

Measuring stable O-isotopes by atom probe tomography: New insights from ~100 mineral analyses

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Atom probe tomography (APT) is a rapidly expanding technique in the fields of Earth and planetary science, providing an avenue to obtain quantitative major, trace and isotope geochemistry at the nanoscale. One of many under-explored areas in APT is the measurement of stable isotope systems in geological materials, including the O-isotope systematics used to interpret crystallization conditions and planetary origin in a wide range of (extra-)terrestrial materials [1].

Challenges to the accurate measurement of O-isotopes include possible APT instrument effects and the currently ubiquitous presence of hydrogen in the sample chamber resulting in isobaric interferences on key O-peaks (i.e. O²H on O³). Indications of O isotope differences in baddeleyite nanodomains that experienced differential Pb-loss [2] are nevertheless intriguing. In order to assess the degree of influence of run conditions and H interferences, H and O isotopic peaks from nearly 100 atom probe analyses (microtips) on five mineral species from numerous APT setups were compared. The minerals include zircon, baddeleyite, apatite, feldspar and pyroxene from Earth, the Moon (both meteorites and Apollo returned samples), Mars, and the asteroid belt (4 Vesta) and come from 12 atom probe laboratories around the world.

Linear O-isotope fractionation trends within different mineral phases were observed, though no reproducible trends can be observed within multi-phase analyses from each unique APT instrument. This suggests that measured ratios are not heavily influenced by instrument parameters, but instead by the bonding nature of O atoms within the lattice of the target material. As a result, we propose that this trend will be correctable in future using a unique regression function based on the analysed mineral phase, allowing for nanogeochemistry of planetary origins and processes in triple O-isotope space.

[1] Valley, 2003. Rev. in Min. & Geochem. [2] White et al., 2017. Nat. Comms.