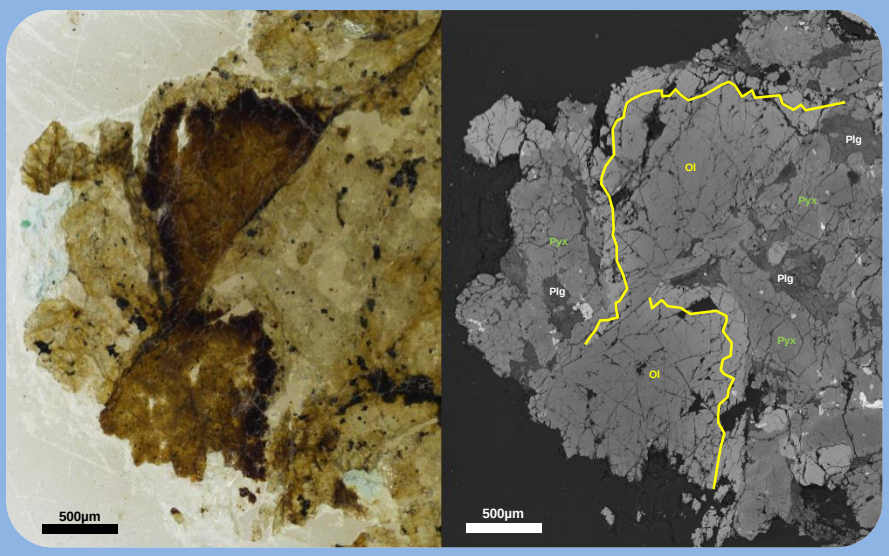
Olivine Alteration of Shergottite Northwest Africa 10416

J. D. Piercy, J. C. Bridges*, L. J. Hicks, J. L. MacArthur, J. Michalowaska
Space Research Centre, Leicester Institute of Space and Earth Observation, University of Leicester, UK, LE1 7RH. (*j.bridges@leicester.ac.uk)

1. Introduction

Northwest Africa (NWA) 10416 is an olivine-phyric Martian Shergottite with olivine grains that show **orange-brown altered cores** and **clear unaltered rims** (Fig. 2). We have performed microanalysis of these olivine grains with various techniques in order to aid test whether the olivine core alteration is terrestrial or not.

◄ ***Figure 1*** – Optical image of our 2.1 g bulk sample of NWA 10416, showing olivine phenocrysts set in a groundmass of pyroxene and plagioclase



▲ ***Figure 2*** – Optical and Back Scatter Electron (BSE) image comparison of a fractured olivine grain in NWA 10416. Altered core-clear rim boundary shown as yellow line on BSE image. Minerals labelled: olivine (yellow), pyroxene (green) and plagioclase (white).

2. Methods

Scanning Electron Microscope

- Back Scattered Electron (BSE) imagery.
- Energy Dispersive X-ray fluorescence (EDX) spectroscopy.

Diamond synchrotron

- Fe-K X-ray Absorption Spectroscopy (XAS)

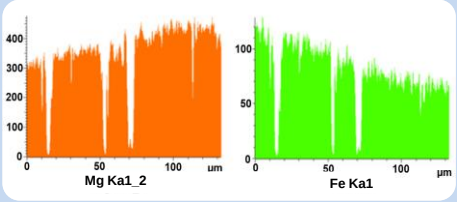
3. Mineralogy

Our sample is without a fusion crust and shows a groundmass of green pyroxene and white plagioclase containing **orange-brown olivine phenocrysts**. Dark shock-melt veins are also present (Fig. 1).

Olivine: The phenocrysts are ~1 mm size and consist of orange cores, dark brown outer bands and clear rims (Fig. 2).

Figure 2 displays a large fracture cutting and displacing half of a olivine grain. It is notable that the orange-brown colouration is also displaced.

The large phenocrysts have undergone **igneous zonation**, leaving them with **Mg-rich cores, $Fo_{78}Fa_{22}$**, and **rims of almost equal Mg and Fe content, $Fo_{52}Fa_{48}$** (Fig. 3).

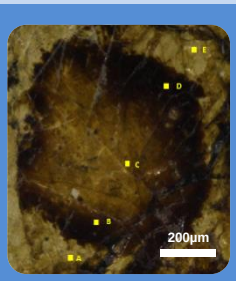


▲ ***Figure 3*** – Line element maps of Mg (orange) and Fe (green) taken from a line cutting an olivine grain from rim to core. The graph shows distance vs counts.

4. XAS Analysis

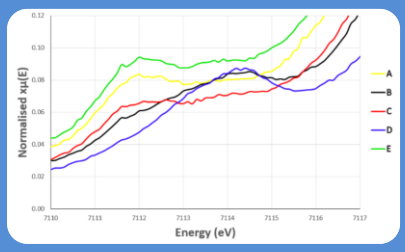
XAS measurements were taken on the sample in order to gather information about the oxidation state across the altered olivine grain.

Figure 5 shows the XAS spectra pre-edge features of the sites indicated in Figure 4, it shows a definite oxidation variation across the grain. Spectra B and D, which represent the **brown boundary of the olivine core**, have shifted to a higher absorption energy **indicating a higher oxidation state.**



◄ ***Figure 4*** – *Optical image showing sites of XAS spectra (Fig. 5). A/E (clear rim), B/D (brown boundary) and C (orange core).*

▼ ***Figure 5*** – *Pre-edge features of XAS spectra taken from sites shown in Figure 4.*



5. Discussion

Previous studies [1,2] have suggested that the olivine alteration is pre-terrestrial. However, oxygen isotope analysis [3] suggests an 'overprinting by terrestrial alteration' in the olivine cores.

Our XAS data indicates an oxidation trend across the olivine grain. It has been observed that **Fo-olivine is more susceptible to alteration over its Fa counterpart under oxidizing conditions when subject to low-temperature surface fluids** [4].

Possible Model

The olivine grains underwent igneous zonation as their environment changed during the fractional crystallisation process. This created the olivines' Mg-rich cores and rims of almost equal Mg, Fe

Martian shock effects caused veins and fracturing of the compositionally zoned olivine grains.

During it's time in Northwest Africa, groundwater exploited the fractures and altered the olivine in a way that was controlled by the pre-existing, igneous zonation.

References: [1] Herd C. D. K. et al. (2016) *LPSC XLVII, Abstract #2527.* [2] Vaci Z. (2016) *LPSC XLVII,* Abstract #2538. [3] Ziegler K. (2016) GSA, Paper #49-5. [4] Hausrath E. M. and Brantley S. L. (2010) *JGR, 115,* 2156–2202.