Zircon survival, rebirth and recycling during crustal melting, crystallization and mixing based on numerical modelling

I. N. BINDEMAN[1] AND O. E. MELNIK[2]

[1]Dep. of Geological Sciences, University of Oregon, USA (*correspondence: bindeman@uoregon.edu)

[2]Inst of Mechanics, Moscow State University, Moscow, Russia

Improved methods of geochronological dating [1] and *in situ* isotopic (O, Hf) and trace elemental distribution in zircons requires a new physical model that explains their behaviour during crustal melting [2]. We present results of numerical modelling of zircon dissolution in melts of variable compositions, water contents, T and thermal histories. This is realised in spherical coordinates with two moving boundaries, uses a simplified phase diagram, and accounts for melting and crystallization of major minerals. Next, we explore in detail dissolution and regrowth of zircon inside of host melt cells of variable size held at different T, and Zr undersaturation and provide an equation for zircon survivability. Similar modelling is performed for other accessory minerals: apatite, rutile, and monazite for which there is solubility and diffusion data available. Rock cell size surrounding zircons plays the critical role of in determining core survivability and rim regrowth. Diffusive flux away from dissolving 100um zircon into a large >3mm cell takes 10^2-10^4 years at 750-950°C, but zircon cores may survive infinitely long in a <1mm cell by reaching solubility. Heating, followed by cooling for similar amount of time leads to dissolution followed by nucleation and growth, but the final size zircon remains smaller than the original one due to geometrical skin effect within the cell. Final zircon size is also investigated as a function of zircon microzircon nucleating on a front of crystallizing major minerals leading to shrinking cell sizes and bulldozing of Zr to the growing zircon. We explore in detail survivability and regrowth of zircon inside and outside of sills of different thickness, temperature and composition, and their effects on surrounding rocks, on timescales of their conductive cooling and heating, respectively. For zircon-saturated rocks, only the largest >500m igneous bodies are capable of complete dissolution/reprecipitation of typically-sized zircons, thinner sills cause only partial dissolution and crystallize rim on the surviving cores. Zircons near the contact of the conductively cooling dikes or sills undergo greater overgrowth then dissolution. In contrast, heat wave propagation from cooling sills completely dissolves and reprecipitate zircons in Zr-poor rocks >200 m away, often 10^3-10^4 years after sill intrusion.

[1] Wotzlaw et al., *Geology*, 2014, **42**: 807. [2] Bindeman and Simakin, *Geosphere*, 2014, **10**: 930.