WATER CONTENTS OF MICROMETEORITES FROM ANTARCTICA. C. Engrand[1,2], E. Deloule[3], P. Hoppe[4], G. Kurat[2], M. Maurette[1], F. Robert[5], [1]CSNSM, F-91405 Campus-Orsay, France; [2]Naturhistorisches Museum, A-1014 Vienna, Austria; [3]C.R.P.G.- C.N.R.S., F-54501 Vandoeuvre-lès-Nancy, France; [4]Physikalisches Institut, Universität Bern, CH-3012 Bern, Switzerland; [5]Département de Minéralogie, Muséum d'Histoire Naturelle, F-75005 Paris, France.

Micrometeorites have high hydrogen contents regardless of their thermal alteration during atmospheric entry (1.4-20 wt.% H_2O equivalent). Also, two cosmic spherules (melted micrometeoroids), retained hydrogen in astonishingly large amounts (1.1 and 2.86 wt.% H_2O). COPS, essentially a P-rich, ferro-ferrioxide - hydroxide, contains between 2.9 and 3.8 wt.% H_2O. The isotopic composition of the hydrogen in all objects is highly variable and has a range similar to that of hydrogen from carbonaceous chondrites (δD -366 ‰ to 501‰).

Introduction. Micrometeorites (MMs) of the size range 25-500 μm collected at Cap-Prudhomme are made of a material mostly related to CM chondrites with possibly some contribution from CI and CR types [1,2]. Investigation of ≈500 MMs in the ≈100-300μm size-range and ≈150 smaller MMs (25-50 μm size-range) did not reveal one single object related to differentiated meteorites (achondrites, irons, or stony-irons).

There are marked differences between CM chondrites and MMs: the latter have a much higher average carbon content (x3), they lack olivine and pyroxenes with very low Fe contents, they are poor in chondrules, and have a ratio of pyroxene to olivine about 10 times that of CM chondrites. We thus concluded, that MMs of the size-range 50-500 μm, which represent the dominant source of extraterrestrial material accreted by the Earth today, represent a new population of primitive solar system objects. Characterization of the hydrous phases in MMs has proven to be difficult because many have been thermally altered during atmospheric entry. It was the purpose of this study to measure - for the first time - the content and isotopic composition of hydrogen in unaltered, altered, and melted MMs, and in the peculiar COPS phase [3] which is associated with MMs and cosmic spherules (see for example the figure).

Analytical procedures. Well characterized phyllosilicate-bearing MMs [2] were analyzed for H contents and H isotope abundances with the Bern SIMS following the procedure of [4]. A set of thermally altered MMs and COPS-rich cosmic spherules (polished sections and crushed samples in gold foil [5]) were analyzed with the SIMS at CRPG, Nancy, following a newly developed procedure [e.g., 6-7]. That procedure utilizes negative oxygen primary ions (≈ 5nA, 10kV) which allows the preferential analysis of H bound in silicates (hydroxyles) in the presence of organic H, inclusive epoxy. Consequently, measurements of fragments of a MM mounted on a gold foil or embedded in epoxy resin provide similar results. Moreover, fragments mounted on gold gave the same H content and D/H ratio before and after heating under vacuum for 12 hours at 120°C, and then for 3 hours at 200°C. This excludes the possibility of a contamination with terrestrial water (in terrestrial clays such a contamination is completely eliminated at 90°C under the same conditions).

Results and discussion. Both procedures applied yielded comparable results which are reported in the Table. As expected, the unaltered phyllosilicate-rich MMs (UMMs) are richest in H (5-20 wt.% H_2O equivalent). Thermally altered, fine-grained MMs (FGs) and partially melted scoriaceous MMs (SMMs) contain between 1.4 and 1.8 wt.% H_2O. Two chondritic cosmic spherules (CSs) have surprisingly high contents of H_2O of 1.1 and 2.86 wt.%, respectively. The COPS phase - as expected - has fairly high H contents (2.9 and 3.8 wt.% H_2O).
The D/H ratios as determined in Bern and Nancy have very similar ranges. The total range found (δD_{SMOW} -366‰ to 501‰) in both thermally altered and not altered MMs is quite similar to that previously found for carbonaceous chondrites. About 40% of these values are clearly extraterrestrial. This fit again outlines the similarity between MMs and carbonaceous chondrites.

We previously reported on a new phase "COPS", representing about 10% of the C-rich grains in both UMMs and SMMs [3]. This phase is a dirty form of iron hydroxide (ferrihydride), differing from a related "PCP" phase found in CM chondrites by its amazingly high content of P and low content of S. We analyzed the constituent water of COPS nuggets from 2 cosmic spherules. It was not surprising to find a high water content. Quite surprising, however, was the high δD of +245‰ found in one of the COPS nuggets, which is clearly outside the terrestrial range. These preliminary results suggest that the COPS phase must have some extraterrestrial source, maybe the micrometeoroid from which the cosmic spherule formed. However, we do not yet understand its origin and the source(s) of its water and high P contents.

The high water contents of both the SMMs and the cosmic spherules (to be reconfirmed for other types of spherules) further demonstrate that the good thermal shielding of micrometeoroids upon atmospheric entry is still

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poorly understood. It is probably related to the very short heating pulse during aerodynamic braking. Furthermore, Bonny and Balageas [8] did show that the partial pyrolysis of the constituent carbonaceous material of MMs contributes to a slight decrease in the frictional heating by means of a network of endothermic reactions. Such a cooling might be further enhanced during the endothermic dehydration of phyllosilicates.

Conclusions. Extraterrestrial, primary hydrogen is retained in unmelted and scoriaceous micrometeorites and also in cosmic spherules. In addition, also one of the two COPS-phases investigated, which have been deposited onto the surface of cosmic spherules, has an extraterrestrial D/H ratio. This must indicate the formation from a reservoire which was dominated by extraterrestrial hydrogen. Both, the water content and the D/H ratio of that water of unmelted MMs, SMMs, and CSs from Antarctica indicate a close relationship between interplanetary dust and carbonaceous chondrites.

Acknowledgements. This work was supported by IN2P3, CNES, and IFRTP in France, the Schweizerische Nationalfonds in Switzerland, and by FWF in Austria

References: [1] Maurette M. et al. (1991) *Nature 351*, 44-47. [2] Kurat G. et al. (1994) *GCA 58*, 3879-3904. [3] Engrand C. et al. (1993) *LPSC XXIV*, 441-442. [4] McKeegan K.D. et al. (1985) *GCA 49* 1971-1987. [5] Engrand C. (1995) *Thesis*, Université Paris XI, Orsay. [6] Deloule E. and Robert F. (1995) *GCA 59*, 4695-4706. [7] Deloule et al. (1991) *GCA Spec. Pub. 3*, 53-62. [8] Bonny P. and Balageas D. (1990) *LPSC XX*, 111-112.

Label	Type	H_2O (wt.%)
M3 2	UMM	21,60
M3 3	UMM	20,40
3M7 A	UMM	15,00
3M7 C	UMM	13,70
3M8 B	UMM	8,00
3M8 C	UMM	7,20
3M8 A	UMM	5,80
3M7 B	UMM	4,80

Table : Water contents of MMs, as measured in Bern (above) and in Nancy (on the right).

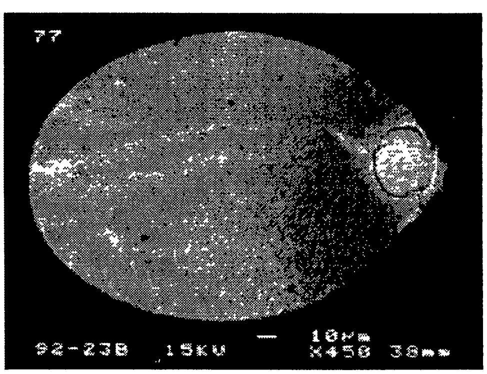

Figure : Cosmic spherule with a COPS nugget (light grey), BSE image.

Label	Type	H_2O (wt.%)	Mean value
95-1-4	FG	3,71	
92-14-6	FG	3,32	
94-18-3	FG	3,25	
95-1-12	FG	3,06	
94-18-29	FG	2,45	
94-10-31	FG	2,14	
94-18-21	FG	2,11	
94-10-11	FG	2,10	
95-1-24	FG	2,08	
94-18-17_3	FG	2,04	
94-10-24	FG	1,99	
94-18-21	FG	1,98	
94-18-13	FG	1,97	
94-18-12	FG	1,95	
92-14-12	FG	1,94	1,83
94-10-09	FG	1,88	
94-18-20	FG	1,87	
94-18-28	FG	1,85	
94-18-7	FG	1,80	
95-1-25	FG	1,65	
94-18-17_3	FG	1,55	
94-10-26	FG	1,52	
94-18-27	FG	1,50	
94-10-31	FG	1,43	
95-1-8	FG	1,19	
94-18-23	FG	1,18	
94-10-34	FG	1,16	
94-10-14	FG	1,13	
92-14-8	FG	1,12	
94-18-23	FG	1,05	
95-1-8	FG	1,00	
94-10-11	FG	0,97	
94-18-26	FG	0,88	
95-1-22	FG	0,88	
95-1-14	SMM	1,85	
94-18-25	SMM	1,84	
95-1-11	SMM	1,75	
95-1-6	SMM	1,70	
95-1-18	SMM	1,67	
94-10-36	SMM	1,65	1,41
95-1-19	SMM	1,48	
94-18-4	SMM	1,29	
94-18-20	SMM	1,22	
94-18-20	SMM	1,05	
94-18-5	SMM	1,01	
95-1-16	SMM	0,37	
93-6C COPS	COPS	3,75	
92-23B-77 COPS	COPS	3,49	3,37
92-23B-77 COPS	COPS	2,86	
92-23B-77	CS	2,86	
93-6C	CS	1,10	1,98