NORTHWEST AFRICA 8159 APATITE VERSUS LAFAYETTE APATITE: EFFECTS OF TERRESTRIAL WEATHERING VERSUS MARTIAN ALTERATION

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Introduction: The Martian meteorite Northwest Africa (NWA) 8159 is a unique augite-rich shergottite of Amazonian age (2.37 ± 0.25 Ga) that has been affected by aqueous alteration in its host-rock environment on Mars, and by terrestrial weathering during its residence time in the Moroccan desert [1-6]. We have previously investigated NWA 8159 apatite (which appears heavily altered and granular) to determine its parental rock composition and the origin of the fluids that have interacted with it; and we have concluded that terrestrial weathering has extensively altered the primary minerals of NWA 8159 [4-6]. Hence, establishing the Martian aqueous alteration products and primary minerals in NWA 8159 requires an analytical comparison of the NWA 8159 mineralogies with those of other Martian volcanic rocks. The Lafayette meteorite, which is a nakhlite of Amazonian age (1.32 ± 39 Ma), has the highest water content amongst the nakhlites [7-10] and exhibits pristine apatite grains. Therefore, by analyzing additionally the apatite in Lafayette, we have acquired an insightful comparison for the origin of the two different apatite species, and for the geochemical reaction pathways of the primary and secondary alteration products that we have observed therein.

Methodology: One thin-section (7.5 × 1.3 mm) and one indium-mounted polished sample (6.5 × 4.5 mm) from NWA 8159, and a semicircular thin-section from Lafayette (10.3 × 8.3 mm) were coated with 20μm carbon and analyzed in this research. We used the Carl Zeiss Sigma (VP-FEG) Scanning Electron Microscope at the University of Glasgow to detect apatite in our NWA 8159 and Lafayette samples. We performed Electron Probe Microscopy Analyses (University of Edinburgh) on NWA 8159 and Lafayette apatite to establish its volatile composition. We then used Transmission Electron Microscopy at the University of Sydney (FEI Themis, Z double-corrected 60-300 kV S/TEM) to define the NWA 8159 apatite texture, and the chemical nature of its Si-rich and Fe-rich intergrown phases. Finally, we conducted Atom Probe Tomography experiments via the Cameca Local Electrode Atom Probe (LEAP) 4000X at the University of Sydney to reconstruct in 3D the elemental composition of the NWA 8159 apatite.

Results & Future Work: We have found that the Si-rich and Fe-rich alteration phases in NWA 8159 apatite are of terrestrial origin, in contrast to the alteration observed in Lafayette [Fig. 1]. Furthermore, our findings imply that the granular and unhedral NWA 8159 apatite has precipitated via a terrestrial weathering mechanism, but this potential geochemical reaction pathway remains ambiguous. Future work via Nanoscale Secondary Ion Mass Spectrometry, Raman and Laser Ablation analyses of the apatite in our NWA 8159 and Lafayette samples should unveil this mystery.

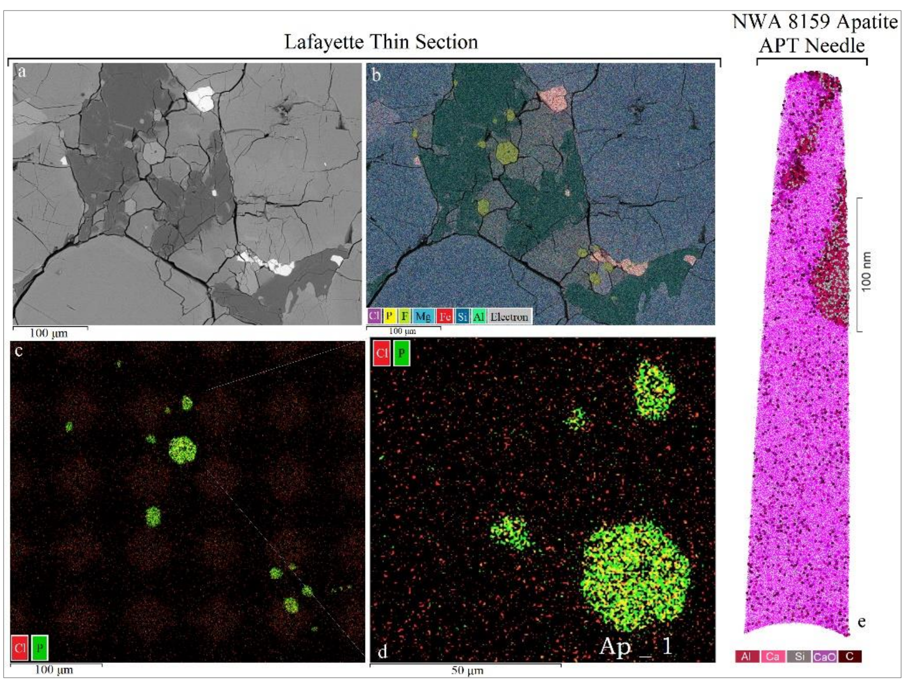

Fig. 1: Apatite identification in the Lafayette sample (a-d) via SEM observations; (a): BSE image of ROI 1, (b-d): false-coloured SEM-EDS maps revealing the apatite (P- and Cl-rich grains). (e): APT 3D reconstruction for the composition of NWA 8159 apatite needle 1, exhibiting the association of NWA 8159 apatite with terrestrial carbonate.

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