ON THE TERRESTRIAL DUST COMPONENT IN THE ICE AT CAP PRUDHOMME, ANTARCTICA; G. Kurat (1), C. Koeberl (2), F. Brandstätter (1), J. Walter (1), and M. Maurette (3); (1) Naturhistorisches Museum, Postfach 417, A-1014 Vienna, Austria (2) Institut für Geochemie, Universität Wien, Dr.-Karl-Lueger-Ring 1, A-1010 Vienna, Austria (3) C.S.N.S.M., Bat. 104, F-91405 Campus Orsay, France.

A non-representative collection of terrestrial dust obtained from blue ice near Cap Prudhomme, Antarctica, has been analyzed by INAA, analytical SEM, and EMP. The dust from the size-fraction 100-400 μm consists of silicates (SiO_2, feldspars, mica, clay minerals), Fe-oxides (magnetite and hematite ± feldspars, SiO_2, mica, TiO_2, and ilmenite), one grain of titaniferous Mn-oxide, and a variety of rust particles (± SiO_2, feldspar, mica, and Fe metal). The lithophile trace element contents of the non-chondritic dust are compatible with a derivation from terrestrial sources with the exception of some Fe-oxide particles which have unfractionated refractory lithophile element abundances. Overall siderophile element contents are compatible with terrestrial sources, except Ir, which is 20-1000-times more abundant in the dust as compared to the terrestrial crust. An extraterrestrial contamination of terrestrial dust is obvious. Some dust particles are so rich in siderophile elements that they may represent condensates of meteoritic vapour in the high atmosphere.

SAMPLES AND METHODS. Thirty-seven mostly black particles were selected for a geochemical and petrological study [1] from the size-fraction 100-400μm of the dust collections 910115A and 910115B from Cap Prudhomme, Antarctica [2]. Of these, seven turned out to be of non-chondritic composition. These, plus five other particles deliberately picked for their non-chondritic appearence (series 5M in the table) from collection 910115B, were analyzed by INAA following the procedure outlined in [3, 4]. The particles were subsequently studied with a scanning electron microscope (SEM) equipped with EDXA. Finally, the particles were mounted in epoxy, polished, and studied by optical microscopy and SEM. Bulk chemical and mineral chemical compositions were determined by utilizing EDXA and an EMP (for details see [1]).

RESULTS. A selection of trace element data is given in the Table and CI-normalized [5] abundance patterns are shown in the Figure. Our collection of non-chondritic particles contains the following mineral associations:

(1) Silicates: (a) SiO_2 (4M4) (b) SiO_2 + K-feldspar + clay mineral (chlorite) (5M6). Particle 5M7 was lost. It contained SiO_2, but the complete mineral association could not be determined.

(2) Iron oxides (magnetite or hematite) with various amounts of K-feldspar, Na-feldspar, SiO_2, biotite, TiO_2, and ilmenite (AM3, AM7, 4M3, 5M9).

(3) Titaniferous Mn-Oxide (not yet identified) with exsolutions of Ti-Mn-Oxide (3M10).

(4) Rust (unidentified Fe-hydroxides) either without (3M1, 4M7, 5MR1) or with silicates (K-feldspar, SiO_2, biotite, AM6), or Fe metal (4M11, 5MR2).

Some particles are partly covered by a rim of variable thickness, which consists of very fine-grained (<2μm) silicate and oxide grains in a carbonaceous matrix (e.g., 3M1 and 3M10).

Lithophile trace element contents of silicate particles (Figure) are high and fractionated corresponding to terrestrial upper crustal rocks [6]. Some SiO_2 and rust grains have low lithophile element contents. Two Fe-oxide particles (AM3 and AM7) have patterns very similar to each other and with almost chondritic refractory element abundances. Fe-oxide particle 4M3 has high and fractionated REE abundances and a pronounced Sc-La fractionation. The Mn-Ti-oxide particle (3M10) has high REE contents with $La_N < Lu_N$. This particle is also very rich in Zn, Ba, Zr, and Hf. Rust particles have lithophile element contents ranging from sub-chondritic (5MR1, 3M1) to bulk crustal abundances (AM6). Occasionally negative Eu anomalies are present and only rarely there are indications of small positive Ce anomalies.

Siderophile element contents of silicate particles are roughly similar to those of terrestrial crustal rocks, except for Ir, which is at least about 100-times more abundant in the dust. Also Au is much more abundant in the poly-silicate particles than it is in the average crust. The Fe-oxide particles have siderophile element abundances which deviate considerably from that of the terrestrial crust. There is an over-abundance of Ir, Au, As, Sb, and Se in the Fe-oxides compared to the crust. The Mn-Ti-oxide particle (3M10) has very high Ir, Ni, Co, An, As, Sb, and Se contents. Rust paticles are typically enriched in all siderophile elements as compared to the terrestrial crust with the exception of Ga. Iridium, Ni, and Co contents can be high and reach up to about 0.2xCI.

DISCUSSION. The lithophile trace element abundances and patterns of all non-chondritic particles

TERRESTRIAL DUST IN ANTARCTIC ICE: KURAT G. et al.

presented here are compatible with a derivation from terrestrial sources. The silicate particles may be derived from sediments of about average continental crustal composition. Iron oxides indicate a similar source, plus a pegmatoidal source, which is also likely for the Mn-Ti-oxide particle 3M10. The rust reflects a similar, terrestrial environment. The highly variable trace element contents are probably the result of variable availability of trace elements for scavenging by the Fe-hydroxide [i.e., 7]. The flat REE patterns of the Fe-oxides (+ silicate) particles AM3 and AM7 may be unusual because they do not show the Sc-La fractionation typical for terrestrial crustal rocks. All particles are depleted in Na as compared to the terrestrial crust which could indicate a chemically weathered source. The highly variable Th and U contents and Th/U ratios indicate derivation of the dust from sources with highly different redox conditions.

All particles are enriched in Ir as compared to the average terrestrial crust. Furthermore, many particles have unfractionated chondritic Ni/Ir ratios, which is difficult to obtain in a terrestrial environment. Consequently, the high contents of Ir and the unfractionated Ni/Ir ratio strongly suggest an extraterrestrial source. Such a source is not likely for the bulk particles, but rather for some component that was added to the particles. Apparently, terrestrial particles were contaminated by extraterrestrial matter. Indeed, such contaminations can occasionally be seen as coatings on particles - e. g., on 3M1 and 3M10, two particles with unusually high siderophile element contents. This extraterrestrial component must be a very fine-grained dust component which - under some circumstances - may account for more than 10 mass-% of a particle (e.g., 3M10). The dust with high Ir (+Ni, Co) contents has interelement ratios that are indicative of a condensation process with elemental abundances increasing with increasing volatility (except for Se). This is exactly the same pattern found in micrometeorites and interpreted as terrestrial contamination [1]. The contaminant could be a condensate of meteoritic vapour in the high atmosphere (e. g., [8]).

ACKNOWLEDGEMENTS. This work was supported by FWF in Austria (project no. P8125-GEO), and by IN2P3 and the European Community SCIENCE (Twinning and Operations) Programme (contract no. SCI-CT91-0618, SSM) in France. We thank Ljuba Kerschhofer and Thomas Presper for help with INAA.

REFERENCES. [1] Kurat G. et al. (1994) Geochim. Cosmochim. Acta 58, 3879. [2] Maurette M. et al. (1992) LPSC XXIII, 859. [3] Koeberl C. (1993) J. Radioanal. Nucl. Chem., Art. 168, 47. [4] Koeberl C. et al. (1992) LPSC XXIII, 709. [5] Palme H. et al (1981) In Landoldt-Boernstein (eds. K. Schaifers and H. H. Voigt), Springer Verlag, pp 257. [6] Taylor S. R. (1992) Solar System Evclution, Cambridge Univ. Press. [7] Koeppenkastrop D. et al. (1991) J. Radioanal. Nucl. Chem., Art. 152, 337. [8] Hunten D. M. et al. (1980) J. Atmos. Sci. 37, 1342.

Table: Elemental abundances in terrestrial particles from Cap-Prudhomme, Antarctica, by INAA (in ppm, unless indicated otherwise)

Type	Silicates		Oxides			Rust		
Particle	4M4	5M6	AM3	3M10	4M3	AM6	4M7	5MR1
Weight/µg	42	4	12	3	43	17	18	57
Na (%)	0,019	0,195	0,02	0,15	0,018	0,013	0,018	0,022
K (%)	0,051	12,6	0,05	0,03	0,46	0,12	0,003	0,498
Sc	0,19	11,6	35,7	324	3,19	3,71	0,35	0,019
Cr	17,5	140	175	1190	268	135	295	8112
Fe (%)	0,32	18,2	69,8	9,49	69,4	74,8	71,8	68,5
Co	6,64	32,4	24,9	3036	34,1	36,6	148	82,4
Ni	45	87	95	1050	65	100	775	294,2
Zn	12	439	87	14700	110	85	110	85,5
Ga	2	10	3,5	0,2	5	34	9,4	46
As	0,34	2,54	3,8	140	18,8	24,8	304	81,5
Se	0,5	2,15	2,5	8,7	0,75	2,5	1,1	3,7
Br	1,03	1,8	0,08	6,7	1,79	0,14	12,9	33,1
Rb	3,3	1051	10,5		23,6	1,2	8	4,4
Zr	7,5	30	19	5470				27
Ru	0,2	2,32					2,8	0,34
Sb	0,11	0,59	5,15	17,4	8,41	2,47	24,3	5,26
Ba	4,3	1573	120	82400	320	480	60	4
La	0,39	35	1,85	58,4	251	15,6	0,21	0,1
Ce	0,63	63,7	6,5	470	309	38,1	0,5	0,358
Nd	0,4	37,3	2,4	153	320	14,4		
Sm	0,085	7,1	0,64	142	62,6	2,58	0,05	0,02
Eu	0,079	0,42	0,16	17,3	9,89	0,41	0,05	0,02
Gd	0,19	7,5	0,8	370	25,8	2,4	0,3	
Tb	0,042	1,4	0,1	91	1,54	0,38	0,07	0,03
Tm	0,02	0,88		30,7	0,45	0,21	0,04	
Yb	0,14	4,87	0,48	208	1,75	1,11	0,32	0,18
Lu	0,02	0,98	0,066	34	0,22	0,21	0,051	0,012
Hf	0,15	3,8	2,88	75,7	3,07	1,81	0,3	
Ta	0,02	2,19	26,5	2,7	0,93	1,46	0,05	0,002
Ir (ppb)	5,2	12	2	85	3,1	2	13,8	3
Au (ppb)	7,8	198	22	225	8,3	8	33,5	142
Th	0,51	27	5,33	17,8	103	23,7	0,11	0,216
U	0,026	0,3	4,2	880	7,4	3,2		0,17
Phases	SiO2	SiO2 + St.	hem + ru	Mn-Ox	Mt + bio	Rust	Rust	Rust

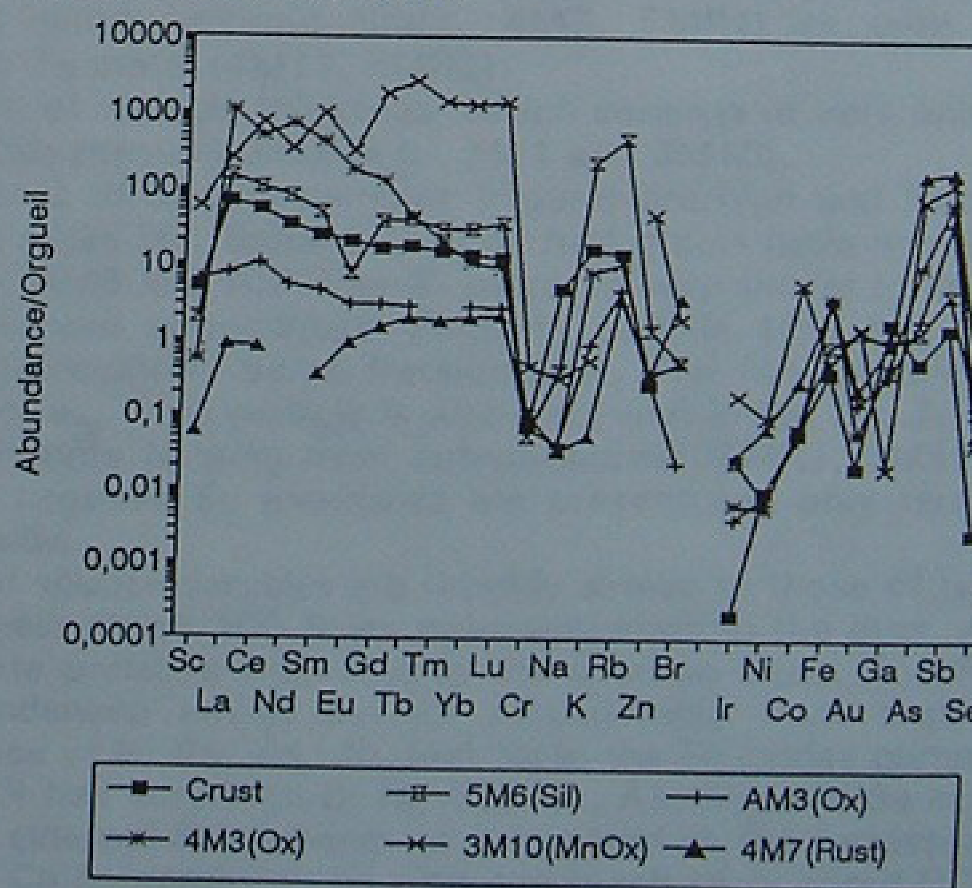

Figure: CI-normalized [5] trace element abundances in terrestrial dust particles from Antarctica.