LA-ICP-MS approaches to depth-profiling and chemical mapping of unpolished zircon

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Zircon, in the presence of alkaline fluids, can undergo coupled dissolution-reprecipitation. This fluid mediated alteration manifests itself as μm-scale rims on the outer surfaces and within existing imperfections of zircon crystals. Laser ablation inductively coupled plasma mass spectrometry (LA-ICP-MS) was examined as a tool to interrogate the lateral and depth variation of isotopic (U-Pb) and elemental (REE) distributions within the rims of unpolished zircons from an Archean metasediment. Our LA-ICP-MS U-Pb depth profile technique was able to identify micron-thin (<3 μm), concordant, isotopically distinct mineral domains (rims) characterized by $^{207}Pb/^{206}Pb$ ages ca. 100 m.y. younger than the zircon interior (2σ age-uncertainties as low ~0.2%). Rims also showed greatly elevated U content (up to an order of magnitude) relative to the interiors. Our calculated penetration rate suggests that each laser pulse excavates depths of ~0.06 μm. Ages resolved through the LA-ICP-MS U-Pb depth profile method overlap, within 2σ uncertainties, the $^{207}Pb/^{206}Pb$ ages measured using SIMS U-Pb depth-profiling on the same population of zircon. The rims are further evinced by the presence of a relative enrichment (>3 orders of magnitude) in REE measured using an independent LA-ICP-MS depth-profiling technique on the same zircon. The enrichment of REE was used as an indicator of rim material. Additional LA-ICP-MS techniques were developed to generate trace element concentration maps of the unpolished zircon grains. These maps illustrate the heterogeneous nature of the crystallization of rim material, commonly demonstrating preferred growth along fractures or within isolated domains on the grain surface. The LA-ICP-MS techniques are capable of quickly identifying, and chemically and isotopically characterising zircon rims, which are an indication of low temperature, yet geologically significant, fluid events that may otherwise remain unidentified.