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Cilva Joseph
Curtin University, Earth and Planetary Sciences, Australia (cilva.joseph@postgrad.curtin.edu.au)

Nanoscale apatite inclusions in xenotime: witness of Pb mobility

Cilva Joseph[1, 2], Denis Fougerouse[1, 2], Steven M. Reddy[1, 2], Aaron Dodd[3], Steven Denyszyn[4], David W. Saxey[2], William D.A. Rickard[2]

[1]School of Earth and Planetary Sciences, Curtin University, Perth, Australia

[2]Geoscience Atom Probe Facility, John de Laeter Centre, Curtin University, Perth, Australia

[3]Microscopy and Microanalysis Facility, John De Laeter Centre, Curtin University, Perth, Australia

[4]School of Earth Sciences, University of Western Australia, Perth, Australia

Discordant ages as measured by $^{206}Pb/^{238}U$ and $^{207}Pb/^{235}U$ ratios in various geochronometers are common. Several mechanisms have been proposed to explain discordant ages in different minerals. These include loss of radiogenic Pb, mixing of different age domains within a mineral, and intermediate daughter radioisotope disequilibrium. Xenotime (YPO_4) is a geochronometer used to date different geological processes, such as diagenesis, metamorphism, and hydrothermal events. However, xenotime commonly yields small degrees of discordancy (<3%) by high precision geochronology techniques. To investigate the mechanism responsible for slightly discordant xenotime analyses, two ~1000 Ma crystals (z6413 and Y1) from Ontario and Western Australia were analysed using atom probe tomography (APT) and transmission electron microscopy (TEM) which provide sub-nanometre scale chemical and crystallographic analysis of minerals. Both samples have not undergone significant metamorphism (T < 300°C) after crystallisation. Combined APT and TEM results revealed the presence of nanoscale apatite [$Ca_5(PO_4)_3(F,Cl,OH)$] inclusions and crystal dislocations in the xenotime grains. APT data indicates that the apatite inclusions are rich in radiogenic Pb and that the dislocations are decorated with Ca, Cl and H. Nanogeochronology of xenotime by APT indicate that the apatite inclusions likely formed by exsolution during the cooling of crystals, capturing radiogenic Pb. Dislocations in the crystals may have acted as fast diffusion pathways leading to radiogenic Pb-loss and caused the U-Pb system disturbance.