PETROLOGY AND OXYGEN ISOTOPES IN NEW ENSTATITE CHONDRITE FRAGMENTS FROM THE ALMAHATA SITTA FALL.

H. Downes[1,2], C. A. Goodrich[3], R. Greenwood[4], A. J. Ross[2], M Shaddad[5] and P. Jenniskens[6]. [1]Dept. of Earth and Planetary Science, Birkbeck University of London, Malet St, London WC1E 7HX, UK (h.downes@ucl.ac.uk); [2] Dept of Earth Sciences, Natural History Museum, Cromwell Rd, London SW7 5BD, UK; [3]Lunar and Planetary Institute, USRA, Houston Texas, USA; [4]School of Physical Sciences, Open University, Milton Keynes, UK; [5]Dept. of Astronomy, University of Khartoum, Khartoum, Sudan; [6]SETI Institute, Mountain View, California, USA.

Introduction: The presence of chondritic fragments within the Almahata Sitta (AhS) polymict meteorite fall gives an opportunity to investigate parts of their parent bodies which may not otherwise be found in our meteorite collections [1]. We have investigated 5 new enstatite chondrite (EC) fragments from the University of Khartoum collection of AhS [2] for texture, mineralogy, mineral compositions, and oxygen isotopes. The pristine nature of the samples enables us to constrain the range of oxygen isotopes shown by the enstatite chondrite parent body/ies, and the origin(s) of metal assemblages in the meteorites [e.g., 3].

Petrography and Mineralogy: Figures 1 and 2 show representative back-scattered electron (BSE) images and combined elemental X-ray maps of two of the new EC samples. All are fractured but nearly unweathered (although oldhamite CaS shows evidence of weathering). All contain enstatite-rich chondrules showing various states of thermal metamorphism, in a matrix of abundant enstatite, metal and sulfides.

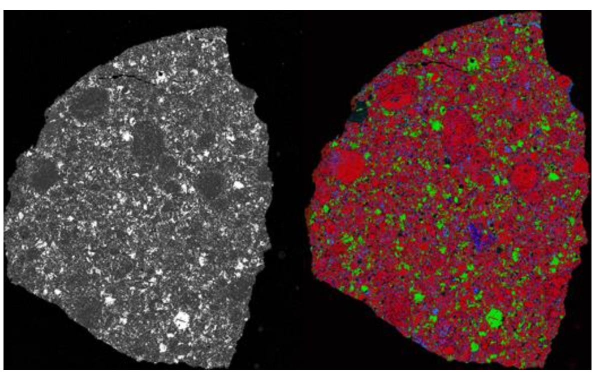

Figure 1. BSE (left) and X-Ray map (right) of EH4-5 sample AhS 2012 (Mg=red; Fe=green; S=blue)

AhS S151 contains more metal than the other samples and has the least well-defined chondrules which are ≤1 mm in diameter. AhS 2012 (Fig. 1) has chondrules with diffuse edges, also no larger than 1 mm. AhS 26 contains very diffuse chondrules, some of which are not circular, with the longest axis of 0.9 mm for the largest chondrule. AhS 1002 (Fig. 2) is distinctly finer grained than the others and contains the best defined and largest chondrules (up to 2.2 mm in diameter), as well as a metal-rich vein. Olivine (Fo_{99}) is occasionally present in some chondrules.

In all samples, enstatite (En_{99}) is the dominant mineral. Albitic feldspars are subhedral to anhedral and up to 50 µm in length. This indicates a high degree of equilibration. Feldspar is almost pure albite. It is commonly associated with the enstatite and a silica phase, which occurs as interstitial anhedral grains up to 40 µm in size. The silica phase contains impurities including 0.5 wt% Al_2O_3 and 0.5 wt% FeO, which is in agreement with its identification as cristobalite.

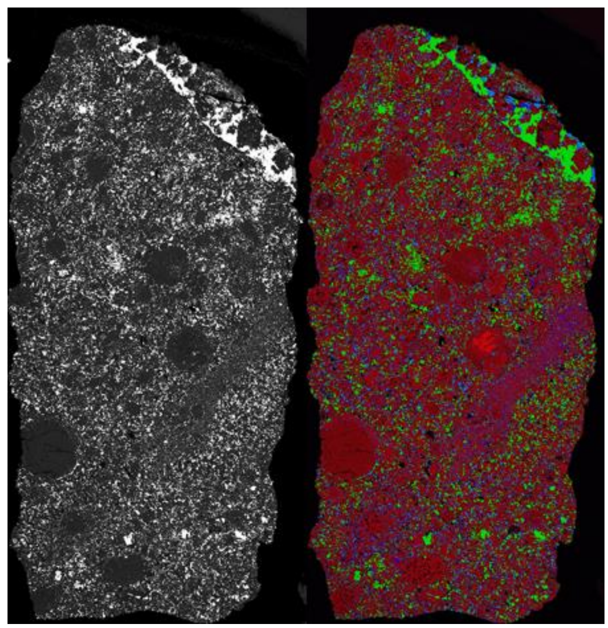

Figure 2. BSE (left) and X-Ray map (right) of EL4-5 sample AhS 1002 showing metal-rich vein (top right) and metal-poor region running from bottom left to middle right of the slide (Mg=red; Fe=green; S=blue)

The samples contain ubiquitous metals and sulfides which are distributed evenly through the sections, except for AhS 1002 in which they are concentrated in a metal-rich vein with sulfides, and are less abundant in a region of finer-grained metal-poor material that is rich in oldhamite (Fig. 2). Metals and sulfides often occur in association with each other, although larger grains of kamacite occur separately. Table 1 shows the average Si and Ni contents of the metals in each of the five samples. Si is found in the metal in all samples.

Sample number	EC Type	Wt. % Si in metal	Wt. % Ni in metal	Wt. % Cr in troilite
AhS 26	EH4-5	2.5	6.5	2.56
AhS 41	EH6	2.5	7.0	2.67
AhS S151	EH4-5	3.1	6.3	1.06
AhS 1002	EL4-5	1.5	7.2	2.80
AhS 2012	EH4-5	2.5	6.7	2.87

Table 1. Average values of Wt. % Si and Ni in metal and Wt. % Cr in troilite in analyzed EC samples.

All samples contain sulfide of a variety compositions including troilite and oldhamite. Niningerite is found in all except AhS 41. Keilite is present in AhS 1002 and AhS 41. Graphite laths are also found sporadically throughout the samples.

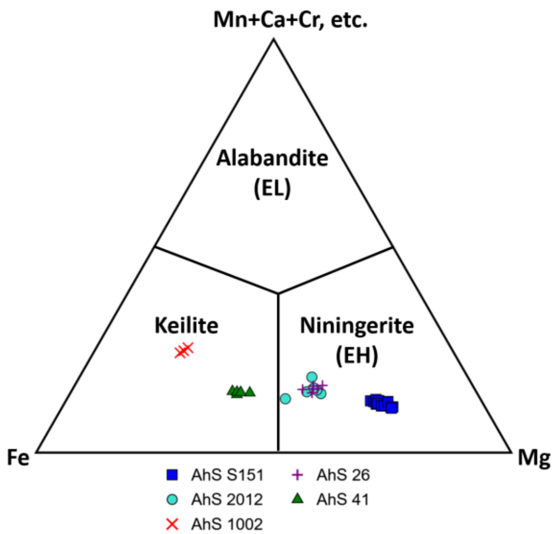

Fig 3 Ternary plot of sulfides from AhS EC samples.

From the petrography and mineralogy, the new samples include one EL4-5 type (AhS 1002), three EH4-5 (AhS S151, AhS 26, AhS 2012) and one EH6 impact melt rock (AhS 41).

Oxygen isotopes: Oxygen isotopes (Fig. 4) were obtained at the Open University using an infrared laser fluorination system. AhS 41 has a $\Delta^{17}O$ value of 0.004 ‰ (using the linear method of [4]), so that the sample lies exactly on the Terrestrial Fractionation Line. Three other samples have $\Delta^{17}O$ values in the range -0.005 to 0.029 ‰. These results are typical of E chondrites and fall within the fields of EL and EH chondrites [6]. Sample AhS S151 has a $\Delta^{17}O$ value of -0.29 ‰ which is lower than the others but still plots within the envelope of data from EH chondrites (Fig. 4) in agreement with its petrography.

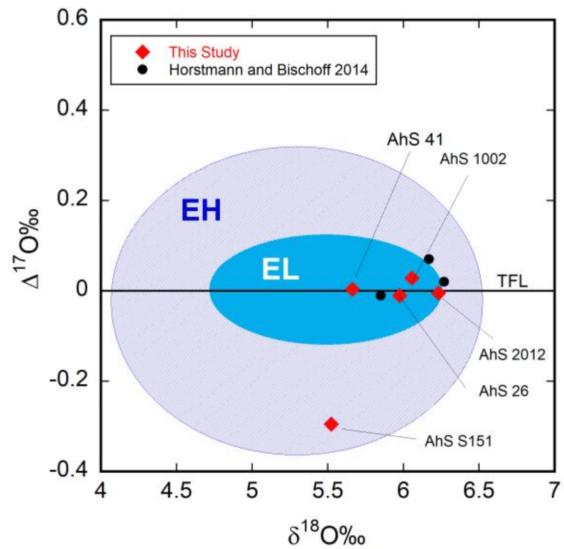

Figure 4. Oxygen isotope data for enstatite chondrite samples from Almahata Sitta analyzed in this study and by [5], compared with fields for ECs [6].

Discussion:

The samples appear to be typical ECs, mostly EH 4-5. Two samples (AhS 2012 and AhS 26) may be paired, but others are clearly derived from different parts of the parent body/ies. The sulfide mineralogy is slightly unusual, as alabandite has not been found in the EL sample AhS 1002, which instead contains keilite. Oxygen isotopes show a remarkably tight field around the $\Delta^{17}O$ = 0‰ line, except for AhS S151 which confirms that the halo of isotopic data on either side of this line is a genuine feature.

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References: [1] Fioretti A M et al. (2017). 48th LPSC Abst #1846. [2] Shaddad M et al., (2010). *Meteoritics & Planetary Science* 45, 1557-1589. [3] Horstmann M et al. (2014). *Geochimica et Cosmochimica Acta* 140 720-744. [4] Miller M. F. (2002). *Geochimica et Cosmochimica Acta* 66, 1881-1889; [5] Horstmann M and Bischoff A (2014). *Chemie der Erde*, 74, 149-183. [6] Newton J et al. (2000). *Meteoritics & Planetary Science* 35, 689-698.