THE PETROGRAPHY AND COMPOSITION OF LUNAR METEORITE NORTHWEST AFRICA 4472.

K. H. Joy[1,2,3], I. A. Crawford[1], A. T. Kearsley[2], V. A. Fernandes[4,5], R. Burgess[5] and A. J. Irving[6], [1]The Joint UCL / Birkbeck Department of Earth Sciences, UK. [2]IARC, Dept. of Mineralogy, The Natural History Museum London, UK [3]STFC, The Rutherford Appleton Laboratory, UK. [4]Berkeley Geochronology Center, USA. [5]University of Manchester, UK. [6]University of Washington, Seattle, USA. (K.Joy@ucl.ac.uk).

Introduction: Northwest Africa (NWA) 4472 is a fragmental breccia that has been classified as having a lunar origin [1 - 4]. The sub-split investigated here is large wedge-shaped slab about 31.6 x 24.3 x 1-3 mm in size. The advantage of studying such a large sample size is important when studying such heterogeneous breccia material. Sub-sections studied in lunar meteoritic research are typically ~1 cm by 1 cm in scale, and as such modal class assessments or bulk composition studies are likely to be biased towards any single large clasts or towards clasts from a single bedrock source that may have become 'nuggeted' together within the local regolith, thus masking the true heterogeneity of the regional setting of the sample.

Methodology: Mineral chemistry was measured at the NHM using a WDS Cameca SX50. Element maps and BSE images were acquired using a JEOL 5900LV SEM EDS fitted with Oxford Instrument's INCA microanalysis software. Bulk clast compositions were determined using the JEOL system with a digitally controlled broad area beam-sweep analysis.

Sample Petrography: NWA 4472 is comprised of a seriate range of polymict lithic clasts (yellow, brown and black coloration) consolidated into a dark grey matrix of glass (Fe-rich and feldspathic), clasts and mineral fragments (Fig. 1a). Rare impact melt beads (<150 µm) occur within the sample matrix, indicating that this breccia was partially fused in the lunar regolith. Clasts range up to ~4 mm in size, and from this we infer that the sample was consolidated in a relatively immature regolith environment [5]. Fractures cross-cut the sample and are infilled with terrestrially deposited minerals (mapped out by yellow fractures in Figure 1b).

Clast Inventory: Lithic fragment (Fig. 2, 3) and mineral (Fig. 3) lithology provenance appears to be diverse within the scale of this sub-split.

There is a small basaltic lithic component (<4 mm, ~10% of the sample) with a range of textures from plumose to sub-ophitic. Most basaltic clasts appear to have been derived from a low-Ti (<3.5 wt. % TiO_2: Fig. 2) to VLT source region, and have mid-range Mg# pyroxene compositions (thereby differing from basaltic lunar meteorites like the LAP paired stones and the Yamoto/Asuka/MET/MIL paired group that were crystallized from Fe-rich, highly fractionated melts).

Clasts of black, quenched, Fe-rich glass (>20 wt. % FeO, >4 wt. % TiO_2: peach diamonds in Fig. 2) are distributed through the matrix, and are likely derived from impact melting of a proximal mare basalt bedrock deposit.

Components with Mg-suite affinities (~10% of the sample) include a rare harzburgitic clast (Fo_{92-93}, $En_{88-90}Fs_7Wo_{3-5}$), a pleonaste spinel-troctolitic fragment (An_{93-96}, Fo_{83-87}, $En_{74-90}Fs_{9-21}Wo_{1-10}$), and several monomict mineral fragments and brecciated clasts containing high-Mg# mafic mineral phases (Fig. 3a,b).

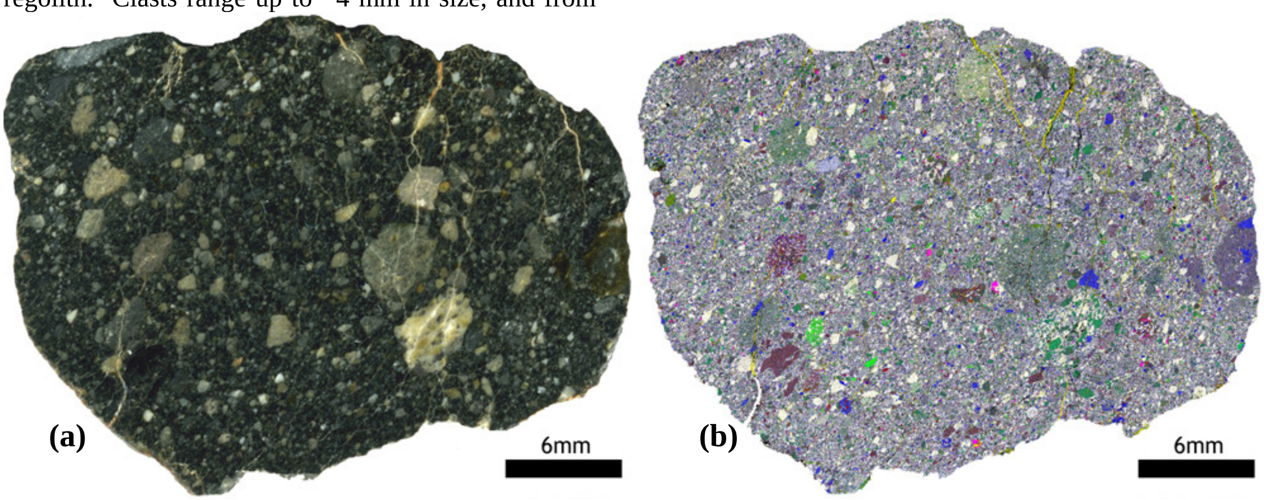

Figure 1. (a) Scanned image of the NWA 4472 slab. Fractures infilled with terrestrially deposited calcite, gypsum and barite cross-cut the sample. (b) Montaged X-ray element map: Si = blue, Al = white, Mg = green, Fe = red, Ca = yellow and Ti = pink. Mare basalt clasts appear red as they are Fe-rich. Mg-suite clasts appear green. Silicic KREEPy clasts appear blue.

Granophyric silica+K-feldspar intergrowth clasts occur throughout the groundmass (<5 % of the sample: Fig. 1: right). They have evolved mineral compositions ($An_{2\text{-}46}Or_{43\text{-}91}Ab_{3\text{-}11;}$ Fig. 3), and are commonly associated with accessory fayalite, Zr-rich minerals and apatite or pockets of ITE-rich glass. These clasts are likely to be the main contributor to the KREEPy geochemical signature of NWA 4472 [2].

Additional lithic clast components include a diverse range of feldspathic, Mg-rich impact melt breccias (~10 to 15% of the sample), fragmental breccias and granulitic feldspathic basalts (Fig. 2). Highly feldspathic clasts (<10% of the sample) have typical lunar ferroan anorthosite (FAN) bulk compositions (Fig. 2).

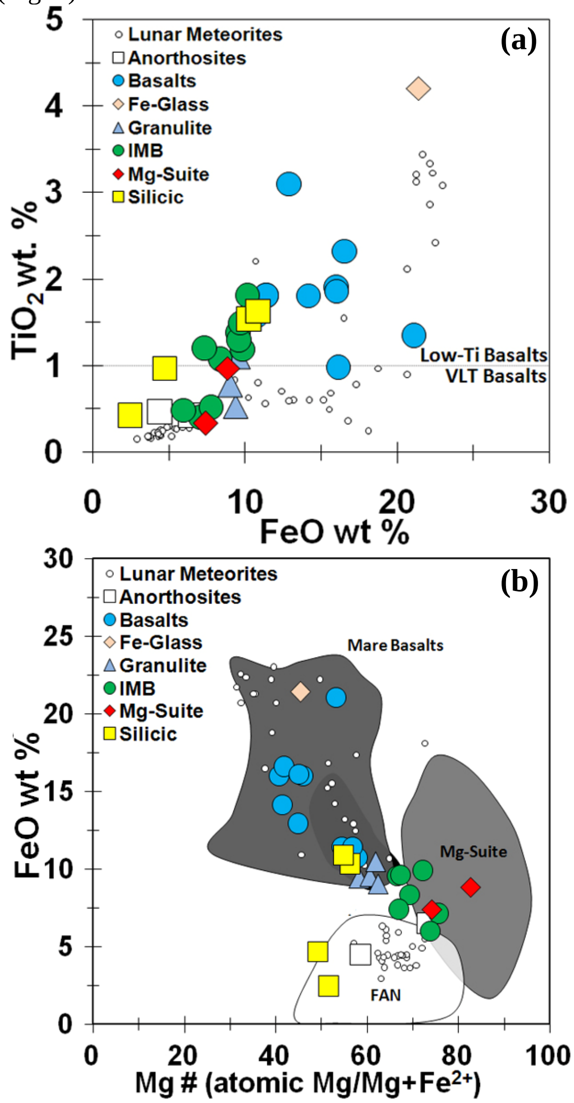

Figure 2. Bulk clast compositions. (a) FeO vs. TiO_2. Mare basalt classification from [6]. (b) Mg# vs. FeO. Apollo and Luna rock compositional fields and bulk lunar meteorite compositions taken from variety of sources including [6 - 9]. IMB = impact melt breccia.

Discussion: NWA 4472 is a heterogeneous breccia containing a mixture of lunar lithologies that are derived from different source bedrock environments, but which were consolidated together in close proximity in the lunar regolith.

The sample has a Sm- and Th-rich bulk composition [2, 3], suggesting that it was derived from a regolith with a high-ITE signature (inferred bulk ~7 – 9 ppm Th). Based on comparisons with the Lunar Prospector datasets, it seems likely that this meteorite was launched from the near-side of the Moon, probably from within the Procellarum KREEP Terrane.

Future Work: The NWA 4472 slab has now been divided into several smaller sub-splits suitable for a wider range of geochemical investigations including Ar-Ar geochronology work and U-Pb radiometric dating of apatite, merrillite and Zr-rich mineral phases.

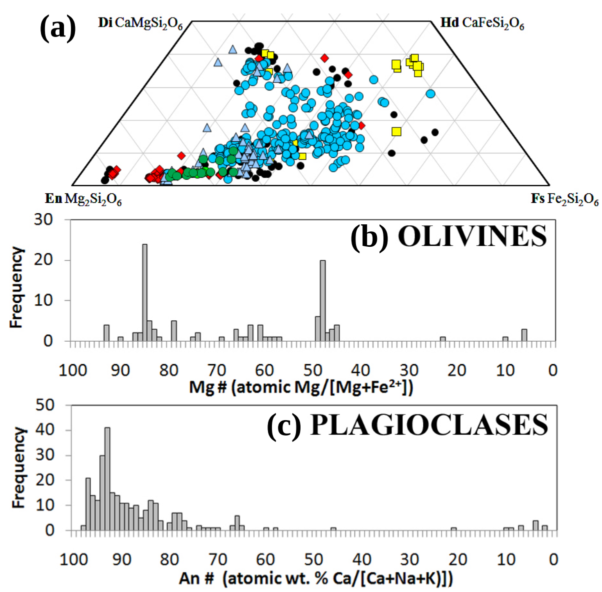

Figure 3. Mineral compositions in lithic and monominerlic clasts. (a) Pyroxene. See Figure 2 for symbol key; black symbols = matrix monomict mineral fragments. (b) Olivine Fo content. (c) Plagioclase An content.

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References: [1] Connolly et al. (2007). *Met. Bull.*, No. 91, *MAPS* 42, A413-A466. [2] Kuehner et al. (2007). *38th LPSC, abst.* no. 1516. [3] Korotev and Zeigler (2007). *38th LPSC, abst.* no. 1340. [4] Joy et al. (2007) *MAPS* Vol. 42 No. 8 *abst.* no. 5223. [5] McKay D.S. et al. (1991). The Lunar Regolith. In *Lunar Sourcebook: A User's Guide to the Moon*. [6] Neal and Taylor (1992) *GCA*. Vol. 56. pp. 2177-2211. [7] Wieczorek et al. (2006) In *New Views of the Moon, Rev. Mineral. Geochem*. Vol. 60. pp. 221-364. [8] BVSP. 1981. *Basaltic Volcanism on the Terrestrial Planets.* [9] Korotev (2005). *Chemie der Erde* Vol. 65, pp. 297 - 346.