Radiation Damage Zoning in Zircon: Intracrystalline Variations in He Diffusion

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One persistent challenge in ZrnHe thermochronology is the mineral's propensity for complex U+Th zonation which, in slowly cooled systems, results in radiation damage zoning that likely causes intracrystalline variations in He diffusivity and ZrnHe date dispersion. Advances in microanalytical techniques such as Raman mapping provide us with tools to investigate this further. We present a case study for Proterozoic zircon crystals from the Lyon Mountain Granite (LMG) in the Adirondack Mountains of New York which have low U+Th cores and high U+Th rims. The LMG is expected to have cooled slowly, so we anticipate strong radiation damage zoning. Laser ablation U-Pb dates for the crystal cores are widely discordant, but the rims yield a mean $^{238}U/^{206}Pb$ date of 1052.3 ± 4.6 Ma (2σ). In order to examine whether or not the LMG zircons show significant intracrystalline variations in radiation damage, we acquired high (2.5 μm) resolution Raman maps of large (400 x 100 μm) polished crystals and used peak width variations of the Raman SiO_4 bending vibration near 350 cm^{-1} as a proxy for variations in accumulated alpha dose. These maps reveal complex radiation damage zoning characterized by predominantly low damage cores and high damage rims, consistent with the radionuclide zoning. Although imperfect, ZRDAAM[1] reproduces the damage-diffusivity relationship for He in zircon to the first order. We couple our radiometric data and radiation damage maps with ZRDAAM to estimate what intracrystalline variations in He diffusivity we might expect for these crystals through time. These predicitive diffusivity maps can help interpret overdispersed ZrnHe datasets for very old zircons with high degrees of U+Th zoning.

[1]Guenthner et al., 2013, *American Journal of Science*