Trace element heterogeneities at twin boundaries: a combined atom probe tomography and transmission electron microscopy study

R. VERBERNE[1,2]*, S.M. REDDY[1,2], D.W. SAXEY[1,2], D. FOUGEROUSE[1,2], W.D.A. RICKARD[1], Z. QUADIR[1], N.J. EVANS[1,2], C. CLARK[2]

[1]John de Laeter Center, Geoscience Atom Probe, Curtin University, Perth, WA 6845, Australia.
[2]School of Earth and Planetary Sciences, Curtin University, Perth, WA 6845, Australia
(*correspondence: rick.verberne@postgrad.curtin.edu.au)

Characterizing the potential pathways by which trace elements can diffuse is crucial to the successful application of geochemical tools like geothermometry and geochronology. With recent advances in atom probe tomography (APT) it is now possible to observe and visualize nanoscale trace element segregations in geological samples. However, in APT data of minerals the structural sites where these trace elements concentrate are inferred from their shape and composition, not by direct observation. Recent correlative investigations on Pb-enriched CaS nanoexsolutions in monazite have successfully combined transmission electron microscopy (TEM) with APT to link this study we combine APT and TEM to characterize a twin boundary in rutile, a common accessory mineral used in a variety of geochemical applications. The rutile grain was sourced from the Dallwitz Nunatak, Napier Complex (East-Antarctica), which is well known for ultra-high temperature metamorphism that could enhance trace element diffusion signatures. These correlative techniques reveal a direct correlation between nanoscale structures and the pattern of compositional heterogeneities. Our results reveal that trace elements segregate into networks of dislocations present at twin boundaries, and therefore indicate that twin boundaries have the potential to act as fast diffusion pathways, affecting trace element concentrations and perhaps impacting applications of geochemical tools.

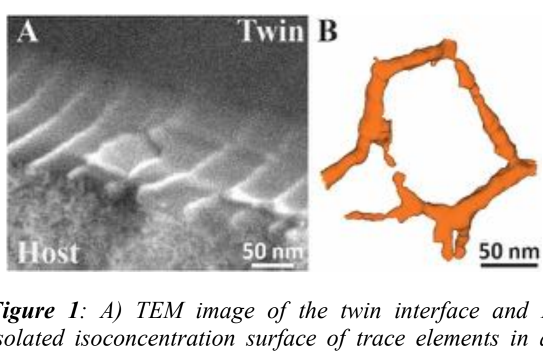

Figure 1*: A) TEM image of the twin interface and B) Isolated isoconcentration surface of trace elements in an APT reconstruction.*