Rare Micrometeorites from the South Pole, Antarctica S. Taylor[1], C. M. O'D. Alexander[2], and S. Wengert[3]. [1]CRREL, 72 Lyme Road, Hanover, NH 03755, [2]Dept. Terrestrial Magnetism, 5241 Broad Branch Road NW, Washington, DC 20001, [3]Dartmouth College, Hanover, NH 03755.

Introduction: Micrometeorites are terrestrially collected extraterrestrial dust particles smaller than about two millimeters. Because of their small size large collections should contain samples of all dust producing objects in the solar system. Analyses of micrometeorites show that all are heated to some degree and about 80% have been melted[1]. Many micrometeorites have textures and compositions that are consistent with heating and melting CI- and CM-like precursor grains[2]. Because the textures and appearance of relict grains provide clues to their composition, micrometeorites that are compositionally unusual can often be identified from SEM images. Here we report on unique or rare micrometeorites, including one containing a barred olivine chondrule, one of four with spinel ($MgAl_2O_4$) relict grains, and two of five spherules composed of Fe-Ni-S and euhedral olivine crystals.

Experimental Methods: In 2000 we collected micrometeorites from 800–1100 AD ice melted by the South Pole water well (SPWW) [3]. The samples were vacuumed from the bottom of the SPWW, a 4,000-m^3 reservoir melting pre-industrial ice. We identified and mounted ~5700 melted and unmelted micrometeorites and have imaged 2628 of them by SEM. We used the SEM/EDAX to identify the unusual micrometeorites reported here, which we then analyzed using an electron microprobe.

The SEM/EDAX analyses were done at Dartmouth College using an FEI XL-30 which has both secondary and backscatter electron detectors and an X-ray microanalysis light element Si(Li) detector for qualitative analyses of all elements heavier than carbon.

The microprobe analyses were made at DTM, Carnegie Institution of Washington, using a JEOL Superprobe JXA-8800L and polished mineral and glass standards.

Results: Fig. 1 shows a micrometeorite containing a barred olivine chondrule. The chondrule appears to be 40µm in diameter, smaller than the mean diameters for CMs (0.3mm), CVs (1.0mm) and OCs (0.3-0.9mm) and most similar in size to chondrules found in CH meteorites (20µm) [4]. Chondrules are common in chondrites with the exception of the CIs. Since most micrometeorites and meteorites are thought to be asteroidal, micrometeorites should contain chondrules or their fragments. Some coarse-grained, unmelted micrometeorites have been interpeted as chondrules and chondrule fragments [5,6].

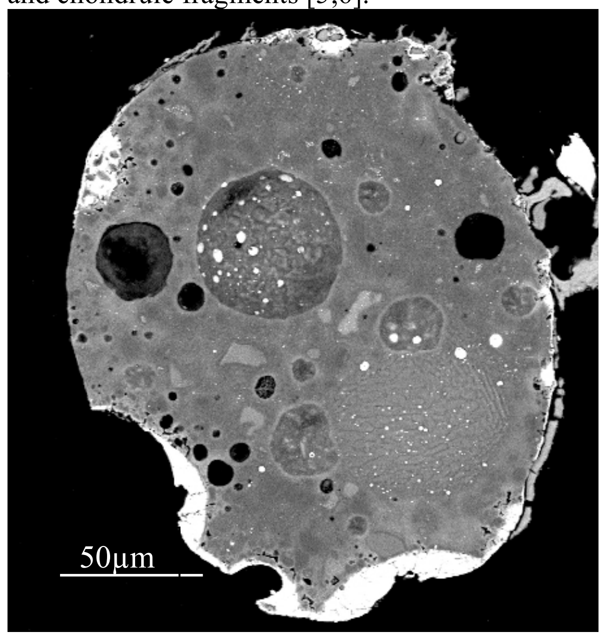

Figure 1. Micrometeorite with a barred olivine chondrule in the lower right area.

Spinel relict grains are found in four micrometeorites. Figs. 2 and 3 show these relicts and Table 1 list the composition of one of the spinels and its surrounding glass. The glass associated with these relicts is Ca-, Fe- and Al- rich. The spinel relicts contain very little Fe but reacted with the surrounding glass during atmospheric entry heating to form a bright, Fe-rich reaction rim. The spinel relicts can be distinguished from forsterite relicts by these reaction rims, and by their appearance: they have a more defined edge (relief) and the spinel is often embayed. Fig. 3 shows how heating changes the spinel from a well defined relict, to one surrounded by an Fe-rich reaction rim, to tiny spinel cores surrounded by Fe-rich rims. Spinel is a refractory mineral and one of a suite of minerals found in calciumaluminum-rich inclusions (CAIs). Peroskovite and fassaite, two other refractory minerals, have also been found in micrometeories[7].

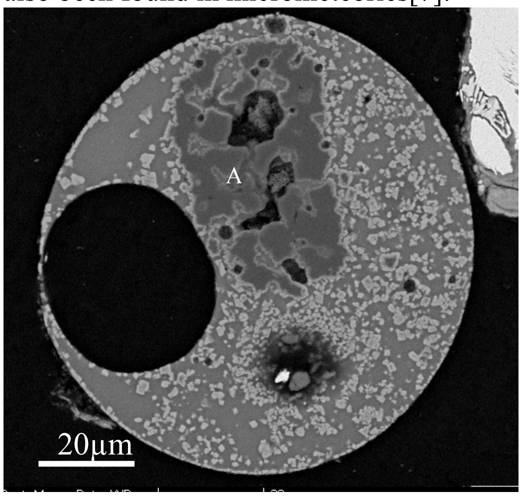

Fig. 2. Spinel relict (A) in spherule B-374.

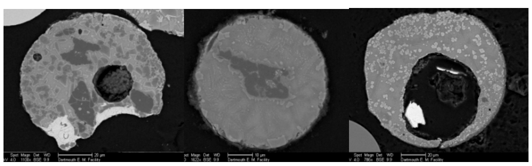

Fig. 3. Effects of increased heating on spinel grains.

Table 1. Microprobe spot analyses of phases in B-374 and olivines in B-249 and B-268.

	B-374		B-249	B-268
Wt%	Spinel (n=3)	Glass (n=2)	Oliv n=2	Oliv n=1
Al_2O_3	71.08±0.47	10.94±0.44	0.72±0.81	0.03
MgO	27.86±0.42	14.66±0.07	38.56±2.43	49.88
Cr_2O_3	0.24±0.02	0.00	0.05±0.06	0.33
FeO	0.96±0.52	18.24±0.2	21.37±1.07	8.00
MnO	0.01±0.01	0.18±.06	0.49±0.14	0.82
TiO_2	0.20±0.01	1.01±0.19	0.03±0	0.01
Na_2O	n.a.	0.19±.02	0.01±0	0.01
SiO_2	n.a.	43.28±0.83	37.24±0.90	39.69
P_2O_5	n.a.	0.10±.07	0.09±0.05	0.00
CaO	n.a.	10.22±0.18	0.52±0.45	0.07
K_2O	n.a.	0.03±0.01	0.02±0	0.00
Total	100.36±0.68	98.84±0.16	99.11±0.64	98.83

We found five spherules composed primarily of an Fe-Ni-S with interspersed olivine and B-268 is one of them (Fig. 4). Tables 1 and 2 list the compositions of the two phases for two of these spherules. The olivines are zoned and have more Mg-rich cores. The sulfide analyses totals are low suggesting that we are missing an element, most likely oxygen. The sulfide is not stoichometric and if it was once pentlandite it has lost a significant amount of S. We would expect isotopic fractionation of the S if the S was lost during atmospheric entry heating.

Table 2. Microprobe analyses of the sulfide portions of B-249 and B-268.

Wt%	B268		B249	
Fe	63.65	64.19	62.70	61.65
Ni	6.06	5.53	6.63	6.83
S	22.30	21.84	22.86	22.71
Total	92.01	91.56	92.20	91.20

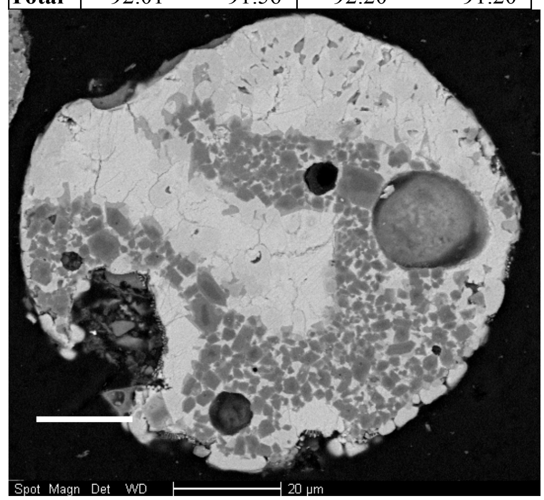

Fig. 4. Micrometeorite B-268, composed of an Fe-Ni-S phase (bright) and zoned olivine (dark).

Conclusions: By examining large numbers of micrometeorites we can ascertain what types of materials are arriving on Earth. Many micrometeorites have similar compositions that are expressed in familiar textures. Unusual compositions can, therefore, often be deduced from unusual textures. Here we describe unique and rare micrometeorites that make up less then 1% of micrometeorite collections and have not been previously described; a barred olivine chondrule, spinel relict grains and spherules composed of sulphides and olivine. More detailed studies will help determine their relationship with specific meteorite types.

References: [1] Taylor et al. (2000) *Meteoritics and Planetary Sciences*, 35, 651-666. [2] Brownlee et al. (1998) *Meteoritics and Planetary Science* **32,** 157–175. [3] Taylor et al. (2001) LPSC, XXXII, 1914.pdf. [4] Brearley A.J. and Jones R.H. (1998) Chondritic Meteorites, *Rev. Min.* **36**, 3-1 - 3-398. [5] Genge et al. (2005) *Meteoritics and Planetary Sciences*, 40, 225-238. [6] Taylor et al. (2007) ESA Publications, SP-643, 145-149. [7] Greshake et al. (1995) *Meteortics*, 30, 513.