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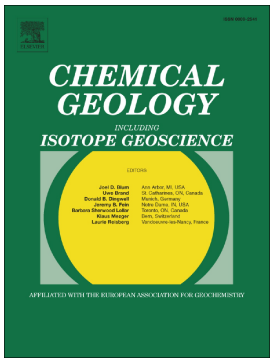

Zircon grain selection reveals (de)coupled metamictization, radiation damage, and He diffusivity

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Zircon grain selection reveals (de)coupled metamictization, radiation damage, and He diffusivity

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ABSTRACT

Broad variability in intrasample effective U concentration (eU) in zircon crystals is required to characterize zircon (U-Th)/He (zircon He) date-eU relationships that resolve thermal histories in ancient rocks. We describe a new protocol for selecting grains for zircon He thermochronometry that leverages visual crystal metamictization, a proxy for radiation damage accumulation, to generate a range in intrasample eU and zircon He date-eU/metamictization trends. Plane polarized light images, eU concentration, and zircon He data from 59 individual grains from six Proterozoic and three Archean North American granitoids reveal a progressive increase in crystal opacity and discoloration that corresponds to increasing eU in each sample. Zircon eU ranges from 89 to 1885 ppm across the dataset and individual samples have eU variations of 538 ppm to 1579 ppm. Three Proterozoic samples yield distinct negative zircon He date-eU patterns with individual dates of ~908 to 20 Ma. Archean grains collectively define a negative date-eU trend from ~661 to 4 Ma. In contrast, three other Proterozoic samples yield uniform ~25 Ma zircon He dates over an 1800 ppm eU range, despite increasing eU with increasing metamictization. Simple thermal history models that account for coevolution of zircon radiation damage and He diffusion demonstrate visible metamictization and diffusivity are either coupled or decoupled depending on a sample's thermal history. Zircon He date-eU/metamictization pediments develop when variable but high eU grains with variable visual damage and closure temperature close with respect to He at the same time. Uniform dates despite progressive increase in eU and visual damage reflect decoupled He diffusion and visual damage, are associated with rapid cooling, and/or imply some forms of damage in zircon may not fully anneal.