PRESERVATION OF HIGH-PRESSURE MINERALS IN THE EUCRITE NORTHWEST AFRICA 8677.

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Introduction: The preservation of high-pressure minerals in eucrites most likely from the asteroid Vesta is of high interest to better understand the impact and post-impact history. Unlike Earth, where tectonics and volcanic activity alter the surface and subsequent minerals, impacts are the main alteration factor in bodies devoid of such geologic processes. High velocity collisions on the surface yield shocks features such as planar deformation fractures, local melting and high-pressure minerals. Evidence of these features in eucrites can provide a temperature and pressure history for impacts for the eucrite parent body.

Previous work on eucrites has reported the presence of preserved high-pressure minerals such as tissintite, (a vacancy-rich clinopyroxene) and majoritic (super silicic) garnet in NWA 8003 [1]. They suggest a shock pressure of approximately 10 GPa and a temperature of roughly 1900°C. In addition, coesite and stishovite were discovered in the shock veins of the eucrite Béréba [2]. The purpose of this study is to constrain the shock pressure and temperature conditions experienced by eucrite Northwest Africa 8677 from its petrographic and mineralogical features

Sample and Methods: A polished thin section NWA 8677 was analyzed petrographically to document shock effects. Areas of interest were determined by proximity to melt regions and locations where recrystallization was observed. The chemistry and textures of the sample were documented using an electron microprobe (JXA-8530F) equipped with a field emission gun in the Eyring Materials Center at ASU. We used a beam energy of 15 keV and a beam current of 15 nA. Compositional data was collected using Energy dispersive spectroscopy (EDS). The structure of polymorphs was confirmed with Raman Spectroscopy using the 532-green laser, operating between 1.3 - 6 mW.

Results: NWA 8677 is a genomict breccia that consists of three lithologies: gabbroic, ophitic, and a brecciated mixture [3], (Figure. 1). In general, the clasts within these lithologies are sub-rounded and angular with subhedral to euhedral crystals. All three lithologies consist of compositionally similar pigeonite and anorthite. Accessory minerals include silica polymorphs ilmenite and zircon. The entire sample contains shock melt, with abundant melt veins and pockets in two corners of the section. Compositionally, the shock melt contains microcrystalline feldspar and pyroxene grains.

Gabbroic clasts exhibit the largest minerals, with the calcic plagioclase ranging from .2 - 1.0 mm. In cross-polarized light, the feldspar crystals have a spherulitic extinction that is not observed in the ophitic lithology. Some of the larger feldspar crystals enclose fragments of pyroxene crystals that appear to have 2 preferred orientations. Optical observations suggest the conversion of some smaller feldspar grains into

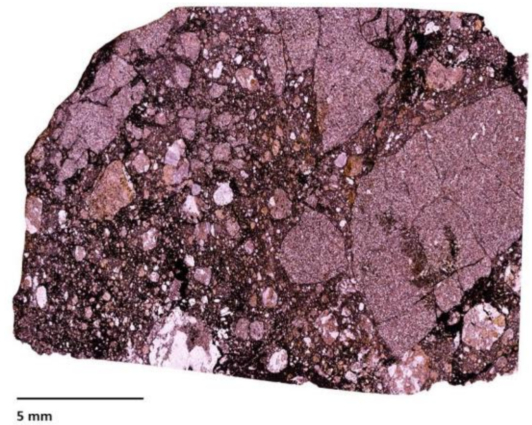

Figure 1: Plane polarized light image of NWA 8677. Darker colored brecciated and gabbroic clasts lie in the shock melt with the lighter material comprising the ophitic clasts.

maskelynite.

The brecciated mix is compositionally similar to the gabbroic and ophitic clasts with the exception of fayalite (Figure 3) and the accessory silica polymorphs. Most of

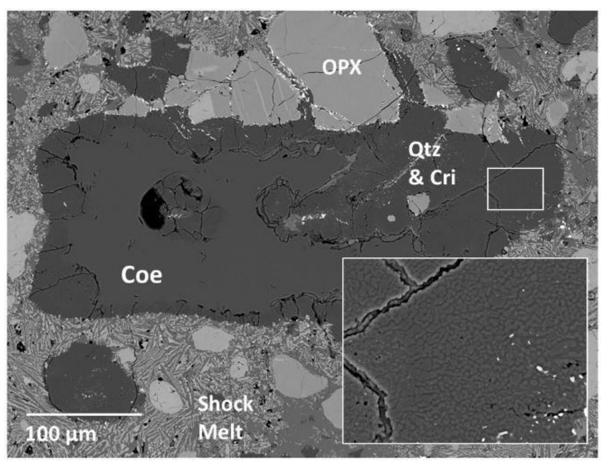

Figure 2: Back-Scatter Electron (BSE) image of silica entrained in shock melt. The grain consists of a core of coesite (Coe) with a rim of quartz and cristobalite (Qtz, Cri). Close up of quartz and cristobalite (Inset). *OPX: Orthopyroxene*.

the silica grains appear to be glassy with recrystallized domains of cristobalite and tridymite (≤ 3μm). Larger silica grains are rimmed with quartz and cristobalite with cores of coesite (Figure 2).

The ophitic clasts are compositionally similar to the gabbroic clasts, but the crystal sizes range from 20 to 50 μm. The presence of twinned feldspars indicate that these clasts did not experience shock sufficient to form maskelynite. A few small shock veins intrude some of the clasts, however there is no evidence of local transformation associated with these veins.

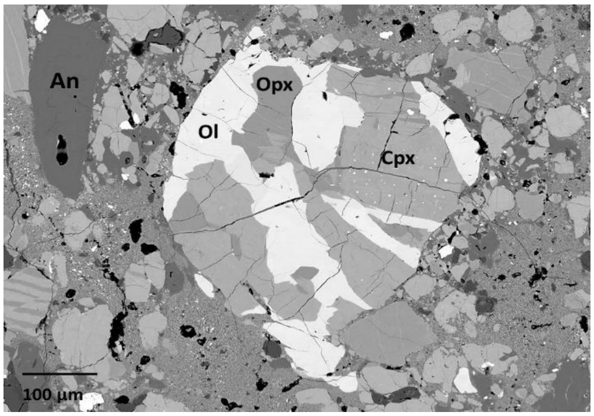

Figure 3: BSE image of olivine (Ol) intergrown with pyroxene in the shock melt.
An: Anorthite. Opx: Orthopyroxene. Cpx: Clinopyroxene

Table 1: EDS data from Figure 3 showing atomic weight percent in olivine.

	Fe	O	Mg	Si	Ca
001	55.01	25.05	3.04	13.90	-
002	53.98	25.34	5.96	14.72	-
003	53.47	25.76	6.49	14.29	-
004	54.30	25.15	6.43	14.12	-
005	49.26	27.26	6.10	16.17	1.21
006	53.95	24.93	6.30	14.82	-
007	54.20	25.20	6.33	14.23	-

Discussion: NWA 8677 likely had a variable impact history based on the heterogeneity of shock deformation features between the gabbroic and ophitic lithologies. The spherulitic extinction feature in the gabbroic clasts suggest that it was subject to higher shock effects than the ophitic clasts that still retain twinned feldspar grains. This may be a result of separate impacts affecting these lithologies. The spherulitic extinction in the feldspars is most likely a result of partial back transformation from glass. Inclusions of pyroxene are present in some feldspar grains and exhibit shape preferred orientation in two directions. This suggests that the feldspar melted to include pyroxene fragments.

The preservation of coesite among the silica polymorphs indicates transformation from low pressure phases during shock. Coesite was formed where the shock melt was hot enough to transform quartz to this high-pressure phase. Low-pressure phases of quartz and cristobalite on the boundaries of the silica grain suggest partial back transformation as a result of high post-shock temperatures after pressure release. The crystallization of a feldspar bearing low-pressure assemblage in the shock veins suggests that crystallization occurred after pressure release demonstrating that the shock melt zones retained a high post-shock temperature. The preservation of coesite indicates that it is not easily back transformed to low pressure silica phases.

References: [1] Pang R.-L. et al. (2016) *Sci. Rep*. 6, 26063. [2] Miyahara M. et al. (2014) *Proc. Natl. Acad. Sci*. 111, 10939-10942. [3] Ruzicka et al. (2017) Met. Bull. 103, 160.

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