GOETHITE IN NORTHWEST AFRICA 8114

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Introduction: NWA 8114 (a pair of NWA 7034) is a polymict, martian regolith breccia [1,2]. The meteorite was likely formed as a result of an impact event [3] which may have led to hydrothermal systems causing further alteration to it [4,5]. Previous study has characterized sections of NWA 8114 and shown partial breakdown and mantling by fine-grained material of pyroxene and basaltic clasts to be associated with oxidation [6]. Our investigation of a goethite inclusion in a basaltic clast aims to determine if the goethite is of extra terrestrial origin and examines the role of water in the regolith evolution. D/H isotope analyses support the martian origin of the hydrated phases [7], and the majority of this water is suggested to be hosted by hydrous Fe oxides, with a minor contribution from apatite [8]. The ferric phases maghemite and goethite have previously been detected [4], and ferrihydrite suggested [9].

Methods: Four sections were characterised using a Phillips XL30 ESEM with INCA 350 EDX and a JEOL 8600 EPMA at UoL. The Microfocus Beamline I-18 at the Diamond Light Source was used for transmission XRD measurements of a variety of clasts taken at 13 keV. I18 was also used for XANES [6]. Beamline B22 was used for FTIR spectrsocopy at 8 cm^{-1} resolution with a spot size of 10 μm x 10 μm [10].

Results and Discussion: Fig. 1a shows the full clast which contains pyroxene ($En_{41-48}Wo_{26-39}Fs_{17-29}$) together with plagioclase ($Ab_{51-65}An_{18-40}Or_{2-22}$) giving a bulk basaltic composition. The Fe oxide inclusion (Fig. 1b) is oxidized [6], and two veins of terrestrial Ca carbonate cross-cut it, therefore the Fe oxide formed earlier than the veins.

XRD d-spacing peaks for the grains marked 'X' (Fig. 1a) indicate a match with magnetite and were used to calculate unit cell dimensions (Å), giving a calculated cubic cell parameter in two locations of 8.389±0.003 and 8.391±0.002 compared with magnetite standards 8.375-8.405 [11]. XRD d-spacing peaks for the area marked gt (Fig. 1b) indicated goethite and were used to give unit cell dimensions of a=3.015±0.002, b=4.634±0.006, c=9.967±0.009 compared with standards a=2.99–3.048, b=4.559-4.641, c=9.854-10.065 [11]. The d-spacings for five of the top seven peaks for NWA 8114 were: 2.524, 2.451, 4.188, 1.721, 1.699 which matched with those for five of the top seven peaks for the goethite standard: 2.520, 2.443, 4.171, 1.715, 1.686.

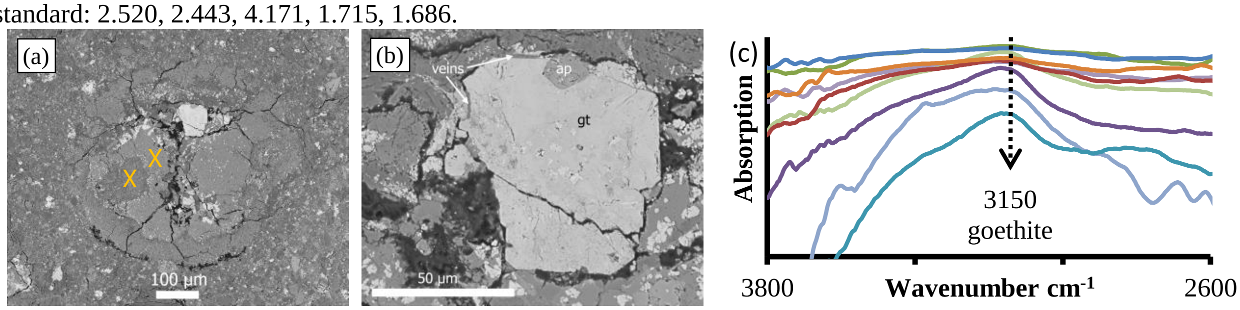

Figure 1: BSE images of (a) basaltic clast with goethite inclusion and magnetite grains (X). (b) goethite (gt) grain cross cut by calcium carbonate veins, with apatite (ap) inclusion. (c) FTIR absorption of 9 measurements taken across the goethite grain.

EPMA data for the area marked gt (Fig.1b) showed total oxide weights of 78.1% (FeO 71.8%, SiO_2 3.6%, MgO 0.6%, CaO 0.9%, NiO 0.9%, Al_2O_3 0.2%, TiO_2 0.1%), consistent with goethite. FTIR reflection data (Fig. 1c) taken from an FTIR map of the clast shows a clear absorption peak at 3150 cm^{-1}, matching the synthetic goethite shown in [9] and distinguishing it from other hydrated iron oxides.

Given this textural evidence of the terrestrial veins cross-cutting the goethite, and the martian D/H isotope analyses [7], the goethite was most likely formed on Mars. This indicates the presence of a liquid in the regolith as it slowly cooled on Mars.

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