FAYALITE IN POLYMICT EUCRITE NORTHWEST AFRICA 6414: EVIDENCE OF METASOMATISM AND FAYALITE-BEARING MAGMAS ON THE HED PARENT BODY? J.T. Mitchell[1], F.M. Willcocks[1] and N.R. Stephen[1,2], [1]Plymouth Electron Microscopy Centre, University of Plymouth, Drake Circus, Plymouth, Devon PL4 8AA, United Kingdom, [2]Geological Society of London, Burlington House, Piccadilly, London W1J 0BG, United Kingdom. Email: jen.mitchell@plymouth.ac.uk.

Introduction: Northwest Africa (NWA) 6414 is a complex polymict breccia composed of a diverse variety of basaltic eucrite lithologies and associated mineral fragments. Among these clasts are a small number of fayalite-bearing (Fe_2SiO_4) lithologies that are distinct from the fayalite-veined pyroxene fragments also observed and are not typical of howardite-eucrite-diogenite (HED) meteorites. Here, we present the preliminary findings of these rare fayalite-bearing clasts and fayalite-veined pyroxene fragments and discuss the potential implications for the magmatic evolution of the HED parent body.

Methods: A polished block of NWA 6414 was analyzed at Plymouth Electron Microscopy Centre (U.K.) using the JEOL 7001F FE-SEM equipped with Oxford Instruments' X-Max 50mm^2 energy dispersive spectroscopy (EDS) detector and AZtec v.6.0 software. Standardized EDS was optimized on a pure Cr standard to 500,000 counts and validated against wavelength dispersive spectroscopy (WDS) data. Analysis was carried out at accelerating voltage 20 keV, probe current 5 nA, and working distance 10 mm, collecting both backscattered electron (BSE) images and EDS data. Mineral endmembers were calculated when appropriate.

Results: The fayalite-bearing clasts in NWA 6414 typically display a fine-grained texture of ferroan augite, calcic plagioclase, fayalite, and a silica phase (Fig.1A). The pyroxenes in these fayalite-bearing clasts are enriched in iron compared to the typical pigeonite-augite trend established by basaltic eucrite clasts elsewhere in NWA 6414 (Fig.1B) and record two distinct groups ($Fs_{44.6}Wo_{39.2}$ and $Fs_{38.4}Wo_{42.0}$ respectively). The fayalite in these clasts ranges from $Fa_{79.0\text{-}90.6}$. Representative fayalite compositions of the fayalite-bearing clasts are presented in Table 1.

Pyroxene mineral fragments with fayalite-veining are observed in the matrix of NWA 6414, composed of host pigeonites that are in keeping with HED compositions [1]. These fragments are somewhat uncommon in the breccia. The fayalite in the veins is $Fa_{69.5\text{-}81.1}$ and is therefore distinct from the fayalite in the clasts (Fig.1C) with minimal overlap. A representative composition of fayalite in the veins is given in Table 1.

Discussion: Fayalite veining in eucrites has been associated with metasomatism on the HED parent body (assumed to be asteroid 4 Vesta [2]), wherein Fe-rich aqueous fluids facilitate the alteration of the host

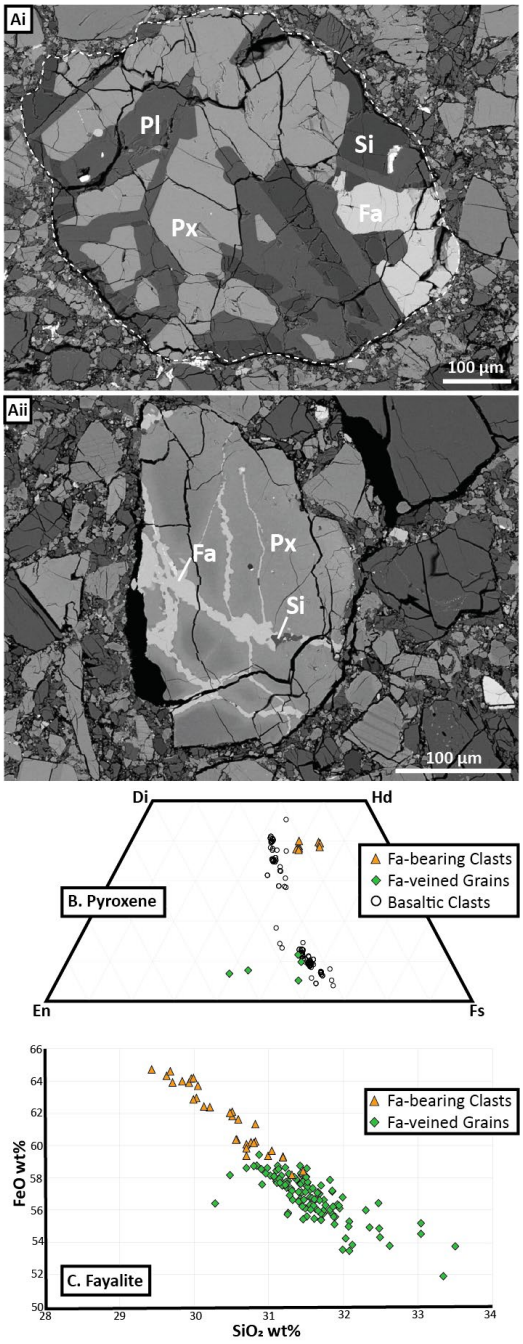

Figure 1. A) BSE images of a fayalite-bearing clast (i) and fayalite-veined pigeonite grain (ii) where Fa = fayalite, Px = pyroxene; Pl = plagioclase, and Si = silica; B) pyroxene compositions of Fa-associated pyroxenes and typical basaltic clasts in NWA 6414; C) Fayalite FeO-SiO_2 wt% of Fa-bearing clasts and veined grains.

Table 1. Representative wt% compositions of fayalite in NWA 6414 clasts and veined pyroxene fragments.

	Fayalite-Bearing Clasts	Fayalite-Veined Pyroxene
SiO_2	30.4	31.7
TiO_2	<0.1	<0.1
Cr_2O_3	<0.1	<0.1
Al_2O_3	<0.1	<0.1
FeO	61.6	56.7
MnO	1.5	1.3
MgO	6.1	9.8
CaO	0.2	0.2
Na_2O	<0.1	<0.1
K_2O	<0.1	<0.1
Mg#	7.1	11.8
Fa	85.1	76.5

pyroxene (here seen as Fe-enrichment towards the fayalite vein in Fig.1Aii) and deposition of Fe-rich olivine [3,4]. Fluid deposition may also explain the small silica phase observed within the fayalite vein in Fig.1Aii [5]. As only a small amount of fayalite-veining is observed, we can therefore infer that metasomatism of these grains occurred prior to the assembly of the modern NWA 6414 breccia and was perhaps a somewhat localized process that did not affect the majority of the lithologies preserved in this meteorite.

The fayalite-bearing clasts are distinct from the fayalite-veined grains in both composition and texture. Both the pyroxene and fayalite in these clasts are significantly enriched in iron relative to the veined grains, and there is often an abundance of a silica phase within the clast. As such, these clasts appear to represent an entirely different lithology with its own unique geological and magmatic evolution.

Experimental studies of highly fractionated Mg-rich eucritic magmas have been shown to generate Fe-rich residual liquids as late-stage products resulting in the crystallization of fayalite and ferroan pyroxenes [6]. Similar material to the fayalite-bearing clasts in NWA 6414 has been identified in a small selection of Antarctic HED polymict breccias [7,8], though a single stone of such a lithology does not appear to exist in the global meteorite collection. It is possible, therefore, that such extensively fractionated melts are rare on Vesta and that they have only been sampled through impact gardening processes.

Conclusions: The fayalite-bearing clasts and fayalite-veined pyroxenes in conjunction with the diversity of other lithologies preserved in NWA 6414 [9] highlight the complexity of igneous and metamorphic activity on large asteroids. The presence of primary fayalite in rare clasts in NWA 6414 provides evidence of late-stage fractionation of eucritic melts, whereas the fayalite veining observed in a small portion of matrix mineral fragments gives insight into secondary alteration and the mechanical reworking of the HED parent body's surface.

From here, we aim to analyze the trace element and REE compositions of the fayalite-bearing clasts in NWA 6414 and combine our observations with geochemical modelling to further investigate the evolution of these potentially highly fractionated melts. NWA 6414 is a relatively large meteorite, and we invite discussion and collaboration from researchers who hold pieces in their collections.

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