Maximising science return from Ryugu using atom probe tomography

L. Daly, J. R. Darling, M. R. Lee, L. J. Hallis, J. Cairney, I. McCarrol, L. Yang, P. A. Bland, G. K. Benedix, L. V. Forman, W. D. A. Rickard, D. Fougerouse, S. Reddy, D. Saxey and P. A. J. Bagot

Introduction

JAXA's Hayabusa2 mission will soon return pristine samples from Ryugu, which are likely to be mainly composed of serpentine, possibly shock-heated [1].

As the volume of material returned will be small, maximising science output from these samples is critical to mission success.

Atom probe tomography (APT) can measure individual atoms in 3D, and here we have tested its potential via the first analysis of phyllosilicates by APT.

Materials & methods

Here we describe APT results from Mg-rich terrestrial serpentine (Ronda peridotite, Spain) and the matrix of CM chondrite Allan Hills (ALH) 83100, which may be a good analogue for Ryugu [2].

APT needles (Fig 1) were extracted from thin sections by focused ion beam using standard preparation protocols and analysed using a LEAP 4000X atom probe at the University of Sydney.

The APT needles yielded multi-million atom datasets.

References

[1] Kitazato K. et al., (2019) Science, 364, 272-275. [2] Le Corre, et al., (2018) Month Not. Royal Astron. Soc., 475-614-623.

[3] Thompson K., et al., (2007) Ultramic., 107, 131-139. [4] Lee M. R., et al., (2015) Meteoritics & Planet. Sci., 50, 1362-1377.

Results

Novel findings from APT include ~20 nm SiO nanophases in the Ronda serpentine (Fig. 1a) and complex nanostructure of alternating Fe-rich and Mg-rich (but water poor) tabular nanophases in ALH 83100 (Fig. 1b).

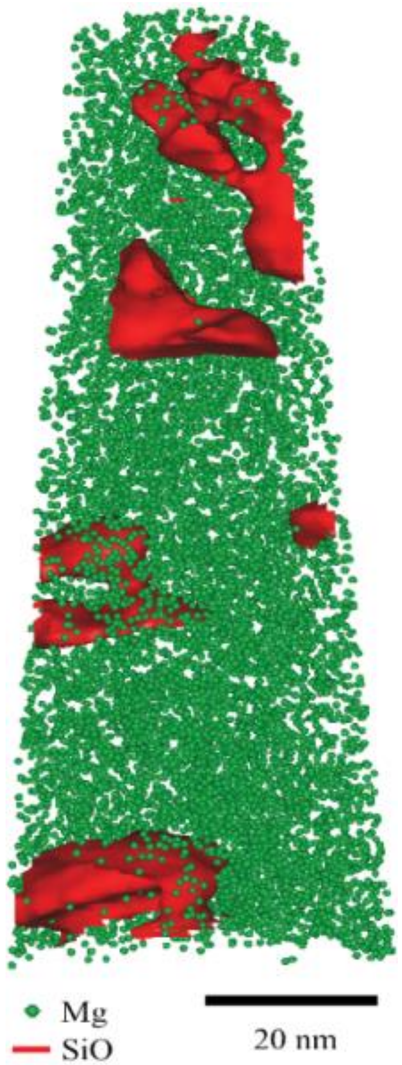

Fig. 1a. Ronda serpentine processed to highlight the distribution of Mg (green), and SiO nanoparticles (red).

Fig. 1b. ALH 83100 matrix serpentine. Pink isosurfaces are relatively rich in Mg & Si, and depleted in H, O & Fe.

Discussion

The most abundant materials likely to be returned from Ryugu can be analysed very effectively by APT.

Our results reveal a diversity of nanoscale phases and structures within terrestrial and meteoritic analogue phyllosilicates, providing a baseline for the returned materials.

SiO nanophases in the Ronda peridotite are likely to be opaline silica. Similar features were observed by TEM in clays from the Nakhla Martian meteorite [4].

The Mg-rich phyllosilicate layers in ALH 83100 could represent an interstratification of different serpentine minerals. However, the water poor nature suggests that these structures could form by thermal dehydroxylation.

Next steps

Prepare and transfer samples to APT under cryo conditions to evaluate volatile species retention during FIB preparation.

Measure coarse grained serpentine from Murchison as an example of a less aqueously altered CM.

We warmly invite you to the first Planetary science atom probe workshop prior to the Metsoc meeting in Glasgow

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Background image: Murchison

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