COSMOGENIC RADIONUCLIDES IN CHONDRITE SHOWER FROM OTWAY MASSIF, ANTARCTICA. K. C. Welten[1], K. Nishiizumi[1], M. W. Caffee[2], M. D. Leclerc[3] and A. J. T. Jull[3], [1]Space Sciences Laboratory, University of California, Berkeley, CA 94720-7450, USA (E-mail: kcwelten@berkeley.edu), [2]Department of Physics, Purdue University, West Lafayette, IN 47907, USA, [3]NSF Arizona AMS Laboratory, University of Arizona, Tucson AZ 85721, USA.

Introduction. In the 2003/04 season, the ANSMET team recovered 83 meteorites in an elliptical area of 1.6 x 0.2 km^2 from a blue ice field near Otway Massif in the Grosvenor Mountains (Fig. 1). The size distribution of the meteorites within this area suggests they are a well preserved strewnfield, with the largest mass (29 kg) on the East end and the smallest masses (~100 g) on the West end [1]. The total mass of the fragments is ~105 kg. Most of the meteorites lack fusion crust, while the larger masses show extensive cracks. The distribution of the meteorites and their lack of fusion crust were interpreted to indicate a low-altitude breakup [1]. To confuse things, some of the meteorites were classified as H5, while the majority (including the largest masses, GRO 03001 and 03002) was classified as L5 chondrites and some as LL5.

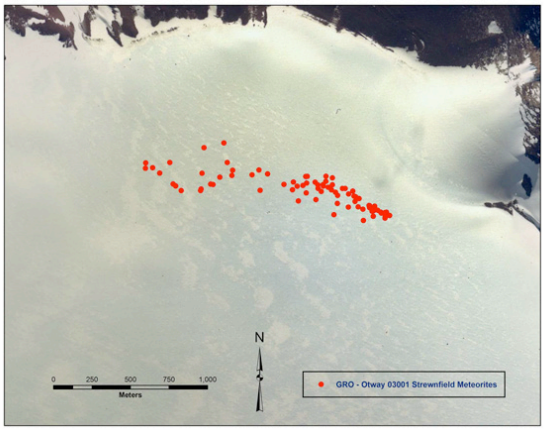

Fig. 1. Distribution of 83 chondrites in Otway Massif strewnfield (from Antarctic Meteorite Newsletter 31-2).

We measured cosmogenic radionuclides in 5 meteorites from the strewnfield area and one found ~1.5 km outside the area (GRO 03017) to determine their terrestrial age and pre-atmospheric size and verify if the meteorites represent fragments of a single object in space. We also measured Ni and Co concentrations in the metal phase of the chondrites to verify their classification as H, L and LL chondrites.

Experimental Methods. We gently crushed 2-3 g of each chondrite in an agate mortar and separated the metal. The metal was then purified by ultrasonic agitation in 0.2N HCl and concentrated HF to remove attached troilite and silicates, respectively. We dissolved 50-100 mg, along with 1-2 mg of Be, Al and Ca carrier and 4-5 mg of Cl, in 1.5 N HNO_3. After dissolution, a small aliquot was taken for chemical analysis (Mg, Fe, Co, Ni) by atomic absorption spectrometry. We separated Be, Al and Cl using ion exchange and acetyl-acetone extraction techniques. For GRO 03001 and 03022 we also measured ^{10}Be and ^{36}Cl in the stone fraction. All AMS measurements of ^{10}Be, ^{26}Al and ^{36}Cl were performed at PRIME lab, Purdue University [2]. We also measured ^{14}C in three bulk samples, GRO 03001, 03022 and 03051 using procedures described previously [3]. The ^{14}C measurements were performed at the University of Arizona [3]. Results of the chemical and radionuclide analysis are summarized in Table 1.

Metal composition. The Ni and Co concentrations of all six chondrites are in the H-chondrite range – even though two were initially classified as L5 or LL5. Classification as H-chondrites is also consistent with their bulk metal content, which ranges from 10-17 wt.%, which is somewhat lower than the range of 15-20 wt.% for H-chondrite falls, but significantly higher than for L-chondrite falls (7-10 wt.%). The lower metal contents of the GRO H-chondrites (relative to falls) are clearly due to terrestrial weathering, as most of these meteorites show moderate to severe rustiness (Table 1).

Terrestrial age and pre-atmospheric size. The ^{10}Be and ^{36}Cl concentrations in the metal phase show three distinct groups: (1) GRO 03017, (2) GRO 03001, 03022 and 03095 and (3) GRO 03051 and 03104. The main pairing group includes 3 chondrites with low ^{10}Be concentrations (2.7-3.3 dpm/kg[metal]) and elevated ^{36}Cl/^{10}Be ratios, which seem to indicate a short CRE age (~1.5 Myr). The undersaturated ^{10}Be concentration precludes us from determining the terrestrial age using the ^{10}Be-^{36}Cl/^{10}Be method [4]. The ^{14}C concentrations of 7±1 dpm/kg in GRO 03001 and 03022 indicate an average terrestrial age of 15.5 ± 1.5 kyr. This age is much longer than the age of <1 kyr which was estimated from the well preserved strewnfield pattern [1].

Based on the recovered mass of ~105 kg (assuming that most fragments are part of the strewnfield), we can constrain the minimum pre-atmospheric radius of the shower to ~20 cm. Due to the undersaturated ^{10}Be concentrations, we cannot directly compare the measured concentrations to calculated depth profiles in objects with known sizes. However, the ^{36}Cl concentrations in the stone phase of GRO

03001/03022 indicate small contributions (1-2 dpm/kg) of neutron-capture ^{36}Cl, suggesting a minimum radius of ~30 cm. Combined with the relatively low ^{10}Be(sto)/^{10}Be(met) ratios of 3.7-4.0, which constrain the radius <45 cm, we conclude that a pre-atmospheric radius of 30-40 cm fits the data.

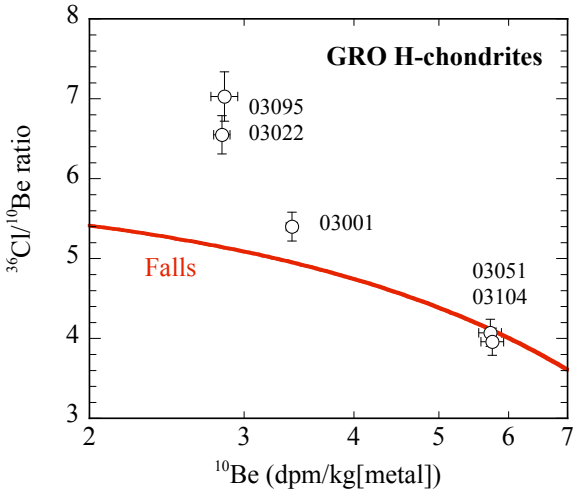

Fig. 2. Measured ^{36}Cl/^{10}Be ratio vs ^{10}Be concentration in the metal phase of GRO H-chondrites. The solid curve represents a least square fit for observed chondrite and iron meteorite falls [4].

The identical and high radionuclide concentrations in GRO 03051 and 03104 suggest that these two meteorites are paired and represent a meteoroid with a small pre-atmospheric size, which is not related to the main strewnfield. The ^{14}C content of 11.3 dpm/kg in GRO 03051 indicates a terrestrial age of 11.7±1.4 kyr. The conclusion that the strewnfield contains at least one other distinct chondrite fall (GRO 03051/03104 pair) is not entirely unexpected, since an area of 0.3 km^2 collects 1 meteorite >100 g every 100 kyr according to the average meteorite influx rate of Halliday [5]. This number could be higher if the the original strewnfield area was larger, and was consequently reduced in size due to compressive iceflow, which is typical for meteorite stranding areas [6]. Finally, GRO 03017, which was found outside the strewnfield area, is distinct from the two other chondrite falls. Its low ^{36}Cl content indicates a terrestrial age of ~200 kyr, even though this meteorite is less weathered than the other GRO H-chondrites.

Conclusions. The radionuclide concentrations in the metal fraction of 6 GRO H-chondrites from the Otway Massif icefield indicate that they represent 3 distinct falls. Three of the meteorites, including the largest mass of 29 kg, represent a shower with a pre-atmospheric radius of 30-40 cm and a terrestrial age of ~15 kyr. It seems plausible that most meteorites in the strewnfield area are part of this shower, but the range in classification from H5 to LL5 lends some uncertainty to this conclusion. Interestingly, the strewnfield was well preserved during the terrestrial residence time of ~15 kyr, indicating that ice flow rates in this area were either very low (a few cm/yr) or perpendicular to the long axis of the strewnfield.

Acknowledgments. This work was supported by NASA grant NNG06GF22G.

References: [1] Kress M. et al. (2007) *Meteorit. & Planet. Sci*. 42, A17. [2] Sharma P. et al. (2000). *Nucl. Instr. Meth*. B172, 112-123. [3] Jull. A. J. T. et al. (1993) *Meteoritics* 28, 188-195. [4] Welten K. et al. (2006) *Meteorit. Planet. Sci*. 41, 1081-1094. [5] Halliday I. et al. (1989) *Meteoritics* 24, 173-178. [6] Cassidy W. et al. (1992) *Meteoritics* 27, 490-525.

Table 1. Metal content and composition (in wt%) and cosmogenic radionuclide concentrations (in dpm/kg) of six ordinary chondrites from Grosvenor Mountains, Antarctica.

Sample	Mass (g)	Type[1]	ABC[1]	metal	Ni	Co	^{10}Be(met)	^{36}Cl(met)	^{14}C(bulk)	^{10}Be(sto)	^{36}Cl(sto)
GRO 03001	29,000	L5	C	13.5	9.5	0.48	3.34±0.10	18.0±0.5	6.2±0.9	12.2±0.2	7.2±0.2
GRO 03022	654	H5	B/C	13.0	10.0	0.49	2.77±0.10	18.2±0.5	8.1±0.8	11.2±0.2	7.3±0.2
GRO 03095	140	H6	C	12.6	10.0	0.47	2.79±0.10	19.6±0.6	–	–	–
GRO 03017	310	LL5	B	17.0	9.2	0.46	–	13.8±1.3	–	–	–
GRO 03051	182	H5	C	12.5	10.4	0.51	5.66±0.18	23.1±0.7	11.3±0.8	–	–
GRO 03104	142	H5	B/C	10.0	11.0	0.48	5.69±0.18	22.5±0.7	–	–	–

[1]Classification and weathering grade (ABC) from Antarctic Meteorite Newsletters 28-2 and 29-1.