Antarctic Meteorite NEWSLETTER

A periodical issued by the Antarctic Meteorite Working Group to inform scientists of the basic characteristics of specimens recovered in the Antarctic.

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!!!!!!!! SAMPLE REQUEST DEADLINE: OCTOBER 20, 1986 (SEE PAGE 2) !!!!!!!!

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ATTACHMENT:

"Unique meteorites attract researchers," by M. E. Lipschutz. Reprinted from <u>Geotimes</u> (November 1985), p. 8-10.

SAMPLE-REQUEST GUIDELINES

All sample requests should be made in writing to

Secretary, MWG
SN2/Planetary Materials Branch
NASA/Johnson Space Center
Houston, TX 77058 USA.

Questions pertaining to sample requests can be directed in writing to the above address or can be directed by telephone to (713) 483-3274.

Requests for samples are welcomed from research scientists of all countries, regardless of their current state of funding for meteorite studies. All sample requests will be reviewed by the Meteorite Working Group (MWG), a peer-review committee that guides the collection, curation, allocation, and distribution of the U. S. Antarctic meteorites. Issuance of samples does not imply a commitment by any agency to fund the proposed research. Requests for financial support must be submitted separately to the appropriate funding agencies. As a matter of policy, U. S. Antarctic meteorites are the property of the National Science Foundation and all allocations are subject to recall.

Each request should refer to meteorite samples by their respective identification numbers and should provide detailed scientific justification for the proposed research. Specific requirements for samples, such as sizes or weights, particular locations (if applicable) within individual specimens, or special handling or shipping procedures should be explained in each request. All necessary information should probably be condensable into a one- or two-page letter, although informative attachments (reprints of publications that explain rationale, flow diagrams for analyses, etc.) are welcome.

Requests that are received by the MWG Secretary before October 20, 1986 will be reviewed at the MWG meeting of October 23-25, 1986 to be held in Washington, DC. Requests that are received after the October 20 deadline may possibly be delayed for review until the MWG meets again in the spring of 1987. PLEASE SUBMIT YOUR REQUESTS ON TIME.

Samples can be requested from any meteorite that has been made available through anouncement in any issue of the *Antarctic Meteorite Newsletter* (beginning with 1(1) in June, 1978). Many of the meteorites have also been described in the following catalogs:

Marvin, U. B. and B. Mason (eds.) (1984) Field and Laboratory Investigations of Meteorites from Victoria Land, Antarctica, *Smithsonian Contr. Earth Sci. No. 26*, Smithsonian Institution Press, 134 pp.

Marvin, U. B. and B. Mason (eds.) (1982) Catalog of Meteorites from Victoria Land, Antarctica, 1978-1980, *Smithsonian Contr. Earth Sci. No. 24*, Smithsonian Institution Press, 97 pp.

Marvin, U. B. and B. Mason (eds.) (1980) Catalog of Antarctic Meteorites, 1977-1978, *Smithsonian Contr. Earth Sci. No. 23*, Smithsonian Institution Press, 50 pp.

EDITOR'S OVERVIEW

James L. Gooding

A NEWSLETTER IN JUNE?

Yes! So many classification data have accumulated that the time between the appearance of issues 9(1) (February 1986) and 9(2) (this issue) was reduced in order to maintain our policy of timely distribution of the latest information. Issue 9(3) will appear in September 1986.

Readers of this Newsletter have become accustomed to seeing two issues each year: one in the spring and one in the fall. By design, each issue has been published so that each recipient has a copy in hand approximately one month before a scheduled meeting of the Meteorite Working Group and can prepare sample requests in time for review by MWG. The system has worked well because the one-month lead time seems to be sufficient for researchers to formulate their sample requests but not so long that the Newsletter information becomes "cold" (and sample requestors forget to act) before the MWG meeting. As noted on page 3, the next MWG meeting will be in October 1986 although sample requests can be submitted at any time. Rather than let this issue become "cold," please feel free to submit, at your earliest opportunity, requests for samples of meteorites announced in this issue.

"NEW" 1978 PEBBLES INCLUDE A UREILITE

In 1980, several research groups agreed to share the workload in classifying numerous "pebble-sized" (< 150 g) meteorite specimens that were collected in 1978. For most specimens, results of those independent classification projects were published in earlier issues of this Newsletter and in the open literature. In this issue, data are presented in Table 1 for the last of the 1978 pebbles, for which classification was undertaken in 1980 by Dr. J. M. Rhodes. We thank Dr. B. H. Mason for helping complete the work.

Please note that one of the pebbles, META78008, is an unusual ureilite. Refer to the description of the rock (p. 19) for more details.

NEW METEORITES FROM 1983-1984 COLLECTIONS

Pages 7-19 contain preliminary descriptions and classifications of meteorites that were completed since publication of issue 9(1) (February 1986). Most large (> 150-g) specimens (regardless of petrologic type) and all "pebble"-sized (< 150-g) specimens of special petrologic type (i.e., carbonaceous chondrite, unequilibrated ordinary chondrite, achondrite, stony-iron or iron) are represented by separate descriptions. However, specimens of non-special petrologic type (i.e., equilibrated ordinary chondrite) are listed only as single-line entries in Table 2. For convenience, new specimens are also recast by petrologic type in Table 3.

Each "macroscopic" description summarizes features that were visible to the eye (with, at most, the aid of a binocular stereomicroscope) at the time the meteorite was first examined. Macroscopic descriptions of stony meteorites were performed at NASA/JSC. Each "thin section" description represents features that were found in a survey-level examination of a polished section that was prepared from a small (usually exterior) chip of the meteorite. Classification is based on microscopic petrography and reconnaissance-level electron-probe microanalyses. For each stony meteorite, the sample number assigned to the preliminary examination section (...,1 or ...,3, etc.) is included as an aid to workers who may later wish to intercompare samples from different locations in the meteorite. Exceptions to that rule occur for descriptions of several specimens that are thought to be members of a single fall. In those cases, a single microscopic description was based on several different thin sections.

Note that Tables 4-6 contain physical data for individual specimens in each of three provisionally suggested pairing groups. Reference to the appropriate table is made in the corresponding petrographic description.

Meteorite descriptions contained in this issue were contributed by the following individuals:

Mrs. Carol Schwarz, Ms. Roberta Score, and Mr. Rene' Martinez
Planetary Materials Laboratory
(NASA/Johnson Space Center)
Northrop Services, Inc.
Houston, Texas

Dr. Brian H. Mason
Department of Mineral Sciences
U. S. National Museum of Natural History
Smithsonian Institution
Washington, DC.

INCLUSIONS IN ALH83100 AND MORE PIECES OF ALH83102 (C2 CHONDRITES)

Although meteorite ALH83100 was formally defined as three fragmented stones, numerous other specimens that were thought to be fragments of the same fall were also collected by the field party. Processing of the many small specimens was recently completed and the resultant physical data are summarized in Table 7. Several of the small specimens show dark inclusions and chondrules that stand in relief on weathered surfaces. Either ALH83100 is more complex than first thought or many of those small carbonaceous-chondrite fragments [illegible]nt separate meteorites. A detailed study of the special fragments noted in Table 7 should be performed to resolve this issue.

As was the case for ALH83100, numerous fragments thought to be paired with ALH83102 were also collected and are summarized in Table 8. Small specimens that were thought to be paired with ALH83102 did not differ significantly in macroscopic appearance from the larger specimen.

COMPREHENSIVE PAIRING DATA

Issue 8(2) summarized possible pairings among meteorites in the U. S. Antarctic collections using a table compiled by Dr. Edward R. D. Scott (Institute of Meteoritics, University of New Mexico, Albuquerque, NM 87131 USA). Ed has updated his data base and has provided the information that is printed here as Tables 9 and 10 and the accompanying references. In addition, Ed provided the following preface:

> These pairing lists include all proposed pairings for Victoria Land and Thiel Mountain specimens. Table 9 gives the specimens in pairing groups and Table 10 lists all these specimens in alphabetical order. Estimates of confidence levels are given:
>
> a = probably paired
>
> b = possibly paired
>
> c = tentatively paired
>
> x = unpaired or highly uncertain pairing.
>
> Table 9 includes from one to five references for each group of paired specimens; additional references are given by Scott (1984). Where possible, references are placed opposite the specimens to which they refer, but in some cases, a paper may refer to specimens on different lines of the same pairing group.
>
> The pairing lists are far from complete. For many of the rarer meteorite types, it is likely that most of the paired specimens have been identified. By contrast, for types 4-6 ordinary chondrites, it is certain that most of the paired specimens have not been recognized.

Note that pairings suggested in Table 1 have not yet been tested by other methods and, therefore, do not appear in Ed's Tables 9 and 10.

ARTICLE BY MIKE LIPSCHUTZ

Each copy of this issue was mailed with a companion copy of the following article:

> Lipschutz, Michael E. (1985) Unique meteorites attract researchers, Geotimes (November 1985), p. 8-10.

Mike's article briefly summarizes major aspects of the collection and study of Antarctic meteorites and is aimed at the general geoscience-oriented audience. Thanks are due to the Lunar and Planetary Institute for covering the cost of reprints.

A few previous issues of the Newsletter have also been accompanied by other excellent, general-interest articles on Antarctic meteorites such as those written by Ursula Marvin, Bill Cassidy, and Lou Rancitelli. Authors of similar articles who would like to make general distributions of reprints are invited to contact the Editor to discuss details.

Table 1.

List of Newly Classified Antarctic Meteorites from the 1978 Collection

Sample Number		Weight (g)	Classification	Weathering	Fracturing	% Fa	% Fs
BTNA78005	*	81.8	H-6 CHONDRITE	B	B	18	16
META78004		30.3	L-6 CHONDRITE	B	A		
META78008	*	125.5	UREILITE	B	B	22	13
META78009		28.8	H-5 CHONDRITE	B	A		
META78011	*	115.7	H-5 CHONDRITE	C	A	17	15
META78012	* $	86.3	H-5 CHONDRITE	B	B	17	16
META78013	$	131.9	H-6 CHONDRITE	B	B		
META78014		100.5	H-6 CHONDRITE	C	A		
META78015		36.8	L-5 CHONDRITE	B	A		
META78016	$	114.1	H-6 CHONDRITE	B/C	B		
META78017	* $	46.9	H-6 CHONDRITE	B/C	A	18	16
META78018		81.9	H-5 CHONDRITE	B	A		
META78019	$	91.1	H-6 CHONDRITE	A/B	B		
META78020	*	63.7	H-6 CHONDRITE	C	A	18	16
META78021		22.6	L-6 CHONDRITE	B/C	B		
META78022	$	48.5	H-6 CHONDRITE	B/C	A		
META78023	*	55.6	H-6 CHONDRITE	B	A	18	16
META78024		22.2	H-6 CHONDRITE	B/C	B		
META78025		58.2	H-6 CHONDRITE	C	B/C		
META78026	*	75.2	H-6 CHONDRITE	C	A	18	15
META78027	* $	52.5	H-6 CHONDRITE	B	B	18	16
RKPA78005		28.7	H-5 CHONDRITE	B	B		

* Classification by B. H. Mason (Smithsonian Institution).
Other classifications by S. E. Haggerty and J. M. Rhodes (University of Massachusetts).

$ Possibly paired with META78012, based on macroscopic observations by R. Score.

Table 2.

List of Newly Classified Antarctic Meteorites

Sample Number	Weight (g)	Classification	Weathering	Fracturing	% Fa	% Fs
ALH 83002	367.1	L-5 CHONDRITE	B	A	23	19
ALH 83003	321.8	H-5 CHONDRITE	A/B	A	17	15
ALH 83004	813.9	L-6 CHONDRITE	B	A	23	19
ALH 83005	227.9	H-5 CHONDRITE	C	B	17	15
ALH 83006	230.2	H-5 CHONDRITE	B/C	C	17	15
EET 83240	247.8	L-5 CHONDRITE	B	A/B	23	20
EET 83260	15.4	L-3 CHONDRITE	B/C	A	7-19	5-25
EET 83262	23.9	H-5 CHONDRITE	A	A	17	16
EET 83267	27.7	H-3 CHONDRITE	B	C	13-23	12-20
EET 83269	8.5	L-5 CHONDRITE	A/B	A/B	23	19
EET 83271	67.3	L-6 CHONDRITE	A/B	A	24	21
EET 83274	82.7	L-3 CHONDRITE	B	A	5-28	5-15
EET 83276	48.9	L-6 CHONDRITE	B	B	24	20
EET 83376	79.3	HOWARDITE	A/B	A/B		21-49
ALH 84002	7554.0	L-6 CHONDRITE	B	A/B	24	20
ALH 84003	3088.7	H-5 CHONDRITE	A/B	A	16	15
ALH 84009	335.6	AUBRITE	A	A	0	0
ALH 84010	303.0	AUBRITE	A	B	0	0
ALH 84012	224.7	AUBRITE	A	A	0	0
ALH 84013	159.9	AUBRITE	A/B	A/B	0	0
ALH 84014	49.4	AUBRITE	A/B	A/B	0	0
ALH 84015	263.9	AUBRITE	A	B	0	0
ALH 84016	149.7	AUBRITE	A	A	0	0
ALH 84017	79.8	AUBRITE	A	B/C	0	0
ALH 84018	81.7	AUBRITE	A	B	0	0
ALH 84019	93.2	AUBRITE	A	A/B	0	0
ALH 84020	191.1	AUBRITE	A/B	A	0	0
ALH 84021	35.7	AUBRITE	A	C	0	0
ALH 84022	12.5	AUBRITE	A	A	0	0
ALH 84023	262.4	AUBRITE	A	A	0	0
ALH 84024	194.4	AUBRITE	A	A	0	0
ALH 84035	3.2	CARBONACEOUS C2	A	A	0.5-6	0.7-7
ALH 84036	2.8	CARBONACEOUS C2	A	A	0.7-40	2-13
ALH 84037	3.0	CARBONACEOUS C3V	B	A	0.8-9	0.5-12
ALH 84038	12.3	CARBONACEOUS C4	A	A	25-30	
ALH 84039	32.8	CARBONACEOUS C2	A/B	A	0.4-31	.8-1.5
ALH 84040	28.7	CARBONACEOUS C2	A	B		
ALH 84041	1.3	CARBONACEOUS C2	A	B		
ALH 84043	16.8	CARBONACEOUS C2	A	B		
ALH 84045	11.4	CARBONACEOUS C2	A	A/B		
ALH 84046	1.5	CARBONACEOUS C2	A	A	.3-2.1	.7-1.0
ALH 84047	4.4	CARBONACEOUS C2	A/B	B		
ALH 84048	12.6	CARBONACEOUS C2	A	B		
ALH 84049	29.4	CARBONACEOUS C2	A	B		
ALH 84050	3.2	CARBONACEOUS C2	A	B		
ALH 84051	34.3	CARBONACEOUS C2	A/B	B		

Table 2 (continued).

Sample Number	Weight (g)	Classification	Weathering	Fracturing	% Fa	% Fs
ALH 84052	10.5	LL-6 CHONDRITE	A/B	A	29	24
ALH 84053	5.2	CARBONACEOUS C2	A	A	.5-1.5	5
ALH 84054	19.4	CARBONACEOUS C2	A	A	.5-36	3
ALH 84065	1641.7	L-6 CHONDRITE	A/B	A	23	20
ALH 84069	1136.3	H-5 CHONDRITE	A	A	19	16

Table 3.

Achondrites

Sample Number	Weight (g)	Classification	Weathering	Fracturing	% Fa	% Fs
ALH 84009	335.6	AUBRITE	A	A	0	0
ALH 84010	303.0	AUBRITE	A	B	0	0
ALH 84012	224.7	AUBRITE	A	A	0	0
ALH 84013	159.9	AUBRITE	A/B	A/B	0	0
ALH 84014	49.4	AUBRITE	A/B	A/B	0	0
ALH 84015	263.9	AUBRITE	A	B	0	0
ALH 84016	149.7	AUBRITE	A	A	0	0
ALH 84017	79.8	AUBRITE	A	B/C	0	0
ALH 84018	81.7	AUBRITE	A	B	0	0
ALH 84019	93.2	AUBRITE	A	A/B	0	0
ALH 84020	191.1	AUBRITE	A/B	A	0	0
ALH 84021	35.7	AUBRITE	A	C	0	0
ALH 84022	12.5	AUBRITE	A	A	0	0
ALH 84023	262.4	AUBRITE	A	A	0	0
ALH 84024	194.4	AUBRITE	A	A	0	0
EET 83376	79.3	HOWARDITE	A/B	A/B		21-49
META78008	125.5	UREILITE	B	B	22	13

Carbonaceous Chondrites

Sample Number	Weight (g)	Classification	Weathering	Fracturing	% Fa	% Fs
ALH 84035	3.2	CARBONACEOUS C2	A	A	0.5-6	0.7-7
ALH 84036	2.8	CARBONACEOUS C2	A	A	0.7-40	2-13
ALH 84039	32.8	CARBONACEOUS C2	A/B	A	0.4-31	.8-1.5
ALH 84040	28.7	CARBONACEOUS C2	A	B		
ALH 84041	1.3	CARBONACEOUS C2	A	B		
ALH 84043	16.8	CARBONACEOUS C2	A	B		
ALH 84045	11.4	CARBONACEOUS C2	A	A/B		
ALH 84046	1.5	CARBONACEOUS C2	A	A	.3-2.1	.7-1.0
ALH 84047	4.4	CARBONACEOUS C2	A/B	B		
ALH 84048	12.6	CARBONACEOUS C2	A	B		
ALH 84049	29.4	CARBONACEOUS C2	A	B		
ALH 84050	3.2	CARBONACEOUS C2	A	B		
ALH 84051	34.3	CARBONACEOUS C2	A/B	B		
ALH 84053	5.2	CARBONACEOUS C2	A	A	.5-1.5	5
ALH 84054	19.4	CARBONACEOUS C2	A	A	.5-36	3
ALH 84037	3.0	CARBONACEOUS C3V	B	A	0.8-9	0.5-12
ALH 84038	12.3	CARBONACEOUS C4	A	A	25-30	

Table 3 (continued).

Chondrites - Type 3

Sample Number	Weight (g)	Classification	Weathering	Fracturing	% Fa	% Fs
EET 83267	27.7	H-3 CHONDRITE	B	C	13-23	12-20
EET 83260	15.4	L-3 CHONDRITE	B/C	A	7-19	5-25
EET 83274	82.7	L-3 CHONDRITE	B	A	5-28	5-15

Table 4.

New specimens tentatively paired with ALH83009 (Aubrite), based on preliminary examination data.

Sample Number	Weight (g)	Dimension (cm)	Field Number
ALH84009	355.6	8.5 x 5.5 x 6	2556
ALH84010	303.0	9 x 5.5 x 3	1456
ALH84012	224.7	6 x 4 x 5	2836
ALH84013	159.9	8 x 4 x 6	2569
ALH84014	49.4	4 x 3 x 3	2847
ALH84015	263.9	8.5 x 5 x 4	2541
ALH84016	149.7	6 x 6 x 2	2846
ALH84017	79.8	6 x 2.5 x 3	2529
ALH84018	81.7	4.5 x 3.5 x 3	2856
ALH84019	93.2	4.5 x 4 x 3.5	1540
ALH84020	191.1	6 x 4 x 4	2838
ALH84021	35.7	<1.5 cm fragments	2510
ALH84022	12.5	2 x 2 x 3	2588
ALH84023	262.4	6 x 4 x 5	2869
ALH84024	194.4	5 x 5 x 4	2839

Table 5.

New specimens tentatively paired with ALH83100 or ALH83102 (C2 Chondrite), based on preliminary examination data.

Sample Number	Weight (g)	Dimension (cm)	Field Number
ALH84035	3.2	<1 cm fragments	2513
ALH84040	28.7	5 x 3 x 2	2052
ALH84041	1.3	1.6 x .8 x 1	1542
ALH84043	16.8	4.5 x 2 x 1.5	2007
ALH84045	11.4	3 x 2.5 x 1.5	2079
ALH84047	4.4	2.5 x 2 x .8 1 x 1.5 x .8	2041
ALH84048	12.6	3.5 x 2.5 x 2	2097
ALH84049	29.4	4.5 x 2.5 x 2	2060
ALH84051	34.3	4 x 3.5 x 2.5	2070

Table 6.

New specimens tentatively paired with ALH84033 (C2 Chondrite), based on preliminary examination data.

Sample Number	Weight (g)	Dimension (cm)	Field Number
ALH84036	2.8	2 x 1.8 x 1	2042
ALH84039	32.8	4.5 x 4 x 2.5	2539
ALH84046	1.5	1.5 x 1.5 x .6	1455
ALH84050	3.2	1.8 x 1.5 x 1	2511
ALH84053	5.2	<1 cm fragments	2017
ALH84054	19.4	3 x 3 x 2	2426

Table 7.

Newly processed specimens of ALH83100 (C2 Chondrite)
(compiled by Carol Schwarz).

Split	Weight (g)	Special Macroscopic Features *
13	98.030	
14	136.800	
15	47.500	
16	74.500	
17	59.300	
18	98.900	
19	98.200	
20	109.800	
21	97.000	
22	96.100	
23	60.010	
24	5.220	
25	71.000	
26	20.750	
27	13.740	
28	8.180	
29	23.400	A.
30	13.440	
31	1.240	
32	5.140	
33	73.860	
34	7.870	
35	10.750	
36	9.140	
37	26.910	
38	4.630	
39	11.210	B.
40	56.750	
41	11.530	B.
42	10.960	
43	6.250	
44	7.480	
45	5.990	
46	2.120	
47	2.530	
48	18.390	
49	26.220	C.
50	19.020	
51	8.090	
52	13.290	
53	66.620	D.
54	45.230	
55	27.970	
56	27.140	
57	28.800	
58	55.090	
59	21.850	
60	19.130	
61	121.020	E.
62	63.140	
63	97.640	
64	71.810	F.
65	39.720	

*
A. Weathered [illegible] clast/chondrule surrounded by radiating fractures.
B. 4-5 mm dark clast/chondrule.
C. 5 x 3 cm dark clast and several 1-mm chondrules.
D. 8 x 5 mm fractured retangular shaped dark inclusion.
E. Several 3-5 mm dark clasts/chondrules.
F. 5-mm diameter distinct dark clast/chondrule and many <1-mm chondrules.

Table 8.

Newly processed specimens of ALH83102 (C2 Chondrite)
(compiled by Carol Schwarz).

SPLIT	WEIGHT (g)	SPLIT	WEIGHT (g)
3	99.710	12	3.530
4	75.150	13	44.650
5	21.390	14	4.080
6	25.340	15	18.280
7	66.760	16	1.290
8	14.560	17	1.160
9	16.580	18	1.100
10	70.570	19	23.760
11	36.900	20	20.560

Sample Nos.: ALH84009, 010, 012, 013, 014, 015, 016, 017, 018, 019, 020, 021, 022, 024 Location: Allan Hills

Meteorite Type: Aubrite

See Table 4 for weights, dimensions, and field numbers.

Macroscopic Description: Rene' Martinez
Most of these aubrites have thin patchy brown to yellow fusion crust. All specimens are slightly weathered. Enstatite clasts are as large as 3.5 cm and as small as 1 mm. The clast population ranges from sparse to dense for the different specimens. Dark aphanitic inclusions and metallic inclusions surrounded by oxidation haloes are both common.

Thin Section Description: Brian Mason
Polished thin sections of these specimens show that they are aubrites, and can confidently be paired with ALH84007, 008, and 011 (described in Antarctic Meteorite Newsletter 8(2), and probably with ALH83009 and 015, collected in the same area (Middle Western Icefield). They consist almost entirely of iron-free enstatite, with rare plagioclase (An7-10), forsterite (usually iron-free, but up to Fa9), and iron-free diopside (Wo42). Small amounts of opaque minerals are present; these include troilite, oldhamite, alabandite, daubreelite, and nickel-iron.

Visual inspection of chips of ALH84014, 015, 018, 019, 020, 021, and 022 show that these are also aubrites, probably pieces of the same meteorite.

Sample Nos.: ALH84035, 040, 041, 043, 045, 047, 048, 049, 051 Location: Allan Hills

Meteorite Type: C2 Chondrite

See Table 5 for weights, dimensions, and field numbers.

Macroscopic Description: Carol Schwarz
These carbonaceous chondrite fragments are all fine-grained and black in color. Some of the fragments contain small white inclusions. Salt deposit has formed on most of them.

Thin Section Description: Brian Mason
These meteorites are C2 chondrites characterized by almost complete serpentinization and can confidently be paired with ALH84029, 030, 031, 032, 034, 042, and 044 (Antarctic Meteorite Newsletter 8(2)); ALH83100 and 83102 are very similar. The major component is a brown to black phyllosilicate matrix enclosing green to pale brown phyllosilicate pseudomorphs of chondrules, inclusions, and mineral grains. Minute grains of calcite are common. Rare grains of forsteritic olivine and clinoenstatite may be present.

Sample Nos.: ALH84036, 039, 046, 050, 053, 054 Location: Allan Hills

Meteorite Type: C2 Chondrite

See Table 6 for weights, dimensions, and field numbers.

<u>Macroscopic Description</u>: <u>Carol Schwarz</u>
Some of these specimens have pitted and fractured fusion crust while some have no fusion crust remaining. The interior of all of these is black with numerous clasts/chondrules that are <0.5 mm in longest dimension. Oxidation is present but minimal. Evaporite deposit has formed on ALH84050 and 054.

<u>Thin Section Description</u>: <u>Brian Mason</u>
Thin sections of all these C2 chondrites are so similar that they can be described as a group, and the possibility of pairing should be considered. ALH84033 (Antarctic Meteorite Newsletter 8(2)) is also similar. Olivine-rich chondrules up to 2 mm diameter, chondrule fragments, and irregular olivine-rich inclusions up to 1.5 mm across are present in a black to translucent brown matrix with many small mineral grains. Most of the olivine is near forsterite in composition, but occasional iron-rich grains (up to Fa40) were analysed. Pyroxene is not common, and is polysynthetically-twinned clionoenstatite. Refractory inclusions up to 0.15-0.2 mm in size, and containing spinel + perovskite + hibonite, are common. Blue pleochroic hibonite is present in only a few inclusions in 036, 039, 046, and 054.

Sample No.: ALH84037
Weight (g): 3.0
Dimensions (cm): 1.5 x 1.3 x 1

Location: Allan Hills
Field No.: 2868

Meteorite Type: C3V Chondrite

<u>Macroscopic Description</u>: <u>Carol Schwarz</u>
This fragment has rusty (and in places, shiny) fusion crust on one surface. Broken surfaces are black and rough with abundant weathering. Evaporite deposit is present on both interior and exterior surfaces. The interior is dark gray to reddish from oxidation. Millimeter-sized lighter colored clasts/chondrules were noted.

<u>Thin Section (,2) Description</u>: <u>Brian Mason</u>
The small section (5 mm across) shows ameboid chondrules and irregular inclusions up to 2 mm in maximum dimension set in a small amount of translucent brown isotropic matrix. The chondrules and inclusions consist of granular olivine with minor amounts of polysynthetically twinned clinopyroxene. Microprobe analyses give the following compositions: olivine, Fa0.8-9, mean Fa4 (CV Fe067); pyroxene, Fs0.5-12. The meteorite is a C3V chondrite and is so similar to ALH84028 that it can confidently be paired with it.

Sample No.: ALH84038
Weight (g): 12.3
Dimensions (cm): 2 x 2.3 x 1.5

Location: Allan Hills
Field No.: 2468

Meteorite Type: C4 Chondrite

Macroscopic Description: Carol Schwarz
This carbonaceous chondrite fragment has black to reddish fusion crust on all but one surface. The interior is dark gray and fine-grained with no features visible. Some white evaporite deposit was exposed.

Thin Section (,3) Description: Brian Mason
The section consists largely of finely granular olivine (grains ranging up to 0.1 mm) with rare chondrules and chondrule fragments, and a little opaque material. Microprobe analyses gave the following compositions: olivine, Fa25-30 (one grain Fa39), mean Fa28; pyroxene and plagioclase may be present in small amounts, but were not found with the probe. The meteorite is classified as a C4 chondrite. It is very similar to ALH82135 and the possibility of pairing should be considered.

Sample No.: ALH84052
Weight (g): 10.5
Dimensions (cm): 2.5 x 1.8 x 1.8

Location: Allan Hills
Field No.: 1452

Meteorite Type: LL6 Chondrite

Macroscopic Description: Carol Schwarz
Black to slightly reddish-brown fusion crust covers 50% of this pebble. The remainder of its surface is black. No features are visible in the black interior except for some metal(?) flecks and reddish-brown staining.

Thin Section (,3) Description: Brian Mason
Chondritic structure is barely perceptible, being represented by a few chondrule fragments in a granular matrix consisting largely of olivine and pyroxene; small amounts of nickel-iron and troilite are present as widely dispersed tiny grains, possibly a shock effect. The texture suggests an aggregate of microclasts. Microprobe analyses give the following compositions: olivine, Fa29; pyroxene, Fs24; plagioclase, An11. The meteorite is classified as an LL6 chondrite.

Sample No.: EET83260
Weight (g): 15.4
Dimensions (cm): 3 x 2 x 2

Location: Elephant Moraine
Field No.: 2997

Meteorite Type: L3 Chondrite

Macroscopic Description: Rene' Martinez
This specimen retains fusion crust on all sides which is iridescent and fractured in some areas. The interior is very dark gray with abundant small white inclusions. Sample is very coherent.

Thin Section (,3) Description: Brian Mason
The section shows a close-packed aggregate of chondrules and chondrule fragments, with some black matrix and minor amounts of troilite and nickel-iron. The chondrules are fairly uniform in size, 0.3-1.2 mm across, and show a variety of types. Considerable weathering is indicated by areas of red-brown limonite throughout the section. Remnants of fusion crust are present. Microprobe analyses give the following compositions: olivine, Fa7-19, mean Fa17 (CV FeO22); pyroxene, Fs5-25. The variability of olivine and pyroxene compositions indicates type 3, and the amount of nickel-iron suggests L group: hence, the meteorite is tentatively classified as an L3 chondrite.

Sample No.: EET83267
Weight (g): 27.7
Dimensions (cm): 3 x 3 x 2

Location: Elephant Moraine
Field No.: 2736

Meteorite Type: H3 Chondrite

Macroscopic Description: Rene' Martinez
Pitted and weathered fusion crust covers most of this sample. The interior is light gray with abundant chondrules visible.

Thin Section (,3) Description: Brian Mason
The meteorite is a close-packed aggregate of chondrules, chondrule fragments, and mineral grains, the latter including a moderate amount of nickel-iron and a smaller amount of troilite. Chondrules range from 0.3 to 1.8 mm in diameter and exhibit a variety of types. Fusion crust is present along one edge. The meteorite appears to be relatively unweathered. Microprobe analyses give the following compositions: olivine, Fa13-23, mean Fa18 (CV FeO13); pyroxene, Fs12-20, mean 18. The variability in olivine and pyroxene compositions indicates type 3, and the amount of metal H group; the meteorite is therefore classified as an H3 chondrite.

Sample No.: EET83274
Weight (g): 82.7
Dimensions (cm): 5.5 x 4 x 3

Location: Elephant Moraine
Field No.: 2880

Meteorite Type: L3 Chondrite

Macroscopic Description: Carol Schwarz
No fusion crust remains on this gray-green rounded specimen. Numerous clasts/chondrules, 1-6 mm in diameter, are present on the surface. The interior is mostly reddish-brown with some areas being black and fine-grained. EET83274 is a very coherent specimen.

Thin Section (,3) Description: Brian Mason
The section shows a close-packed aggregate of chondrules and chondrule fragments, with a small amount of interstitial material; this includes small amounts of nickel-iron and troilite. Chondrules range from 0.6 to 3 mm across, and exhibit a variety of types. Extensive weathering is indicated by areas of red-brown limonite throughout the section. Microprobe analyses give the following compositions: olivine, Fa5-28, mean Fa18 (CV FeO35); pyroxene, Fs5-15. The variability of olivine and pyroxene compositions indicates type 3, and the amount of metal suggests L group; the meteorite is therefore tentatively classified as an L3 chondrite.

Sample No.: EET83376
Weight (g): 79.3
Dimensions (cm): 6.5 x 3.5 x 3

Location: Elephant Moraine
Field No.: 1346

Meteorite Type: Howardite

Macroscopic Description: Roberta Score
One quarter of this achondrite fragment is covered with black fusion crust. The exterior surfaces are darker gray than the interior surfaces. This feature extends approximately 3 mm into the interior as a weathering rind. Few small clasts were noted.

Thin Section (,3) Description: Brian Mason
The meteorite is a microbreccia with a wide variety of rock and mineral clasts. The rock clasts range up to 3 mm across, and include gabbroic, anorthositic, and orthopyroxenitic varieties. Mineral grains are mainly plagioclase, orthopyroxene, and pigeonite, with rare opaques. Microprobe analyses give the following compositions: pyroxene, Wo1-22, En29-78, Fs21-49; plagioclase, An80-96. The meteorite is a pyroxene-plagioclase achondrite, and the presence of orthopyroxene of diogenitic composition indicates that it can be classified as a howardite. It is possibly paired with other EET howardites.

Sample No.: META78008
Weight (g): 125.5
Dimensions (cm): 6 x 4.5 x 3.5

Location: Meteorite Hills
Field No.: 342

Meteorite Type: Ureilite

Macroscopic Description: Roberta Score
Two-thirds of this acondrite is covered with frothy black fusion crust that is iridescent in some areas. The surface devoid of fusion crust is a fracture surface which has weathered to a reddish-brown color. Several cracks penetrate the sample. The exposed interior shows abundant well-defined crystal faces. Weathering of this stone is moderate. The overall interior color is dark brown to reddish-brown.

Thin Section (,6) Description: Brian Mason
The section shows an aggregate of anhedral olivine and pyroxene grains (1-2 mm across), rimmed by opaque limonitic and carbonaceous material. Microprobe analyses give the following compositions: olivine, Fa22 (CaO 0.26%); pyroxene, Wo27Fs13 (with Al_2O_3 3.2%, Na_2O 0.62%, MnO 0.46%, TiO_2 0.25%). The meteorite is a ureilite, but is almost unique in having augite as the pyroxene component; the only comparable ureilite is Yamato 74130 (Takeda et al., Mem. Natl, Inst. Polar Research, Tokyo, Special Issue No. 15, p. 54, 1979).

Table 9. Meteorite specimens that have been paired and the confidence levels of these pairings.

Pair Number	Specimens	Confidence Level	References
UNGROUPED METEORITES			
1.1	ALHA77081, 81261, 81315	a	Mason, 1985
EUCRITES AND HOWARDITES			
2.1	ALHA76005, 77302, 78040, 78132, 78158, 78165, 79017, 81009	a	Score et al., 1982b Schultz, 1985
	80102, 81006-81008, 81010, 81012	b	Delaney et al., 1984
	81001	c	Delaney, 1986
2.2a	EETA79004, 79011, 83228, 83229, 83231, 83232, 83234, 83251, 83283	b	Delaney et al., 1984 Delaney, 1986
2.2b	EETA79005, 79006, 82600, 83227, 83235	b	Delaney et al., 1984; Delaney, 1986
Alternative view			
2.2a	EET 83231, 83232	a	Mason, 1986b
	79004	b	
2.2b	EETA79011, 83229, 83234, 83283	c	Mason, 1986b
2.2c	EETA79005, 79006, 82600, 83212, 83227, 83228, 83235, 83251	c	Mason, 1986b
AUBRITES			
3.1	ALH 83009, 83015, 84007-84024	a	Delaney, 1985; Mason, 1986b,c MacPherson 1985b;
3.2	EET 83246, 83247	x	B. Mason, (unpub. data)
UREILITES			
3.4	ALHA78019, 78262	c	Score et al., 1981, 1982b; Berkley and Jones, 1982
3.5	ALH 82106, 82130	a	Mason, 1984b
MESOSIDERITES			
4.1	ALHA77219, 81059, 81098	b	Mason, 1983a,b
4.2	RKPA79015, 80229, 80246, 80258, 80263	b	Clarke and Mason, 1982
IRONS, GROUP IA			
5.1	ALHA76002, 77250, 77263, 77289, 77290	a	Clarke et al., 1980
	77283	x	Malvin et al., 1984
IRONS, GROUP IIB			
5.2	DRPA78001-78016	a	Clarke, 1982
CM2 CHONDRITES			
6.1	ALHA81002, 81004, 82100	b	McSween, 1986b
	78261, 82131, 83016	c	Mason, 1983a; McSween, 1986
	84033, 84036, 84039, 84046, 84050, 84053, 84054	b	Mason, 1986c
	77306	x	Score et al., 1982b

Pair Number	Specimens	Confidence Level	References
6.2	ALH 83100, 83102, 83106	b	Macpherson, 1985a,b
	84029-84032, 84034, 84035, 84040-84045, 84047-84049, 84051	a	Mason, 1986c
CO3 CHONDRITES			
6.3	ALHA77003, 83108	c	Mason, 1986a
	82101	x	Scott, 1984b; Wieler et al., 1985
CV3 CHONDRITES			
6.4	ALHA81003, 81258	c	Mason, 1985
6.5	ALH 84028, 84037	b	Mason, 1986c
C4 CHONDRITES			
6.6	ALH 82135, 84038	c	Mason, 1986c
EH3/4 CHONDRITES			
7.1	ALHA77156, 77295	a	McKinley and Keil, 1984;
	81189	x	Wieler et al., 1985; Scott, 1986
7.2	EET 83307, 83322	b	Mason, 1986a
E6 CHONDRITES			
7.2	ALHA81021, 81260	c	Mason, 1985
H4 CHONDRITES			
8.1	ALHA77004,77190-77192, 77208, 77223-77226, 77232, 77233	b	Cassidy, 1980
	77221	c	Scott, 1984b
8.2	ALHA77009, 81022	c	Score et al.,1984;Mason, 1983a
	78084	x	Scott,1984b;Sarafin et al.,1985
8.3	ALHA78193, 78196, 78223	b	Anonymous, 1981
8.4	ALHA80106, 80121, 80128, 80131	c	Mason and Clarke, 1982
8.5	ALHA81041, 81043-81052	c	Score, 1983; Mason, 1983b
8.6	RKPA80237, 80267	b	Mason and Clarke, 1982
	80232	x	Scott, 1984
H5 CHONDRITES			
9.1	ALHA77014, 77264	c	Cassidy, 1980
9.2	ALHA77021, 77025, 77061, 77062, 77064, 77071, 77074, 77086, 77088	c	Cassidy, 1980; Score et al., 1981
	77102	x	
9.3	ALHA77118, 77119, 77124	c	Cassidy, 1980
9.4	ALHA78209, 78221, 78225, 78227, 78233	b	Anonymous, 1981
9.5	ALHA79031, 79032	b	Score et al., 1981
9.6	ALHA80111, 80124, 80127, 80129, 80132	c	Mason and Clarke, 1982; Vogt et al., 1985
9.7	RKPA80217, 80218	c	Score et al., 1982a

Pair Number	Specimens	Confidence Level	References
9.8	RKPA80220, 80223	c	Score et al., 1982a
9.9	RKPA80250, 80251	c	Score et al., 1982a
9.10	TIL 82412, 82413	c	Mason, 1984b
9.11	TIL 82414, 82415	c	Mason, 1984b
H6 CHONDRITES			
10.1	ALHA77144, 77148	c	Cassidy, 1980
10.2	ALHA77271, 77288	a	Cassidy, 1980; Scott, 1984
10.3	ALHA78211, 78213, 78215, 78229, 78231	b	Anonymous, 1981
10.4	ALHA80122, 80126, 80130	c	Mason and Clarke,1982
10.5	ALHA81035, 81038, 81103, 81112	c	Mason, 1983a,b; Anonymous, 1984
10.6	MBRA76001, 76002	a	Weber and Schultz, 1980
10.7	RKPA80203, 80206, 80208, 80211, 80213, 80214, 80221, 80254, 80255, 80265, 80266	b	Mason and Clarke, 1982; Scott, 1984
	80231, 80262	c	
10.8	EET 82610, 82615	c	Mason, 1984b
10.9	PCA 82526, 82527	c	Mason, 1984b
L3 CHONDRITES			
11.1	ALHA77011, 77015, 77031, 77033, 77034, 77036, 77043, 77047, 77049, 77050, 77052, 77115, 77140, 77160, 77163-77167, 77170, 77175, 77178, 77185, 77211, 77214, 77241, 77244, 77249, 77260, 77303, 78013, 78015, 78017, 78037, 78038, 78041, 78162, 78170, 78176, 78180, 78186, 78188, 78235, 78236, 78238, 78239, 78243, 79001, 79045, 80133, 81025, 81030-81032, 81053, 81060, 81061, 81065, 81066, 81069, 81085, 81087, 81121, 81145, 81156, 81162, 81190, 81191, 81214, 81229, 81243, 81259, 81272, 81280 81292, 81299	a	McKinley et al., 1981; Scott, 1984, 1986; Nishiizumi et al., 1983; Wieler et al., 1985
11.2	ALHA77215-77217, 77252	a	Score, 1980; Nautiyal et al., 1982
11.3	RKPA79008, 80207	x	Wieler et al., 1985; Scott, 1986
11.4	ALHA78046, 83008	c	Mason, 1986b
L4 CHONDRITES			
12.1	RKPA80216, 80242	b	Score et al., 1982a
L5 CHONDRITES			
13.1	ALHA81018, 81023	c	Mason, 1983a
	81017	x	Marvin, 1986

Pair Number	Specimens	Confidence Level	References
13.2	PCA 82504, 82505	c	Mason, 1984a
13.3	RKPA80209, 80228, 80268	c	Mason and Clarke, 1982
L6 CHONDRITES			
14.1	ALHA76003, 76007	x	Weber and Schultz, 1980
14.2	ALHA77001, 77292, 77293, 77296, 77297	b	Cassidy, 1980
	77150, 77180, 77305	x	Anonymous, 1984; Scott 1984
14.3	ALHA77272, 77273	a	Cassidy, 1980
	77280, 77282	b	Goswami and Nishiizumi, 1983
	77231, 77269, 77270, 77277, 77281, 77284	x	Anonymous, 1984; Scott, 1984
14.4	ALHA78043, 78045	b	Score et al., 1981
14.5	ALHA78103, 78105	b	Anonymous, 1984
	78104, 78251	x	Scott, 1984
14.6	ALHA78112, 78114	x	Score et al., 1981; Nishiizumi et al., 1983
14.7	ALHA78126, 78130, 78131	x	Score et al., 1981; Scott, 1984
14.8	ALHA80101, 80103, 80105, 80107, 80108, 80110, 80112-80117, 80119, 80120, 80125	a	Score et al., 1982a; Mason and Clarke, 1982
	81017, 81107, 81262	b	Marvin, 1986
14.9	ALHA81027-81029	b	Mason, 1983a,b
14.10	BTNA78001, 78002	a	Score et al., 1981; R.Score, unpubl. data
14.11	EET 82605, 82606	c	Mason, 1984a
14.12	RKPA78001, 78003	b	Score et al., 1981
	79001, 79002, 80202, 80219, 80225, 80252, 80261, 80264	c	Mason and Clarke, 1982; Scott, 1984
LL3 CHONDRITES			
15.1	ALHA76004, 81251	b	Scott, 1984; Wieler et al., 1985
15.2	ALHA79003, 83007	c	Mason, 1986a
LL6 CHONDRITES			
16.1	RKPA80238, 80248	a	Mason and Clarke, 1982;
	80222	b	Sarafin and Herpers, 1983; Signer et al., 1983
16.2	ALHA78153, 81123, 83070	c	Mason, 1986a

*Confidence levels: a, high (>95%); b, medium (80-90%); c, low (50-75%); x, unpaired or highly uncertain pairing.

Table 10. Numerical list of meteorite specimens that have been paired and the confidence level of these pairings.

SPECIMEN NUMBER	PAIR NUMBER	CONFIDENCE* LEVEL	SPECIMEN NUMBER	PAIR NUMBER	CONFIDENCE* LEVEL
ALHA					
76002	5.1	a	77185	11.1	a
76003	14.1	x	77190-77192	8.1	b
76004	15.1	b	77208	8.1	b
76005	2.1	a	77211	11.1	a
76007	14.1	x	77214	11.1	a
77001	14.2	b	77215-77217	11.2	a
77003	6.3	c	77219	4.1	b
77004	8.1	b	77221	8.1	c
77009	8.2	c	77223-77226	8.1	b
77011	11.1	a	77231	14.3	x
77014	9.1	c	77232	8.1	b
77015	11.1	a	77233	8.1	b
77021	9.2	c	77241	11.1	a
77025	9.2	c	77244	11.1	a
77031	11.1	a	77249	11.1	a
77033	11.1	a	77250	5.1	a
77034	11.1	a	77252	11.2	a
77036	11.1	a	77260	11.1	a
77043	11.1	a	77263	5.1	a
77047	11.1	a	77264	9.1	c
77049	11.1	a	77269	14.3	x
77050	11.1	a	77270	14.3	x
77052	11.1	a	77271	10.2	a
77061	9.2	c	77272	14.3	a
77062	9.2	c	77273	14.3	a
77064	9.2	c	77277	14.3	x
77071	9.2	c	77280	14.3	b
77074	9.2	c	77281	14.3	x
77081	1.1	a	77282	14.3	b
77086	9.2	c	77283	5.1	x
77088	9.2	c	77284	14.3	x
77102	9.2	x	77288	10.2	a
77115	11.1	a	77289	5.1	a
77118	9.3	c	77290	5.1	a
77119	9.3	c	77292	14.2	b
77124	9.3	c	77293	14.2	b
77140	11.1	a	77295	7.1	a
77144	10.1	c	77296	14.2	b
77148	10.1	c	77297	14.2	b
77150	14.2	x	77302	2.1	a
77156	7.1	a	77303	11.1	a
77160	11.1	a	77305	14.2	x
77163-77167	11.1	a	77306	6.1	x
77170	11.1	a	78013	11.1	a
77175	11.1	a	78015	11.1	a
77178	11.1	a	78017	11.1	a
77180	14.2	x	78019	3.4	c

SPECIMEN NUMBER	PAIR NUMBER	CONFIDENCE* LEVEL
ALHA (continued)		
78037	11.1	a
78038	11.1	a
78040	2.1	a
78041	11.1	a
78043	14.4	b
78045	14.4	b
78046	11.4	c
78084	8.2	x
78103	14.5	b
78104	14.5	x
78105	14.5	b
78112	14.6	x
78114	14.6	x
78126	14.7	x
78130	14.7	x
78131	14.7	x
78132	2.1	a
78153	16.2	c
78158	2.1	a
78162	11.1	a
78165	2.1	a
78170	11.1	a
78176	11.1	a
78180	11.1	a
78186	11.1	a
78188	11.1	a
78193	8.3	b
78196	8.3	b
78209	9.4	b
78211	10.3	b
78213	10.3	b
78215	10.3	b
78221	9.4	b
78223	8.3	b
78225	9.4	b
78227	9.4	b
78229	10.3	b
78231	10.3	b
78233	9.4	b
78235	11.1	a
78236	11.1	a
78238	11.1	a
78239	11.1	a
78243	11.1	a
78251	14.5	x
78261	6.1	c
78262	3.4	c
79001	11.1	a
79003	15.2	c
79017	2.1	a
79031	9.5	b
79032	9.5	b
79045	11.1	a
80101	14.8	b
80102	2.1	b
80103	14.8	b
80105	14.8	b
80106	8.4	c
80107	14.8	b
80108	14.8	b
80110	14.8	b
80111	9.6	c
80112-80117	14.8	b
80119	14.8	b
80120	14.8	b
80121	8.4	c
80122	10.4	c
80124	9.6	c
80125	14.8	b
80126	10.4	c
80127	9.6	c
80128	8.4	c
80129	9.6	c
80130	10.4	c
80131	8.4	c
80132	9.6	c
80133	11.1	a
81001	2.1	b
81002	6.1	b
81003	6.4	c
81004	6.1	b
81006-81008	2.1	b
81009	2.1	a
81010	2.1	b
81012	2.1	b
81017	13.1	x
	14.8	b
81018	13.1	c
81021	7.2	c
81022	8.2	c
81023	13.1	c
81025	11.1	a
81027-81029	14.9	b
81030-81032	11.1	a
81035	10.5	c
81038	10.5	c
81041	8.5	c
81043-81052	8.5	c
81053	11.1	a
81059	4.1	b
81060	11.1	a
81061	11.1	a
81065	11.1	a
81066	11.1	a
81069	11.1	a
81085	11.1	a
81087	11.1	a

SPECIMEN NUMBER	PAIR NUMBER	CONFIDENCE* LEVEL
ALHA (continued)		
81098	4.1	b
81103	10.5	c
81107	14.8	b
81112	10.5	c
81121	11.1	a
81123	16.2	c
81145	11.1	a
81156	11.1	a
81162	11.1	a
81189	7.1	x
81190	11.1	a
81191	11.1	a
81214	11.1	a
81229	11.1	a
81243	11.1	a
81251	15.1	b
81258	6.4	c
81259	11.1	a
81260	7.2	c
81261	1.1	a
81262	14.8	b
81272	11.1	a
81280	11.1	a
81292	11.1	a
81299	11.1	a
81315	1.1	a
82100	6.1	b
82101	6.3	x
82106	3.5	a
82130	3.5	a
82131	6.1	c
82135	6.6	c
83007	15.2	c
83008	11.4	c
83009	3.1	a
83015	3.1	a
83016	6.1	c
83070	16.2	c
83100	6.2	b
83102	6.2	b
83106	6.2	b
83108	6.3	c
84007-84024	3.1	a
84028	6.5	b
84029-84032	6.2	a
84033	6.1	b
84034	6.2	a
84035	6.2	a
84036	6.1	b
84037	6.5	b
84039	6.1	b
84040-84045	6.2	a
84046	6.1	b
84050	6.1	b
84053	6.1	b
84054	6.1	b
BTNA		
78001	14.10	a
78002	14.10	a
DRPA		
78001-78016	5.2	a
EETA		
79004-79006	2.2	b
79011	2.2	b
82600	2.2	b
82605	14.11	c
82606	14.11	c
82610	10.8	c
82615	10.8	c
83227-83229	2.2	b
83231	2.2	b
83232	2.2	b
83234	2.2	b
83235	2.2	b
83246	3.2	x
83247	3.2	x
83251	2.2	b
83283	2.2	b
83307	7.2	b
83322	7.2	b
MBRA		
76001	10.6	a
76002	10.6	a
PCA		
82504	13.2	c
82505	13.2	c
82526	10.9	c
82527	10.9	c
RKPA		
78001	14.12	b
78003	14.12	b
79001	14.12	c
79002	14.12	c
79008	11.3	x
79015	4.2	b
80202	14.12	c
80203	10.7	b
80206	10.7	b
80207	11.3	x
80208	10.7	b
80209	13.3	c

SPECIMEN NUMBER	PAIR NUMBER	CONFIDENCE* LEVEL	SPECIMEN NUMBER	PAIR NUMBER	CONFIDENCE* LEVEL
80211	10.7	b	80250	9.9	c
80213	10.7	b	80251	9.9	c
80214	10.7	b	80252	14.12	c
80216	12.1	b	80254	10.7	b
80217	9.7	c	80255	10.7	b
80218	9.7	c	80258	4.2	b
80219	14.12	c	80261	14.12	c
80220	9.8	c	80262	10.7	c
80221	10.7	b	80263	4.2	b
80222	16.1	b	80264	14.12	c
80223	9.8	c	80265	10.7	b
80225	14.12	c	80266	10.7	b
80228	13.3	c	80267	8.6	b
80229	4.2	b	80268	13.3	c
80231	10.7	c			
80232	8.6	x	TIL		
80237	8.6	b	82412	9.10	c
80238	16.1	a	82413	9.10	c
80242	12.1	b	82414	9.11	c
80246	4.2	b	82415	9.11	c
80248	16.1	a			

* Confidence levels: a, high; b, medium, c, low; x, unpaired or highly uncertain pairing.

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Unique meteorites attract researchers

Antarctica—the largest, highest, coldest, driest terrestrial desert—for decades has been the site of many expeditions aimed at uncovering its history and resources. Today, scientific teams are there to mine extraterrestrial materials from asteroids, the Moon, and probably Mars.

The first Antarctic meteorite was found in 1912 in Adelie Land by a member of the party led by Australian explorer Mawson, during the 'heroic era' of Antarctic exploration. By 1964, American and Russian glaciological teams had found 3 other meteorites, irons or stony irons easily recognized as 'peculiar'. They were discovered in the Lazarev, Neptune and Thiel mountains, widely separated parts of the continent. The true significance of these finds was not recognized until 1969 when a Japanese Antarctic Research Expedition team found 9 fragments in the Yamato Mountains. They included representatives of 4 major meteorite classes, so they could not have been part of the same fall. Japanese discoveries of nearly 1,000 more fragments in the same area during the 1973-1975 field seasons demonstrated that something unusual was happening: Outside of Antarctica, meteorites are not found that often. The total number of non-Antarctic meteorite finds (those not observed to fall) is only 1,700 over all time, essentially in the last 200 years. (Some finds can consist of many fragments.)

Starting in 1976, William Cassidy, University of Pittsburgh, has led annual Antarctic Search for Meteorites trips, mainly to collect samples and for related studies. During the first 3 seasons, U.S. and Japanese teams worked together in the Allan Hills region of Victoria Land; discoveries were shared equally by the 2 countries. In 1979, teams led by Cassidy and Keizo Yanai of the Japanese National Institute of Polar Research, in Tokyo, began collecting independently. More than 7,000 fragments have now been collected, about 5,000 of those by J.A.R.E. teams. This past season, German glaciologists discovered 40 samples in the Frontier Mountains near Allan Hills in their first collecting effort. Antarctic discoveries correspond to 1,200 to 3,500 distinct meteorite impacts: just a little more than 2,600 are known from the rest of the world.

The scientific potential of Antarctic meteorites was recognized very early by the National Science Foundation, the National Aeronautics & Space Administration and the Smithsonian Institution, which coöperate in managing the meteorite-collecting and curating program and in supporting their study. Meteorites are studied because they include the oldest Solar System materials available and because they are samples of a wide range of parent bodies. Antarctic meteorites not only have this space connection, but, because they are associated with the ice sheet covering Antarctica, contain unique information on the ice sheet's history. An obvious question, not yet satisfactorily answered, is why Antarctica contains such a meteorite trove. Since Antarctic meteorites are generally associated with old, blue ice upstream from a barrier such as a mountain, the ice sheet must play an important role in collecting, preserving, transporting and concentrating entrapped samples.

John Annexstad (NASA Johnson Space Center) photographs a meteorite in Antarctica, while a Navy helicopter crewman holds the tape measure. (Photo from Michael E. Lipschutz)

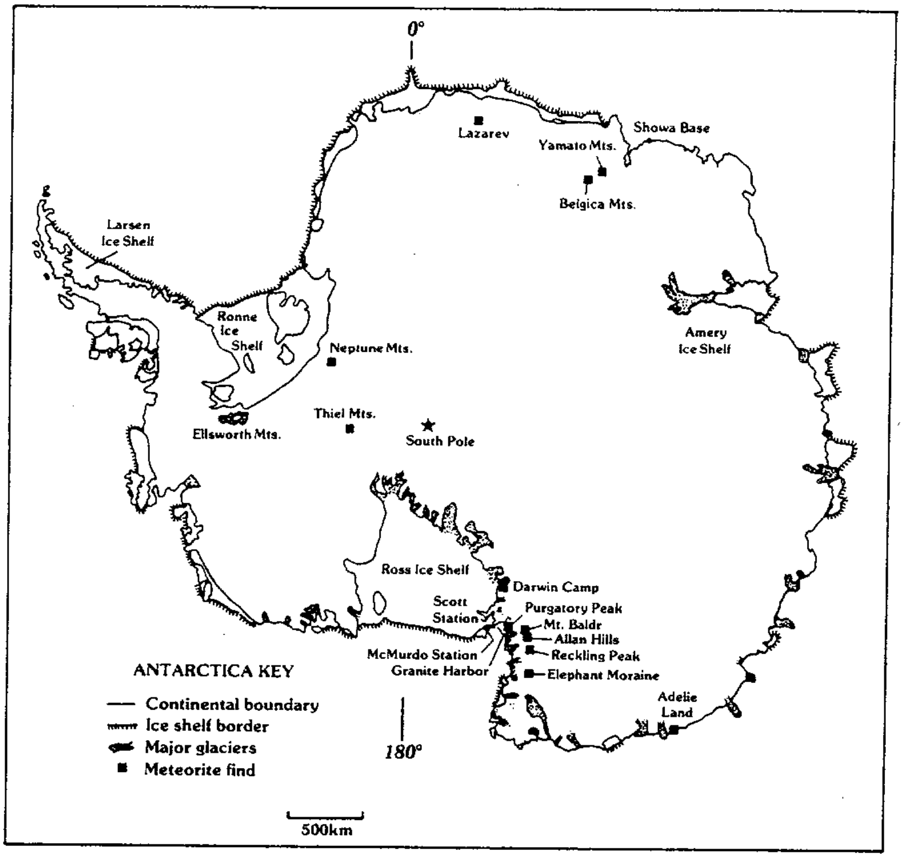
In the U.S. program, promising blue-ice areas are identified on satellite images or by air or ground reconnaissance. After A.N.S.M.E.T. teams have landed by ski-equipped C-130 airplanes, they travel by snowmobile. The dark meteorites, easily seen against the blue ice, are photographed, documented, collected using clean procedures, and put in Teflon bags. Specimens are kept frozen until they arrive at Johnson Space Center, in Houston, where they are classified and curated as carefully as were the lunar samples. Iron meteorites and thin sections from stony meteorites are sent to the Smithsonian Institution for classification and curation. Careful documentation is maintained during curation so that researchers can later obtain samples near those of particular interest.

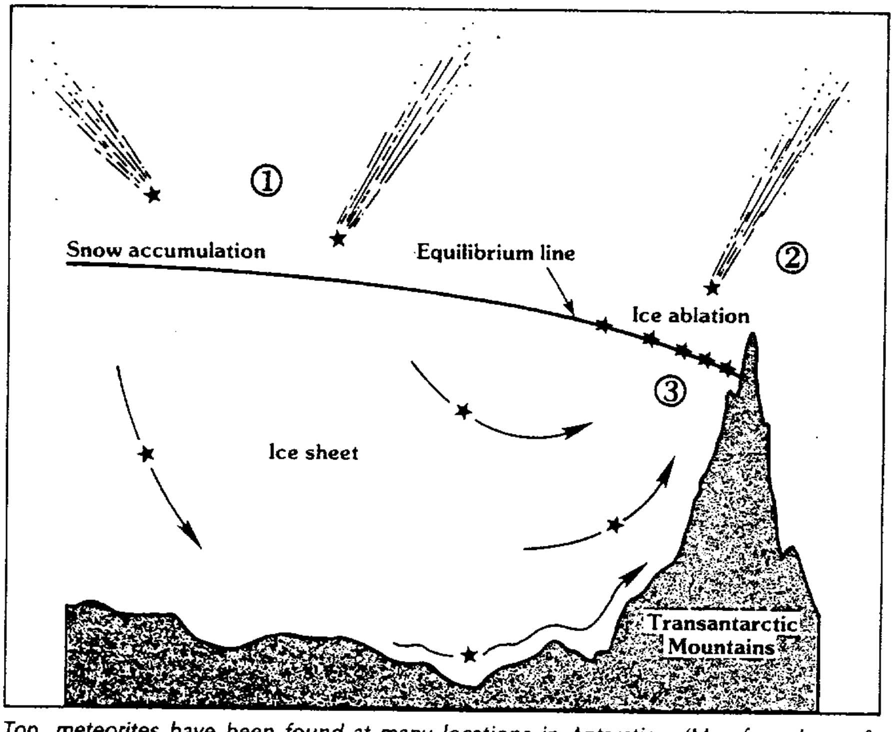
The Meteorite Working Group, a panel of university and government researchers directed by the Lunar & Planetary Institute, in Houston, advises the 3 U.S. agencies. The Japanese work similarly; curating is done at N.I.P.R. German samples are studied at the Max-Planck-Institut für Chemie, in Mainz. As of December 1984, the U.S. program had provided 2,764 sub-samples to 142 groups of investigators in 17 countries. Japan has provided additional samples to international scientific groups.

Why are such efforts expended to obtain and study Antarctic samples? The sudden availability of many samples wasn't the main reason for interest in them. Just as many other people are attracted to oddities, meteorite researchers are interested in unusual specimens. Practically from the first, Kou Kusunoki of N.I.P.R. recognized that Antarctic meteorites include a substantial proportion of rare or unique types compared to the non-Antarctic meteorite population. The recovery and study of exciting specimens has turned out to be nearly an annual event.

For example, in the 1974 season, the first 3 eucrites were found. Such meteorites were known from studies of non-Antarctic samples to be basaltic meteorites formed early in the Solar System's history at low pressures in the absence of solid-liquid fractionation. Many more Antarctic eucrites have been discovered, and they consistently turn out to be texturally and compositionally unique from non-Antarctic samples.

The discovery on Earth of naturally transported lunar samples was more exciting. The first, a 31-gram piece,





Top, meteorites have been found at many locations in Antarctica. (Map from Lunar & Planetary Institute)

Bottom, meteorites that fall on the ice move with it and are crowded together in the blue-ice ablation zone at the mountain barrier. (Diagram from Lunar & Planetary Institute, based on a model proposed by Ian Whillans, Institute of Polar Studies, Ohio State University, and William A. Cassidy, University of Pittsburgh)

was found in December 1981 and immediately thought to be lunar. A consortium of 22 groups including our own used a total of only 1 gram while analyzing it. We reported at the Lunar & Planetary Science Conference, in March 1983, in Houston, that Allan Hills 81005 originated from a previously unsampled part of the lunar highlands. It was relatively unshocked (even compared with ordinary meteorites), all the more surprising since it must have been launched at escape velocity, more than 2.4 km a second, during an impact on the Moon. 3 more lunar samples, 2 of which look very similar and may well be paired, from the Yamato Mountains, were later identified. The first, Y 791197, weighed 52 grams and was studied by 21 groups, including ours. We reported at the Antarctic Meteorite Symposium in March, in Tokyo, that the sample came from the same general lunar highlands region as ALHA 81005 but was definitely not paired with it. Whether ALHA 81005 and Y 791197 were ejected from the Moon in the same large explosive impact is not yet known. Samples of the remaining lunar samples, Y 82192 and 82193, have not yet been distributed to many researchers.

As a result of the Antarctic discoveries, the shergottites, another basaltic meteoritic group, aroused renewed interest. Shergottites are heavily shocked and crystallized only recently (1.3 billion years ago). Some researchers have suggested they came from Mars. One argument raised against a Martian origin was that naturally transported lunar samples were unknown on Earth, even though the Moon is much closer and has a lower escape velocity, 2.4 instead of 5.0 km a second. With the discovery of relatively unshocked samples like ALHA 81005 and Y 791197, the argument vanished. Then 2 more shergottites were found in Antarctica, doubling the number known of the rare type. One is especially interesting: The 7.9-kg Elephant Moraine (EETA) 79001 is the only meteorite known with contact between 2 igneous lithologies. Donald Bogard and Pratt Johnson, Johnson Space Center, showed that it contains noble gases in proportions known from data taken by the Viking landers to be characteristic of Mars. Furthermore, Robert Becker and Robert Pepin, University of Minnesota, showed that glass samples from EETA 79001 contain nitrogen with an isotopic signature indicating a mixture of the atmospheric compositions unique to Mars and Earth. Consortiums (our group is a member) have been studying the chemistry of shergottites to learn about the origin of Mars, from which no samples have yet been returned by spacecraft. A meteorite is a 'poor man's space probe'.

Why are these and other rare or unique meteorites found in such numbers in Antarctica? Our group has been studying the trace-element chemistry of ordinary chondrites and concludes that the subtle compositional differences between them and non-Antarctic chondrites occur because the 2 sets derive from different mixtures at their extraterrestrial sources. The problem is that existing dynamic models of the orbits of meteorites would not lead us to predict that.

The 2 main Antarctic samplings (J.A.R.E. and A.N.S.M.E.T.), taken from opposite ends of the continent, exhibit some curious differences. Usually A.N.S.M.E.T. samples are much larger than J.A.R.E. samples; the cause of the meteorite-size difference between the 2 collecting regions is of great interest. The A.N.S.M.E.T. samples have generally been on Earth longer than the J.A.R.E. samples; the average terrestrial ages, measured by decay of radioactive elements produced by cosmic rays, are 300,000 and 100,000 years. The maximum age so far is 700,000 years. Those differences hint at some difference in ice-sheet dynamics, which the special properties of Antarctic meteorites can help probe. To explore the unexplained differences, 2 workshops have been held.

The first, Workshop on Antarctic Glaciology & Meteorites, was convened by Colin Bull, Ohio State University, and me in April 1982 at the Lunar & Planetary Institute. It focused on the relationship between the seemingly very different research areas of meteorites and glaciology and on how results in one area can affect results in the other. (Copies of report 82-03 are available from the Lunar & Planetary Institute.)

The follow-up Workshop on Antarctic Meteorites was convened by Ludolf Schultz, Max-Planck-Institut, and John Annexstad, Johnson Space Center, in July in Mainz, West Germany. (A report will be available later this year or early next year, also from the Lunar & Planetary Institute.) The workshop focused on the Antarctic meteorites and on recent results from their study, which can often be applied to terrestrial problems. For example, Kunihiko Nishiizumi, University of California, La Jolla, told how techniques to determine meteoritic cosmic-ray exposure and terrestrial-residence ages can be applied to determining the age of ice samples and the time since a mountain barrier was last covered by an ice sheet (1 million years in the case of the Allan Hills). Perhaps the most valuable part of the workshop was the concluding discussion. Future A.N.S.M.E.T. and J.A.R.E. plans were outlined by Cassidy and Yanai, as were planned collecting trips by other countries.

Some might ask, 'Don't you already have enough Antarctic meteorites?' If only because of the number of unusual Antarctic meteorites recovered so far, the answer is 'No: the more meteorites recovered, the greater the number of unusual ones.' If even ordinary meteorites found in Antarctica differ genetically from non-Antarctic ones, the Antarctic population constitutes a whole new sample of extraterrestrial material, perhaps from asteroids that no longer exist. Will the next exciting discoveries arise from samples collected by J.A.R.E., A.N.S.M.E.T., or some other program? This matters little in view of the unparalleled international scientific coöperation that already exists in this area. Will the next discoveries tell us more about extraterrestrial parent bodies or will they reveal more about the terrestrial ice sheet? In a research area developing as rapidly as this one, it is impossible to predict.

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