CONSTRAINING THE THERMAL HISTORY OF MARTIAN BRECCIA NORTHWEST AFRICA 8114.

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Introduction: The martian regolith breccia, Northwest Africa (NWA) 8114 and its pairs NWA 7034, 7475, 7533 etc, offer the first opportunity to examine thermal conditions in the near-surface, near an impact crater on Mars. Regolith ejecta blankets on Mars are gradually modified by heating, transport and alteration processes, resulting in reprocessed rocks [1]. Some carbonaceous chondrite material has been incorporated, as indicated by the presence of Ni and Ir, making these samples impact-regolith breccias [2,3]. NWA 8114 contains a wide range of clasts from basalt to alkali feldspar, although olivine is largely absent. Iron oxides, Cl-apatite, chromite, and pyrite are also present in the clasts and matrix [2-6]. Accretionary clasts and dust rims could have formed in an ejecta plume, density current [3] or during fallout [7], analogous to pyroclastic emplacement mechanisms. Hydrated iron oxides [5,8] and monazite-bearing apatite suggest some parts of the breccia experienced aqueous alteration [9]. A range of ages have been determined, with ancient ~4.4 Ga U-Pb [7] Sm-Nd [10] ages for some zircons and younger 1.1-1.7 Ga U-Pb [7,11] U-Th-Pb [9] ages for other zircons [7], chlorapatite [11] and monazite [9] in NWA 8114. Here we report the results of our mineralogical study used to constrain the regolith's thermal history.

Methods: An individual clast from NWA 8114 was separated and divided into 2 fragments, to probe both its age and mineralogy. One fragment was neutron-irradiated for ^{40}Ar-^{39}Ar dating. The other fragment was polished for SEM-EDX analysis. SEM, EPMA, FIB-STEM and synchrotron XAS, XRD, XRF and FTIR studies were carried out on three other polished sections as a comparison.

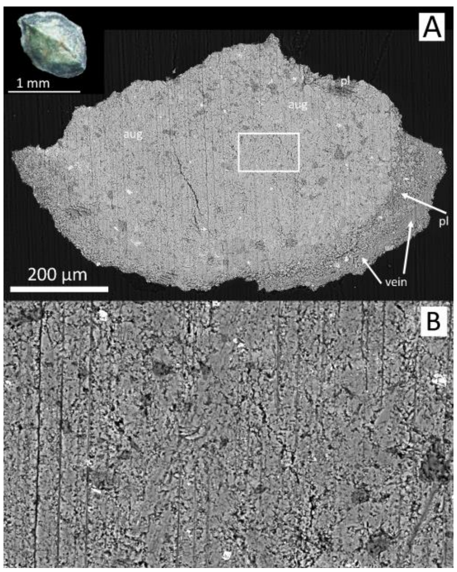

Fig. 1. (A) BSE image of a separated clast showing mainly augite (aug) $En_{24-39}Fs_{13-26}Wo_{48-50}$, plagioclase (pl) inclusions, $Ab_{15-74}An_{12-84}Or_{0-17}$ and a calcite vein and fine grained, accretionary rim. (B) BSE image of augite (inset, A) with iron oxide grains (white) and porosity (black).

Results: In polished section, a predominantly augitic clast shows up to 5% porosity and iron oxide grains (Fig. 1) and Fe K XANES indicates it has up to 25% $Fe^{3+}/\Sigma Fe$. These features are consistent with our previous TEM work [12], showing high temperature partial breakdown of pyroxene to iron oxide and amorphous Al-silicate. A maximum ^{40}Ar-^{39}Ar age of 1130 Ma - 1250 Ma was obtained for the clast.

Discussion: The observed oxidation and breakdown of pyroxene (also seen in paired stone NWA 7533 [13-14]) has some similarities with the breakdown of pyroxene in ureilites by impact smelting [15], albeit under much more oxidizing conditions on Mars, FMQ+2 to +4 units [6]. Experimental shock analyses of pyroxene show that $Fe^{3+}/\Sigma Fe$ can increase 2–6 times, even without free oxygen, possibly by incorporating H+ ions into the crystal structure [16]. We relate the maximum ^{40}Ar-^{39}Ar age of 1130 – 1250 Ma in the NWA 8114 clast to the impact shock event and subsequent high-temperature oxidative breakdown of many of the pyroxenes, immediately after the impact ejecta was deposited within a regolith blanket. In other pyroxene clasts, feldspar veins crosscut the oxidized pyroxene and rims, suggesting temperatures that were near the basaltic eutectic, sufficient to remobilize and partially melt clasts. A simple Fourier cooling model suggests that a burial depth of 5 m is enough to maintain sufficiently high temperatures for ~30 days that could explain the pyroxene breakdown and partial melting.

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