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FRACTIONATED TRACE ELEMENT ABUNDANCES IN MICROMETEORITES FROM ANTARCTICA;
Gero Kurat, Naturhistorsiches Museum, Postfach 417, A-1014 Vienna, Austria, Christian Koeberl, Institut für Geochemie, Universität Wien, Dr.-Karl-Lueger-Ring 1, A-1010 Vienna, Austria, Michel Maurette, Centre de Spectrometrie Nucleaire et de Spectrometrie de Masse, Batiment 108, F-91405 Orsay, France.

Major and trace element contents of two unmelted, three scoriaceous micrometeorites (MMs) and one cosmic spherule are presented. The data confirm previous observations which showed that MMs have bulk compositions similar to those of hydrated carbonaceous chondrites but have experienced some alterations which led to depletions and enrichments of certain elements as compared to chondritic abundances. The new data also show various degrees of depletions of MMs in Na, Rb, Zn, Ni, Co, Au, and Se and enrichments in K, Br, Fe, Au, As, and Sb. Correlations between the degree of melting and some elemental depletions (Na, Zn, Au, Se) suggest elemental loss by volatilization, presumably during atmospheric entry. Depletions in Ni and Co could be due to leaching of soluble salts from the MMs. However, because the cosmic spherule shows a Ni,Co-depletion similar to that of the MMs, another mechanism causing the depletion must exist. We tentatively suggest that preferential loss of Ni,Co-bearing sulfates by decrepitation during the atmospheric heating event is responsible for the depletion. All enrichments of MMs in volatile elements are believed to be the result of re-condensation of meteoritic vapors onto and into the MMs in the high atmosphere. Unusual enrichments of our MMs in refractory lithophile elements could be due to (unknown) contents of refractory minerals.

SAMPLES and METHODS. Indivudual particles were selected from the 100-400 μm size fraction of the dust collection made on January 15, 1991, from the blue ice near the French Antarctic station Dumont d'Urville [1]. The particles we report on here were selected because of their irregular shape and dark color, with the expectation that some of them will be unmelted micrometeorites. Particle masses ranged from 2.5 to 5 μg. In addition, one large (mass 59 μg), irregular cosmic spherule covered by COPS [2,3] was selected. Particles were analyzed by INAA following the procedure outlined in [4]. The samples are now being sectioned for petrographic and mineral chemical analyses.

RESULTS. Preliminary trace element data are given in the Table and normalized abundance patterns are shown in the Figure. Refractory lithophile elements have unfractionated chondritic abundances only in the cosmic spherule 5M1. The scoriaceous MMs (5M2, 5M5, 5M8) and unmelted MMs (5M3, 5M10) have fractionated refractory lithophile element contents, three of them (5M2, 5M10, 5M3) at super-chondritic abundances. The moderately volatile elements Na, K and the volatile element Zn are depleted in the spherule and in some scoriaceous MMs. Potassium is enriched in one unmelted, Rb in one scoriaceous, and Br in all MMs. Also the spherule has a chondritic Br content. The siderophile elements show a peculiar pattern which is similar in all samples. Osmium and Ir have chondritic to super-chondritic abundances and are unfractionated. Nickel and Co are depleted with respect to Os and Ir. The abundance pattern always follows the sequence Ni$<$Co$<$Fe. The Au abundance of the MMs is highly variable and ranges from about chondritic to enriched (~20xCI). The spherule is strongly depleted in Au. All MMs are strongly enriched in As and Sb, their average Se abundance is chondritic. The spherule has a similar pattern at a considerably lower abundance level.

DISCUSSION. The largest sample, spherule 5M1, has refractory trace element abundances between 1 and 2xCI. The depletions in elements more volatile than Cr must be the result of volatilization during melting in the upper atmosphere [6,7]. However, many elements, which are more volatile than Na or Au, are not depleted in spherule 5M1. Because it is covered by large amounts of COPS, we may speculate that the most volatile elements reside in this phase. Consequently, they were added to the spherule after it was formed in the high atmosphere. Similar enrichments of volatile elements in micrometeorites must have a similar cause [4,7,8] although these elements apparently do not reside in an identifyable phase. Similar enrichments observed in stratospheric IDPs (interplanetary dust particles) have also been shown to be likely of terrestrial [9] rather than primordial [10] origin. Depletions of MMs in non-volatile elements such as Ni and Co have been interpreted as indicating loss of Ni,Co-bearing salts from the MMs by dissolution in water [7,8]. However, the fact that spherule 5M1 shows a Ni/Ir fractionation identical to that of the MMs requires an additional mechanism, involving similar compounds such as Ni,Co-bearing sulfates. A possible - speculative - way could be a preferential loss of such phases by decrepitation during the heating event in the high atmosphere. The fractionated REE patterns displayed by most of our MMs are unusual. Such patterns have not been observed before [e.g., 4,6,7,11] except for a CAI-bearing

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MM described by [12]. Some refractory grains might be present in these MMs which, however, we have not yet been able to identify.

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Figure: Orgueil-normalized [5] abundances of selected elements in unmelted (5M3, 5M10) and scoriaceous (5M2, 5M5, 5M8) MMs and cosmic spherule 5M1.

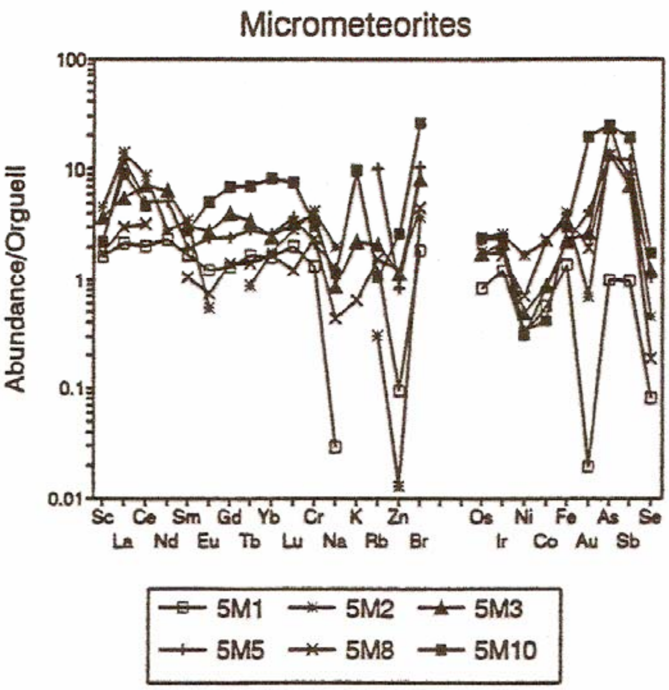

Table: INAA of Antarctic micrometeorites (ppm)

	5M1	5M2	5M3	5M5	5M8	5M10
Mass	59	2.7	5	3	5	2.5
Na(%)	0.014	0.98	0.425	0.627	0.213	0.543
K(%)	<1	<1	0.128	<1.8	0.036	0.55
Sc	9.51	27	21.7	12.8	10.3	13
Cr	3580	11390	10340	5700	6350	8210
Fe(%)	25.1	74.2	41.8	40.6	66.2	54.5
Co	285	1140	438	430	1165	213
Ni	3459	18800	5370	3390	7550	3570
Zn	29.4	4	352	258	383	816
Ga	60	20	1	5	1	2
As	1.84	26.7	43.5	24	25	46
Se	1.5	8.25	22.4	18.9	3.4	32
Br	6.5	13	29	37	15.9	92.8
Rb	3.1	0.7	4.9	22.9	3.6	2.4
Sr	19	15	75	117	110	45
Zr	4	<10	5	40	15	60
Ru	0.81	2.7	2.3	4.5	0.52	3
Sb	0.13	1.2	0.94	1.6	0.94	2.5
Cs	<0.14	0.07	0.64	0.12	<0.83	<0.7
Ba	4.1	<20	<50	<40	5	6
La	0.51	3.3	1.3	2.9	0.72	2.2
Ce	1.26	5.4	4.5	3.2	2	2.9
Nd	1.08	1.3	3	2.4	<2.4	<6.3
Sm	0.246	0.5	0.45	0.28	0.15	0.4
Eu	0.068	0.03	0.15	0.13	0.04	0.28
Gd	0.26	<0.2	0.8	0.48	0.28	1.4
Tb	0.06	0.03	0.12	0.1	0.05	0.25
Tm	0.06	<0.1	<0.18	<0.27	<0.28	<0.74
Yb	0.267	0.3	0.41	0.44	0.28	1.38
Lu	0.05	0.07	0.08	0.09	0.03	0.19
Hf	0.34	<0.08	0.41	0.08	0.4	0.55
Ta	0.01	0.02	0.03	0.02	0.03	0.03
Os(ppb)	402	1190	830	810	875	1140
Ir(ppb)	574	1230	1030	870	805	1100
Au(ppb)	2.8	98	390	610	280	2770
Th	0.067	0.35	0.46	0.6	0.48	0.7
U	0.004	<0.1	<0.05	0.02	0.02	<0.1