CRUMBS FROM THE CRUST OF VESTA: ACHONDRITIC MICROMETEORITES FROM THE SOUTH POLE WATER WELL. Jeremy S. Delaney,[1] G.F. Herzog[2] and S. Taylor[3], (1)Dept. of Geological Sciences, (2)Dept. of Chemistry and Chemical Biology, Rutgers University, 610 Taylor Rd, Piscataway NJ 08854, USA; jsd@rci.rutgers.edu., (3) CRREL, 72 Lyme Road, Hanover, NH 03755.

Introduction: Appreciable numbers of micrometeorites (MM) may form when larger (>1 cm) bodies fragment in the Earth's atmosphere [1]. If fragmentation affects all incoming bodies similarly, then MM collections should resemble meteorite collections. Compositional and isotopic data support this inference in the broad sense that most MM appear to be "chondritic" [2-5]. Relative to conventional meteorites, however, micrometeorites comprise a larger fraction of carbonaceous material [3,5,6], few or no irons [7], and, to date, no achondrites.

Several factors probably account for these differences. First, some MM may arrive as small bodies - dust - rather than as parts of larger bodies. The principal sources for dust are not necessarily the same as those for conventional meteoroids [8]. Second, the varying toughness of meteoroids and asteroids may influence their susceptibility to break-up. Third, our ability to search for achondritic MM is limited absolutely by the relatively small numbers of MM analyses available.

In addition, problems related to sampling and hence to recognition of unusual precursor objects arise because individual grains in differentiated meteorites are often larger than micrometeorites. This last problem may be overcome in the cosmic spherules (CS), which melt either partially or completely as they traverse the Earth's atmosphere. The melting process, especially if it begins on the surface of a larger body, may sweep up and combine portions of several grains. Here we will argue based on mineralogy and elemental composition that we have identified four or perhaps five stony cosmic spherules (sCS) that came from achondritic precursors.

Experimental methods: During petrographic examination and electron microprobe analyses of particles from the South Pole Water Well (SPWW) collection , we noticed one, SP37-3, which has a non-chondritic composition and mineral assemblage. For this work we made numerous additional electron microprobe analyses of the plagioclase grain and of the glass, respectively, in SP37-3 by using the electron microprobe at Rutgers University.

Results - a 'HEDdy' discovery: SP37-3 is a vesicular glassy spherule that includes a small plagioclase feldspar in the exposed surface (Figure 1; scale bar = 50 µm). Table 1 shows the results of the elemental analyses. The plagioclase is homogeneous and calcic. The associated glass is fairly homogenous compositionally although the back-scattered electron image shows some swirling textures indicative of small scale heterogeneity.

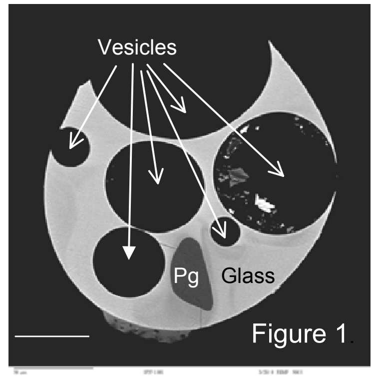
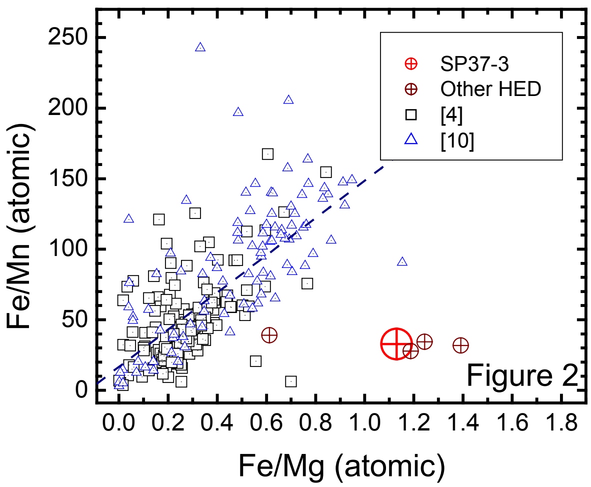


Figure 1

Discussion: Mn-Mg-Fe systematics can be a good indicator of planetary pedigree [9]. Figure 2 shows Fe-Mg-Mn systematics for ~260 micrometeorites from the SPWW (data from [4,10]). With sCS SP37-3, 18-7, 24-79, 29-45, and 29-51 excluded (see below), the best fit has a slope (Fe/Mn atomic) of 132±8 and an intercept of 17±3 with R=0.70. The slope of 132 is comparable to bulk C-chondrite Fe/Mn ratios, which range from ~90 for CI chondrites to ~160 for CO and CV chondrites [11]. In contrast, the Fe/Mn atomic ratios of the glass in SP37-3 (average 33±3; range 26-51) are typical of eucritic pyroxene (33; [12]); diogenitic pyroxene (30; [12]) and also similar to those of martian meteorites (~42±6;

Table 1: Average composition (wt%) of glass and feldspar in particle SP37-3.

	Glass		Feldspar
	wt %		wt %
SiO_2	50.15±2.0		45.2±0.4
TiO_2	0.46±0.15		0.01±0.01
Al_2O_3	11.1±7.7		34.5±0.4
Cr_2O_3	0.15±0.05		0.01±0.02
FeO	13.39±4.0		0.37±0.11
MnO	0.40±0.12		0.02±0.02
MgO	6.6±2.1		0.03±0.05
CaO	16.1±0.6		17.8±0.3
Na_2O	0.3±0.2		1.07±0.05
K_2O	0.00		0.06±0.01
Total	98.52		99.00
	Atom/atom		Mole %
Fe/Mg	1.14±0.09	An	89.9±0.4
Fe/Mn	32.7±3.4	Or	0.36±0.09



e.g., [13]). Fe/Mn ratios for lunar pyroxenes (~69; [12]) and LL chondrites (~70; [11]) are clearly higher than the measured values for SP37-3. The Na/Ca atomic ratios of the glass (0.030±0.020) and the feldspar (0.11±0.01) of SP37-3 are lower than those of bulk martian meteorites for which Na/Ca~0.19 (e.g., [13,14]).

In comparing elemental ratios above, we have assumed the equality of measured and preatmospheric values for the sCS. This assumption needs examination as small extraterrestrial particles are susceptible to mass loss [15], and occasionally perhaps to mass gain [16]. Fortunately, of the elements relevant here, Mg is fairly refractory and relatively constant measured ratios of Mn to refractory elements (Taylor et al., 2004, this conference) imply nearly conservative behavior for Mn. Further, loss of iron, although a likely eventuality for many sCS [15,17], shifts points along rather than off the trend line of Figure 2. We conclude that SP37-3 along with spherules 18-7, 29-45, 29-51, and possibly 24-79, came from an HED-like parent body.

The composition of the glass in SP37-3 is generally consistent with the howarditic / polymict breccia meteorites that probably are the most representative samples of the diversity that is present in the achondrite planetoid crust.

Vesiculation is rare in meteorites [18] but fairly common in sCS, and present in SP37-3 and the other HED-like spherules. It seems improbable that indigenous vesicles would have survived the melting that gave SP37-3 its rounded shape. Other possible sources of vapor are 1) the major phases; 2) phases that formed as a result of chemical reactions during the atmospheric heating process; or 3) the Earth's atmosphere. Possibilities 1 and 3 seem unlikely. In considering 2, Wilkening and Anders [19] argue that the vapor pressure of sulfur in equilibrium with FeS is too small and the abundance of H_2O too low to account for vesicles in the eucrite Ibitira. Carbon in the form of CO [19] or CO_2 [18] could have filled the vesicles and, by extension, in SP37-3.

Conclusion: We have identified four stony cosmic spherules from the South Pole Water Well as likely samples from HED parent-bodies. It is not clear whether they arrived on Earth as small bodies or parts of larger ones.

References: **[1]** Lal. D. and Jull A.J.T. (2003) *GCA 67*, 4925-4933. **[2]** Brownlee D.E. et al. (1997) *MPS 32*, 157-175. **[3]** Engrand C. and Maurette M. (1998) *MPS.* **33**, 565-580. **[4]** Taylor S. et al. (2000) *MPS 35*, 651-666. **[5]** Alexander C.M.O'D. et al. (2002) *GCA 66*, 173-183. **[6]** Genge M.J. and Grady M.M. (2002) *LPS XXXIII*, Abstract 1010. **[7]** Herzog G.F. et al. (1999) *GCA 63*, 1443-1457. **[8]** Kortenkamp S.J. and Dermott S.F. (1998) *Icarus* **135**, 469-495. **[9]** Goodrich C.A. and Delaney J.S. (2000) *GCA 64*, 149-160. **[10]** S. Taylor, pers. comm. **[11]** Wasson J.T. and Kallemeyn G.W. (1988) *Phil. Trans. R. Soc. Lond* A **325**, 535-544. **[12]** Papike J.J. et al. (2001) *LPS. XXXII*, 1009.pdf. **[13]** Lodders K. (1998) *MPS 33*, A183-A190. **[14]** Lodders K. and Fegley Jr., B. (1998) *The Planetary Scientist's Companion*.Oxford University Press, New York, 371 pp. **[15]** Taylor S. et al. (2002) *LPS. XXXIII* 1136.pdf. **[16]** Jessberger E.K. et al. (1992) *EPSL 112*, 91-99; Kurat G. et al. (1994) *GCA 58*, 3879-3904. **[17]** Genge M.J. and Grady M.M. (1998) *MPS 33*, 425-434. **[18]** McCoy T.J. et al. (2003) *LPS. XXXIV*, 1187.pdf. **[19]** Wilkening L.L. and Anders E. (1975) *GCA 39*, 1205-1210.