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Making the most out of the minimum: atom probe tomography's role in characterising returned extraterrestrial samples.

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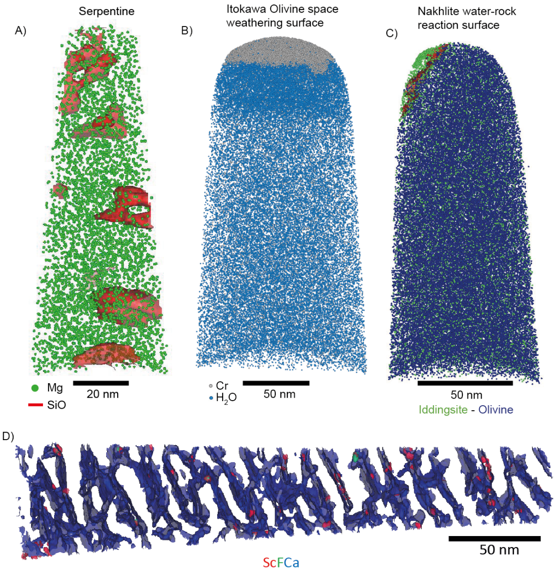

Figure 1. *APT data sets from a variety of extraterrestrial materials A) nano-phase opaline silica within serpentine from the Ronda peridotite. B) the near surface of an olivine grain from the asteroid Itokawa showing a concentration of water molecules up to 40 nm below the grain surface consistent with H ion implantation from the solar wind. C) The interface between iddingsite clay and olivine in the Martian nakhlite meteorite NWA 817. D) Nanophase complexity revealed by APT within carbonates hosted in CM meteorites.*

Atom probe tomography (APT) is a relatively new technique in planetary science [1] that enables the collection of atomic-scale chemical, isotopic and spatial information in 3D from small sample volumes (<0.01 μm^3 [2-3]). As such, APT has the potential to provide unique insights into the nanoscale heterogeneity of extraterrestrial materials. [1,2,4-6].

In this talk we will provide a brief overview of the APT technique, and sample preparation protocols [4] including the effectiveness of using a cryo-focused ion beam transfer mechanism to minimize volatile element loss from hydrous samples. We give examples of recent key advances in developing APT for its application to extraterrestrial materials that have been, and will be delivered to Earth from asteroids, the Moon, and Mars [1,2,4-11] by sample return missions. Specifically, we will outline the how APT has been used to directly detect water molecules in the space weathered surfaces of mineral grains from the asteroid Itokawa [12], water rock reaction interfaces in Martian nakhlite meteorites, and the first APT measurement of phyllosilicates in a terrestrial peridotite [13] and CM chondrite meteorites (Figure 1). Our work demonstrates that APT measurements, particularly when coordinated with conventional microanalytical techniques, are providing a new avenue to investigate extraterrestrial processes from asteroid impacts to space weathering [1,2,4-11].

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