Atomic scale resolution of trace element variation in zircon reveals multiple metamorphic processes

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Metamorphosed detrital zircon grains with igneous cores found within kyanite-garnet schists from the Rhodope Metamorphic Complex (eastern Greece) and the Goshen Dome (Massachusetts, USA) feature an anomalous interface domain between the core and rim. The nanometer-scale core-rim interface domain is characterized by a cathodoluminescence (CL)-dark domain immediately adjacent to the core, surrounded by a CL-bright domain with convolute zoning.

Atom probe microscopy was used to characterize the structure and composition of these domains to evaluate the mechanisms of recrystallization in response to metamorphism. Our results show: (1) toroidal domains c. 10-20 nm enriched in Pb (±Y± Al), (2) a sequence of c. 20 nm thick cross cutting planar bands of enrichment and depletion in Y and U and (3) clustered domains c. 50 nm enriched in Y+Yb+Al+P, located within the planar domains enriched in Y.

We interpret that these trace element domains were produced by the following processes as part of the zircon's response to metamorphism. The toroidal domains formed by trace element accumulation into migrating dislocation loops at the onset of metamorphism; the planar domains formed as a reaction front propagated through the grain; the clustered domains formed within the enriched planar domains from $xenotime_{ss}$ exsolution from $zircon_{ss}$ as the sample passed the solvus.