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Twelve cosmic spherules, visually free of terrestrial contamination, were analyzed for major and trace element contents by INAA and EMPA. Comparison of the data for these spherules with those of crystalline micrometeorites and chondrules from carbonaceous chondrites reveals some similarities between them. In particular, some coarse-grained crystalline micrometeorites could be precursors for cosmic spherules. Some of these objects are similar in chemical composition to typical chondrules from carbonaceous chondrites, especially with respect to low siderophile element contents and fractionated Ni/Ir ratios. However, spherules and crystalline micrometeorites rich in siderophile elements are abundant. This is clearly different from chondrules from CV and CM chondrites, but similar to those from CO chondrites, which, however, differ from cosmic spherules in being depleted in Mn with respect to refractory lithophile elements. Because all cosmic spherules investigated have decoupled abundances of Ir and Ni, their precursors could have been processed in a way similar to those of Allende chondrules.

SAMPLE AND METHODS: Cosmic spherules and crystalline micrometeorites were selected from the 100-400 μm size-fraction of EUROMET dust collections 910115A and 910115B from Cap Prudhome, Antarctica [1]. Twelve spherules and eleven crystalline micrometeorites were analyzed by INAA, following procedures outlined in [2,3]. These particles were subsequently studied with a scanning electron microscope (SEM), equipped with an EDXA system. Finally, the samples were mounted in epoxy, polished, and studied by optical microscopy and SEM. Bulk and mineral analyses were obtained by EDXA and EMPA (for details see [4]).

RESULTS. Most data for crystalline micrometeorites have been published in [4]. Major and trace element data are given in the Table for a selection of cosmic spheres, which were free of the COPS phase [5], a terrestrial contaminant rich in C, O, P, S, and Fe. Normalized elemental abundances [6] of cosmic spherules and a selection of crystalline micrometeorites (from [4]) are plotted in the Figure. All non-COPS-bearing spherules contain from a few to abundant bubbles - a feature which clearly distinguishes them from the mostly bubble-free COPS-bearing spherules. In addition, all COPS-free spherules have porphyritic textures. They are commonly dominated by FeO-bearing olivine dispersed in a FeO-rich pyroxenitic matrix. One spherule (7M8) is dominated by low-Ca pyroxene and two others (8M2 and 8M3) contain relictic FeO-poor olivines (2-6 wt-% FeO). Refractory lithophile trace element abundances in the spherules are chondritic to superchondritic (Figure). Rare earth element (REE) abundances are fractionated from each other in three and unfractionated in two spherules. Moderately volatile lithophile elements (Cr, Mn, Na) are either unfractionated or depleted with respect to refractory lithophile elements. The volatile lithophile elements (K, Rb, Br) commonly have high abundances. However, the Br contents vary over a wide range and are highest in spherules with high light REE contents. Refractory siderophile element abundances vary from about 0.02*CI to 10*CI. All spherules have fractionated siderophile element abundances with $Ir_N > Ni_N \leq Co_N$ and are usually enriched in volatile siderophile elements (Au, As, Sb) with respect to common siderophile elements (Ni,Co). Selenium abundances are between 0.1*CI and 0.8*CI.

DISCUSSION. Comparison of elemental abundance patterns of cosmic spherules with those of crystalline micrometeorites (Figure) reveals some similarities between these two objects. The refractory lithophile elements show similar abundances in both the micrometeorites and cosmic spherules. Exceptions are spherules 7M8 and 8M2, which have high light REE abundances. However, they also have strongly fractionated Sc/La ratios, which are suggestive of a crustal contamination [e. g., 4,7]. The high abundances of volatile lithophile elements are probably due to contamination and, therefore, their abundances are not diagnostic. In contrast to most published chemical analyses of cosmic spherules [8-10], our set does not show depletions in the abundances of the moderately volatile elements Cr and Mn with respect to the refractory elements. The only exception is spherule 4M2, which has a Cr-Mn depletion pattern comparable to that of some chondrules from Allende [11,12], Ornans [13], and Murray [14]. The (non-contaminated) lithophile trace element patterns of our COPS-free spherules are compatible with either a bulk CM chondrite or some CM chondrite chondrule precursor. The siderophile element patterns of cosmic spherules and crystalline micrometeorites are very similar to each other. Exceptions are micrometeorites M6 and M7, which have chondritic Os-Ir-Ni abundances. However, both chondritic and non-chondritic Ir-Ni abundances are common among chondrules from carbonaceous chondrites [11-13]. The diagnostic value of siderophile element abundances for the identification of chondrules or chondrule-like objects has previously been pointed out in a comparison of chemical compositions of cosmic spherules and Allende chondrules [15,16]. Our data confirm this observation and suggest that crystalline micrometeorites and COPS-free cosmic spherules are relatives of chondrules of some carbonaceous chondrites. Curiously, not only chondrules fit the siderophile element abundance patterns of cosmic spherules and crystalline micrometeorites, but also some ureilites [17]. For possible answers see [18].

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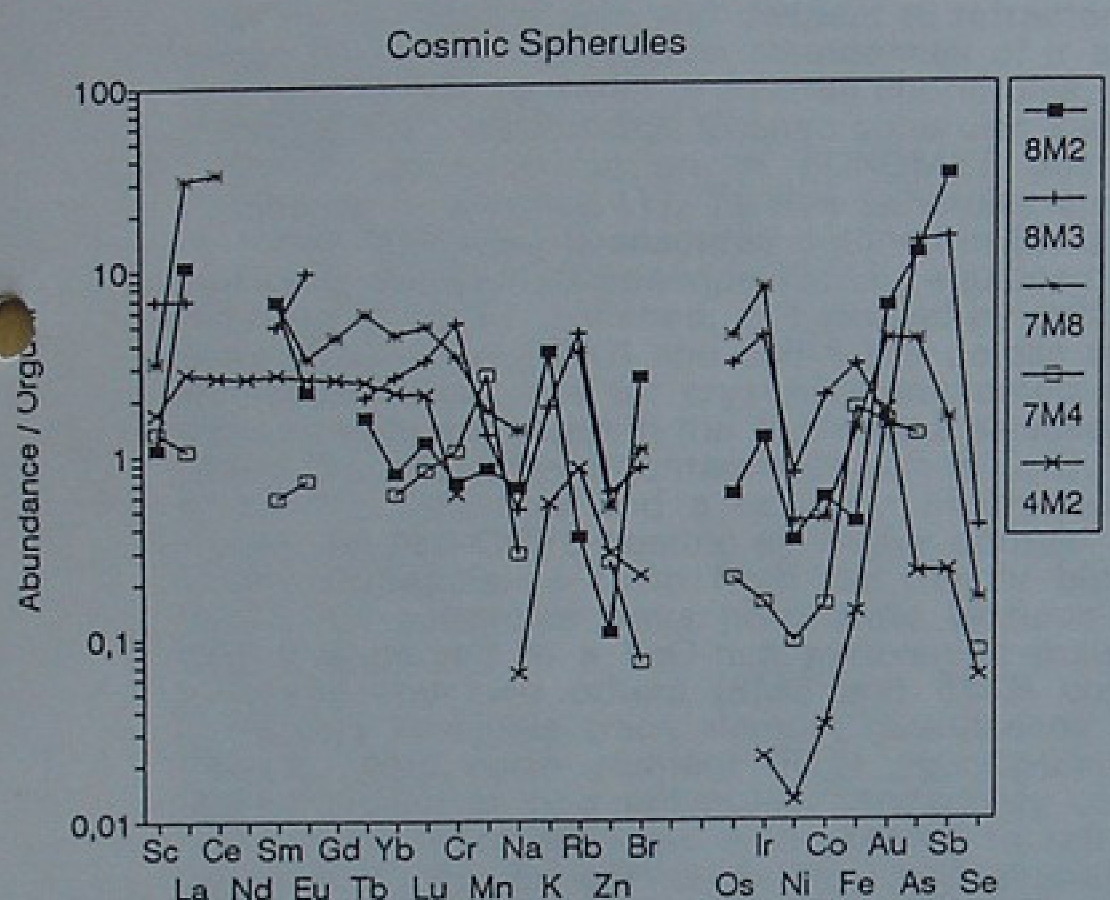

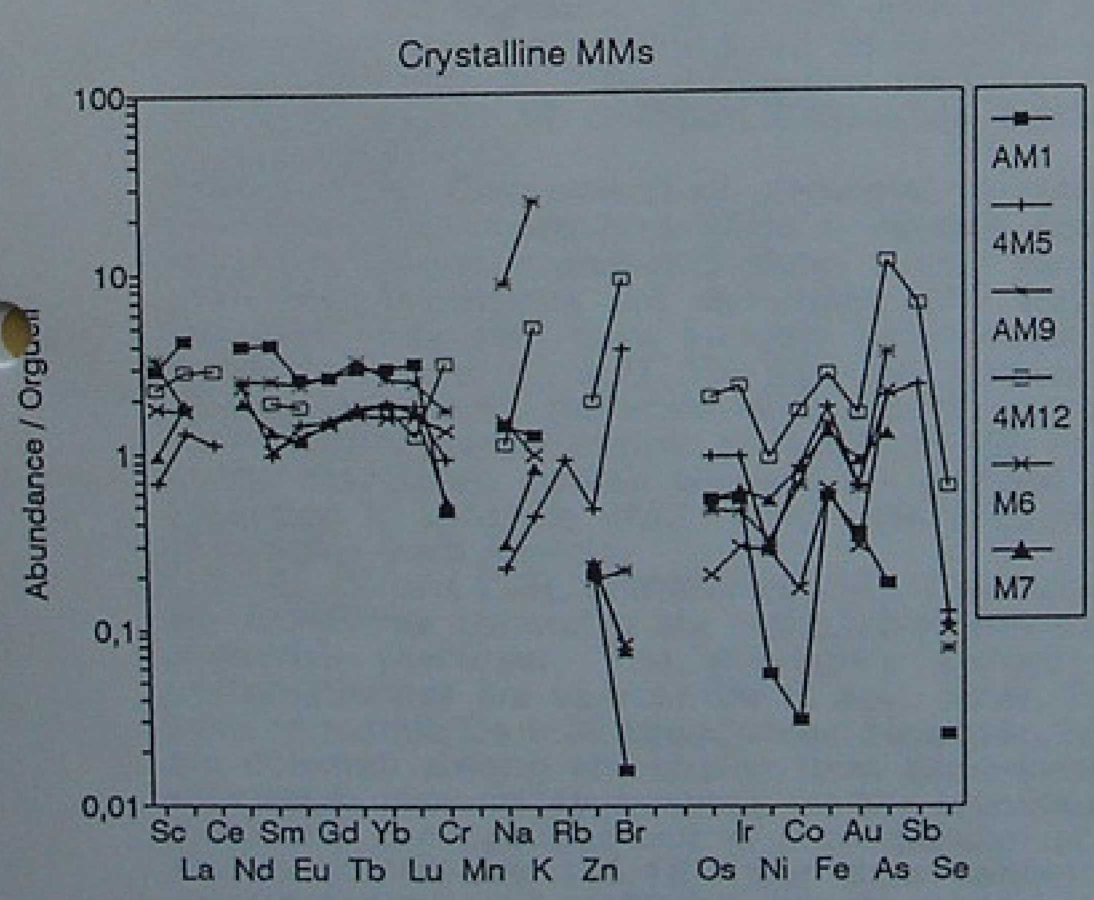

Table: Major and trace element contents of COPS-free cosmic spherules from Cap Prudhome, Antarctica

	4M2	7M4	7M8	8M2	8M3
Mass/[ug]	23	4	1,5	29	3
Na(%)	0,031	0,14	0,65	*0,32*	*0,24*
Sc	9,71	7,74	18,6	*6,29*	*39,9*
Cr	1615	2730	8960	*1848*	*13480*
Fe(%)	2,53	32,14	24,3	*7,69*	*54,7*
Co	16,5	76,3	219	*288*	*1018*
Ni	140	1030	4600	*3692*	*8455*
Zn	89	80	158	*33*	*190*
Ga	4	20	8	*15*	*40*
As	0,41	2,284	7,35	*21,7*	*25,1*
Se	1,1	1,5	2,9	*<1.7*	*7,1*
Br	0,77	0,26	3,69	*9,02*	*2,94*
Rb	1,9	<30	8	*0,8*	*10*
Ru	0,55	<1.5	1,77	*<0.9*	*<5*
Sb	0,03	n.d.	0,2	*4,19*	*1,9*
Ba	15	<200	300	*12,41*	*175*
La	0,65	0,25	7,31	*2,47*	*1,62*
Ce	1,64	<2	20,7	*<10*	*<50*
Nd	1,2	<10	<20	*<2*	*<5*
Sm	0,39	0,084	0,99	*0,96*	*0,711*
Eu	0,14	0,04	0,18	*0,12*	*0,52*
Gd	0,5	<0.2	0,85	*<0.3*	*<0.5*
Tb	0,086	<0.06	0,2	*0,056*	*0,071*
Tm	0,05	<0.1	<0.2	*<0.1*	*<0.2*
Yb	0,35	0,1	0,72	*0,132*	*0,43*
Lu	0,051	0,02	0,12	*0,028*	*0,078*
Hf	0,41	<0.2	<0.7	*<0.08*	*0,81*
Os(ppb)	<150	100	2040	*289*	*1456*
Ir(ppb)	10,5	73	3636	*576*	*1985*
Au(ppb)	242	205	582	*875*	*209*
Th	0,09	<0.422	1,78	*<0.1*	*<0.6*
U	<0.05	<0.9	0.43	*0,09*	*<1*

Figure: Normalized [6] element abundances in cosmic spherules and crystalline micrometeorites (from [4]) from Cap Prudhomme, Antarctica