FOUR NEW ANTARCTIC ACHONDRITES RECOVERED BY THE LOST METEORITES OF ANTARCTICA PROJECT. J. L. MacArthur[1], K. H. Joy[1] T. A. Harvey[1], R. H. Jones[1], G. W. Evatt[2], N. V. Almeida[3], J. Malley[4], R. C. Greenwood[4] and R. Findlay[4]. [1]Dept. of Earth & Environmental Sciences, University of Manchester, UK (jane.macarthur@manchester.ac.uk) [2]Dept. of Mathematics, University of Manchester, UK. [3]Dept. of Earth Sciences, Natural History Museum, London, UK. [4]School of Physical Sciences, Open University, Milton Keynes, UK.

Introduction: The Lost Meteorites of Antarctica Project [1,2] retrieved ~120 postulated meteorites from two expeditions in austral summer 2019 and 2020 from the Outer Recovery (OUT) Icefields and Hutchison (HUT) Icefields, named meteorite dense collection zones, in blue icefields located south of the Shackleton Mountain Range [1,2]. A goal of the Lost Meteorites project is to investigate the statistics for different meteorite groups in this previously unsearched part of Antarctica and to understand if there is a sampling bias for stony and iron/stony-iron meteorite types [3]. Four of the 30 meteorites formally classified to date [4] are achondrites which we describe here (Fig. 1). Samples can be requested from the Meteorite Curator at the Natural History Museum (NHM), London.

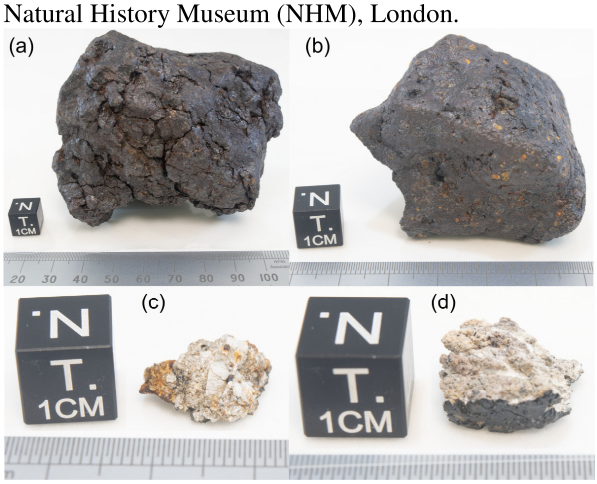

Figure 1. *Main masses of (a) mesosiderite OUT 18014 (b) mesosiderite OUT 18018, (c) aubrite HUT 18034 and (d) eucrite HUT 18035.*

Methods: Details of the curation procedures are described in [5]. Magnetic susceptibility and electrical conductivity were measured for the mesosiderites and are discussed in [6,7]. Chips were prepared into polished blocks and/or thin sections and analysed by SEM at the University of Manchester (UoM). All mineral analyses were by EPMA at the UoM and University of Bristol. Oxygen isotope analysis was conducted at the Open University by laser fluorination of ~2 mg of a larger homogenized sample, reported as per mil deviation from the standard VSMOW [8].

Results: Mesosiderite, Outer Recovery Icefields (OUT) 18014: Two stones were found ~5 metres apart on the blue ice. The first (main mass, 527.30 g) is an irregular, part stone with no fusion crust and dark-gray exterior. Minor orange rust patches were visible on the exterior surface (Figure 1a). The second stone (233.46 g), which is also irregular in shape, has a dark-gray exterior with no fusion crust. Given the similar appearance of the stones and close collection proximity we consider the two stones to be paired.

Petrography: A section from the main mass was examined and found to contain mineral and lithic clasts and a network of metal grains up to 1 mm in size (Figure 2a). Approximately 30% of the stone is low-Ni Fe-metal (with minor taenite), with the remainder comprising 30% pyroxene (mostly low-Ca pyroxene $Fs_{30.7\pm0.3}Wo_{3.1\pm0.2}$ (N=6) but including minor Ca-rich pyroxene), 22% plagioclase ($An_{93.1\pm2.4}Ab_{6.8\pm2.4}$ (N=6)), 8% silica, with minor iron sulfide and merrillite. Silicate grains range up to 1.0 mm in size. Based on the above details, this is a type 3A mesosiderite [9,10].

Oxygen isotopes: A ~105 mg homogenized sample gave results of $\delta^{17}O$=0.153‰, $\delta^{18}O$=0.761‰, $\Delta^{17}O$=-0.246‰. The $\Delta^{17}O$ value was calculated using the linearized method [11] with a slope value of 0.5247. This is consistent with a mesosiderite classification, with oxygen values shifted to lower $\delta^{18}O$ values due to Antarctic weathering.

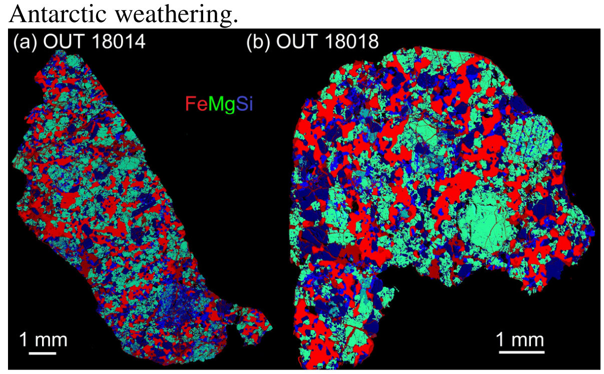

Figure 2. *False colour X-ray element maps of mesosiderites (a) OUT 18014 (b) OUT 18018 where Fe=red, Mg=green, Si=blue. Metal is red, pyroxene is green and plagioclase is blue.*

Mesosiderite, Outer Recovery Icefields (OUT) 18018: A blocky, 153.4 g, part stone with 85% dark gray fusion crust and a dark gray exterior was found on the blue ice. Orange rust patches were visible on the exterior surface (Figure 1b).

Petrography: The meteorite contains mineral and lithic clasts and a network of Fe-metal grains up to 1 mm in size (Figure 2b). Approximately 30% of the stone is low Ni Fe-metal (with minor taenite) with the remainder comprising 30% pyroxene (mostly low-Ca pyroxene ($Fs_{30.6\pm0.5}Wo_{3.3\pm0.7}$ (N=10), with some minor Ca-rich pyroxene), 23% plagioclase ($An_{92.3\pm1.9}Ab_{7.6\pm1.8}$ (N=4)), 6% silica, with minor iron sulfide and merrillite. Silicate grains range up to 1.5 mm in size. Based on the above details, this is a type 3A mesosiderite [9,10]. This stone was found ~1.75 km to the north of the OUT 18014 stones. Further analysis is needed to determine whether the samples are paired.

Aubrite, Hutchison Icefield (HUT) 18034: An irregular, white-gray 0.81 g part-stone with visible white grains (enstatite) and 40% black fusion crust was found on firn (compacted snow) at the edge of a blue icefield. Several orange-brown stained areas, some with inclusions of silvery metallic grains, are visible on the non-fusion crusted surface (Figure 1c).

Petrography: A polished section (Figure 3) consists of predominantly enstatite grains up to 3 mm in a brecciated matrix dominated by enstatite ($En_{98.9\pm0.4}$ $Fs_{0.0\pm0.0}Wo_{1.1\pm0.4}$ (N=10)). Additional minerals include ~8% diopside ($En_{55.9\pm1.2}Fs_{0.1\pm0.1}$ $Wo_{44.0\pm1.2}$ (N=6)), some containing abundant enstatite exsolution lamellae, ~4% plagioclase ($An_{5.0\pm4.6}Ab_{92.0\pm3.8}Or_{3.0\pm0.9}$ (N=5)), ~3% forsterite ($Fo_{100\pm0}$ (N=7)) and occasional grains of Ti-bearing troilite, daubreelite and schreibersite.

Oxygen isotopes: An ~18 mg homogenized sample gave results of $\delta^{17}O$=2.414‰, $\delta^{18}O$=4.531‰, $\Delta^{17}O$=0.058‰. $\Delta^{17}O$ values are calculated using a slope of 0.52. The oxygen isotope analysis plots close to the terrestrial fractionation line (TFL) and is consistent with other aubrite analyses [12,13].

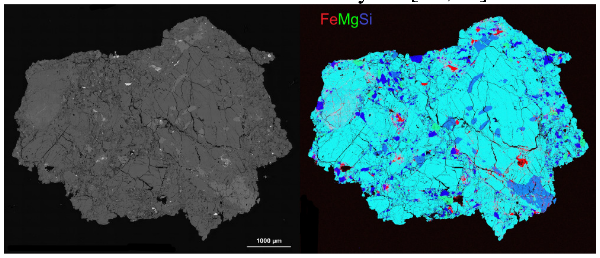

Figure 3. *BSE image and false colour X-ray element map of aubrite HUT 18034 where Fe=red, Mg=green, Si=blue. Enstatite is cyan, diopside is mid-blue, plagioclase is dark blue and forsterite is green.*

Eucrite, Hutchison Icefield (HUT) 18035: An irregular, 1.66 g, part stone with 40% shiny black fusion crust on two sides and sandy colored interior with white clasts (Fig. 1d) was found close to the firn edge of a blue icefield.

Petrography: The meteorite has a brecciated texture composed of fragmented pyroxene and plagioclase grains, as well as igneous clasts comprised of pyroxene and plagioclase with a granular texture (Figure 4). Pyroxene is augite and orthopyroxene with ubiquitous Ca-rich exsolution lamellae, up to 0.6 mm; average pyroxene composition is $Fs_{42.2\pm13.7}Wo_{26.4\pm16.1}$ (N=141). Plagioclase is up to 0.7 mm, $An_{86.8\pm1.5}$ $Ab_{12.6\pm1.5}$ (N=31). Minor silica, ilmenite, phosphate and chromite are present. The Fe/Mn (atomic) in orthopyroxene is 30.3±0.9 (N=44).

Oxygen isotopes: An ~18 mg homogenized sample gave results of $\delta^{17}O$=1.598‰, $\delta^{18}O$=3.485‰, $\Delta^{17}O$=-0.229‰. The $\Delta^{17}O$ value was calculated using the linearized method [11] with a slope value of 0.5247. This plots within ± 2σ of the field for the HEDs [8]. Based on the above details, this is a basaltic eucrite.

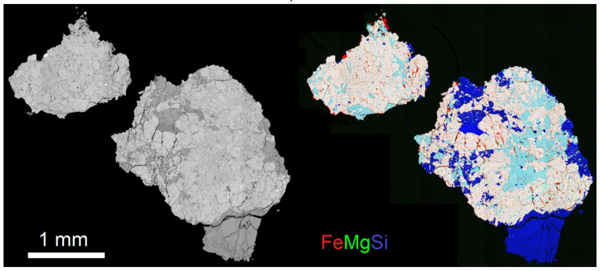

Figure 4. *BSE image and false colour X-ray element map of eucrite HUT 18035 where Fe=red, Mg=green, Si=blue. Pigeonite is pink, augite is cyan and plagioclase is blue.*

Conclusions: 30 meteorites collected by the project have been classified to date: the 4 achondrites reported above and 26 ordinary chondrites (OC): 14 H, 10 L and 2 LL [4]. Antarctic studies show that field areas with smaller meteorite populations (<1000) have an overabundance of unusual meteorite types, whereas those where >1000 meteorites were collected converge at ~90% OC [14]. Our collection has a similar OC abundance. Statistics of previous Antarctic collections show 0.83% are eucrites, 0.09% are aubrites and 0.13% are mesosiderites [4]. Our recovery of an aubrite and two mesosiderites from ~120 samples is unusually higher than these values. This may be partly a result of observing a small sample population from only two different collection areas [14].

Acknowledgments: We thank the Leverhulme Trust and BAS for supporting the field campaigns. Funding for curation and classification work was provided by UoM, NHM, and the Royal Society.

References: [1] Joy K.H. et al. (2019) *50th LPSC,* 2132. [2] www.ukantarcticmeteorites.com [3] Evatt G. W. et al. (2016), *Nat. Comm. 7*, 10679. [4] www.lpi.usra.edu/meteor/metbull.php [5] MacArthur J.L. et al. (2020) *BPSC*. [6] Harvey T.A. et al. (2021) *52nd LPSC*, 2548. [7] Harvey T.A. et al. (2022) *53rd LPSC* 1857. [8] Greenwood R.C. et al. (2017), *Chemie Der Erde - Geochemistry 77*, 1-43. [9] Hewins R.H. (1988) *Meteoritics 23*, 123-129. [10] Powell B.N. (1971) *GCA 35*, 5-34. [11] Miller M.F. (2002) *GCA 66*, 1881-1889. [12] Barrat J-A. et al. (2016) *GCA 192*, 29-48. [13] Newton J. et al. (2000) *MaPS 35,* 689-698. [14] Corrigan C.M. et al. (2020) *51st LPSC*, 2233.