Targeting the timing of zircon deformation with atom probe and correlative microscopy

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U–Pb data from deformed zircon may lie on discordia whose intercepts coincide with deformation events, the timing of which are known independently. However, in many cases such ages cannot be constrained. Extracting deformation ages from zircon requires a knowledge of the mechanisms underlying trace element migration associated with different types of microstructure. Atom probe microscopy provides 3D, (sub)nanometre resolution, compositional information that provides critical insights into the nature of these mechanisms. Here, we present CL, EBSD, TKD, SEM ToF-SIMs, SHRIMP and atom probe data from different microstructures, preserved in a single zircon that formed during the ~1.17 Ga Stac Fada bolide impact. The zircon grain preserves complex trace element distributions in a range of microstructures that developed during this single, very high-strain rate event. Substitutional and interstitial ions have a tendancy to show similar distributions, indicating coupling between different mobility mechanisms. We interpret the rapid formation and migration of oxygen vacancies and dislocations into low energy configurations to be responsible for substitutional and interstitial ion migration. However, differences in trace element mobility associated with primary growth zoning in the zircon represents a subtle compositional control on trace element mobility by these mechanisms. The results provide a framework for understanding trace element migration during deformation and provide a context for targeting isotopically reset U–Pb domains to yield better constraints on the timing of zircon deformation events.