Correlations between TEM and APT analyses of nanoscale features within zircon

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Atom probe tomography (APT) of specimens prepared from a metamorphosed zircon grain revealed several nanoscale features characterized by high trace element concentrations. The zircon core contains abundant toroidal clusters c. 20 nm in diameter with high Pb (+Y+Al); the core-rim interface domain contains cross-cutting planar features with high concentrations of Y+Yb+P (+Al) [1]. To evaluate the mechanisms interpreted to produce the features observed by APT, we analyzed a section of the same zircon grain by transmission electron microscopy (TEM).

Bright field (BF) scanning TEM (STEM) images confirm the presence of 10–150 nm diameter dislocation loops exclusively within the zircon core. Compositional maps collected via TEM-EDS show high Pb concentrations within the dislocation loops, consistent with the hypothesis that the toroidal Pb clusters are decorated dislocation loops that formed in response to annealing of radiation damage. We also observed numerous nano-inclusions within the zircon core that are dark in HAADF-STEM images, indicating a negative density contrast. These inclusions are compositionally and morphologically distinct from the Pb-rich dislocation loops and may be xenotime. Lastly, BF-STEM images reveal complex dislocation arrays near the core-rim interface of the zircon. The origin of these dislocations remains unclear, but their size, distribution, and spatial correlation with the core-rim interface domain suggests that they may relate to the planar features observed via APT. Because these nanoscale features record the mobility of key elements for geochronology, resolving the mechanims that produce these features will improve our understanding of dates measured at the nm- to µm-scale from discrete domains within zircon.

[1] Peterman *et al.,* (2018) *Goldschmidt Abstracts* no. 2009