $K' = 4.8 \pm 0.2$, and $V_0 = 263.94 \pm 0.08 \text{Å}^3$. In this case the reidite structure does not appear until $P$ exceeds 22.5 GPa. Our results suggest that trace element concentration levels may have a significant effect on the compressibility and phase transition kinetics in zircon (and by analogy perhaps in other silicates). Our measurements can be used to refine models of trace element uptake into the zircon structure, and models of zircon-melt trace element partitioning.