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METEORITIC ABLATION AND FUSION SPHERULES IN ANTARCTIC ICE

K.Thiel, J.Peters, G.M.Raisbeck*, and F.Yiou*
Nuclear Chemistry Dept., University of Köln
* Laboratoire René Bernas, C.N.R.S., Orsay

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In the course of two Antarctic expeditions in 1980/81 and 1982/83 approx. 4 metric tons of documented ice samples were collected from the Atka Bay Ice Shelf (70°37'S/8°22'W), Antarctica, and subsequently shipped to Köln for cosmic dust studies. After filtration of the melt water using 0.8µm pore size acetate filters ∿700 Antarctic spherules (AAS) in the size range 5...500µm were handpicked from the filter residue under optical microscopes. From their physical properties ∿600 black metallic, mostly magnetic spherules (mean diameter 41±24µm, mean density $5.2\pm2.3 gcm^{-3}$) and ∿100 glassy transparent spherules (95±25µm; $2,0\pm1.2 gcm^{-3}$) can be distinguished.

For the chemical investigation of single dust grains the following techniques were applied: Scanning electron microscopy (SEM), X-ray analysis (EDAX), instrumental neutron activation analysis (INAA), laser microprobe mass analysis (LAMMA), and accelerator mass spectroscopy (AMS). For more than 95% of the total mass (>100 spherules) the bulk and trace elements were determined in single grain analyses using EDAX, INAA, and LAMMA. The largest sphere (306µg) was additionally analysed for Be-10 applying AMS at the Laboratoire René Bernas, Paris Sud.

The element pattern of the dust particles was compared with that of typical terrestrial material (crustal rock, volcanic fly ash, steel) as well as meteoritic matter (C1-chondrites, iron meteorites, mesosiderites, pallasites).

The majority of the spherules exhibit elemental compositions compatible with meteoritic element patterns (cf. fig 1). One sphere representing approx. 40% of the total mass of all spherules was shown to be definitely extraterrestrial by accelerator mass spectrometry yielding $(1.9\pm0.7)\cdot10^9$ atoms/g Be-10.

The analytical results lead to the conclusion that 93wt-% (spherule size 0.2...20µg) to 99wt-% (spherule size 0.2...300µg) of all AAS show element patterns similar to meteoritic material the percentage depending on the size range of the spherules.

From their outer appearance (roughness and texture of the surface) in the scanning electron microscope five different groups (A...E) of metallic spherules may be distinguished, containing also different fractions of the bulk elements Fe, Si, and Mg (see table).

Type	Fe_2O_3	SiO_2	MgO
A	ca 94%	ca 3%	n.d.
B	" 90%	" 5%	ca 5%
C	" 74%	" 19%	" 2%
D	" 81%	" 3%	" 8%
E	" 64%	" 19%	n.d.

Table 1. Main types of metallic opaque spherules from Atka Bay/Antarctica.

(n.d. not detected)

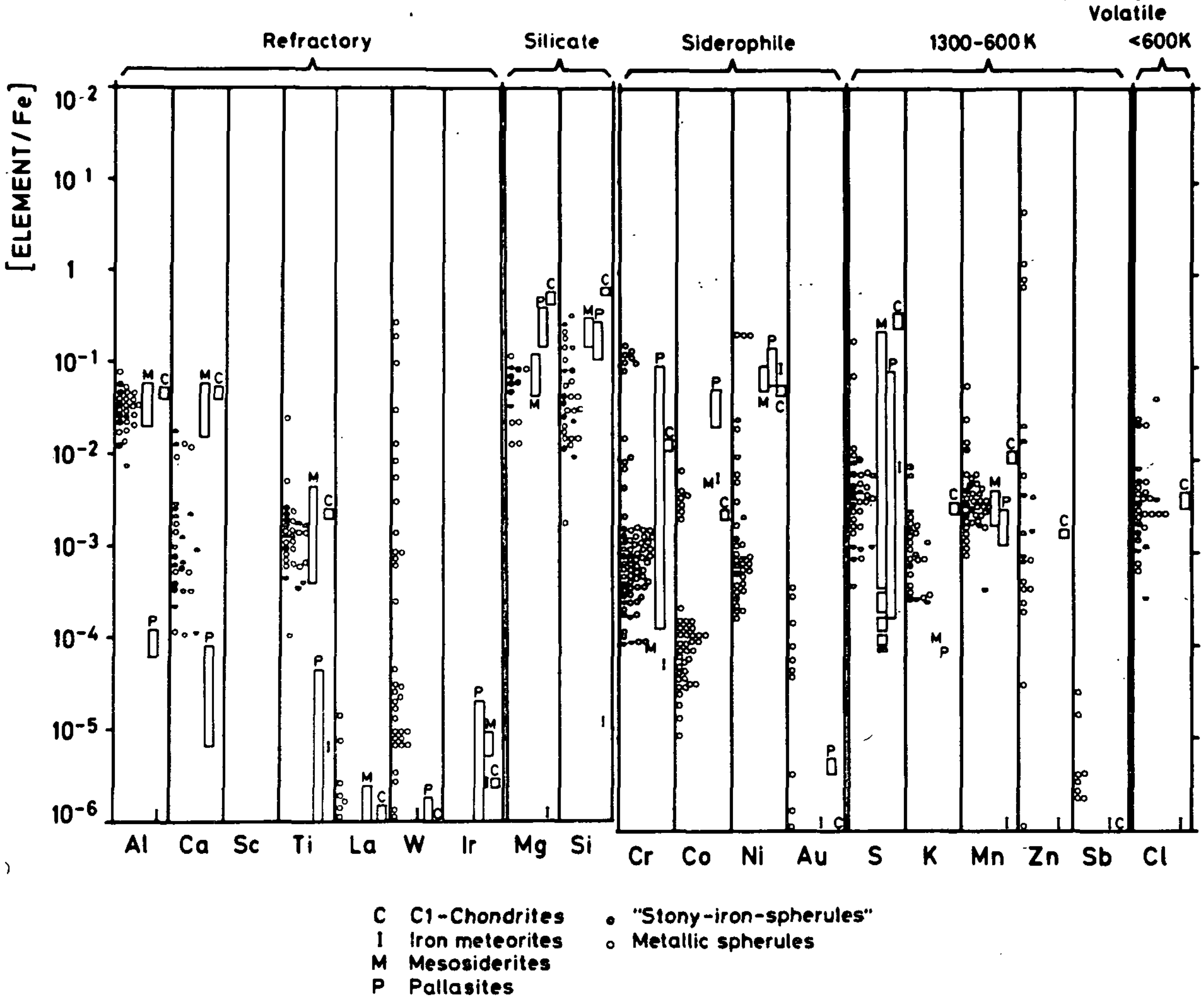

Fig 1. Element pattern of some of the AAS compared with the mean composition of meteorites

Most of the glassy transparent type of spherules turned out to be of terrestrial origin.
From the mass frequency distribution of the AAS in the mass range $>10^{-6}$g the cumulative particle flux N of spherules having masses m exceeding a given particle mass m_p can be derived to be

$$N(>m_p) = 5.87 \times 10^{-14} m_p^{-1.143} \{m^{-2}s^{-1}\}$$

This flux is higher than the (extrapolated) interplanetary meteoroid flux in the mass range $<10^{-6}$g by a factor of 2...3 (fig 2).

The discrepancy is discussed in terms of a contribution to the AAS objects due to atmospheric ablation and/or fusion of micrometeorites in the mass range $>10^{-6}$g.

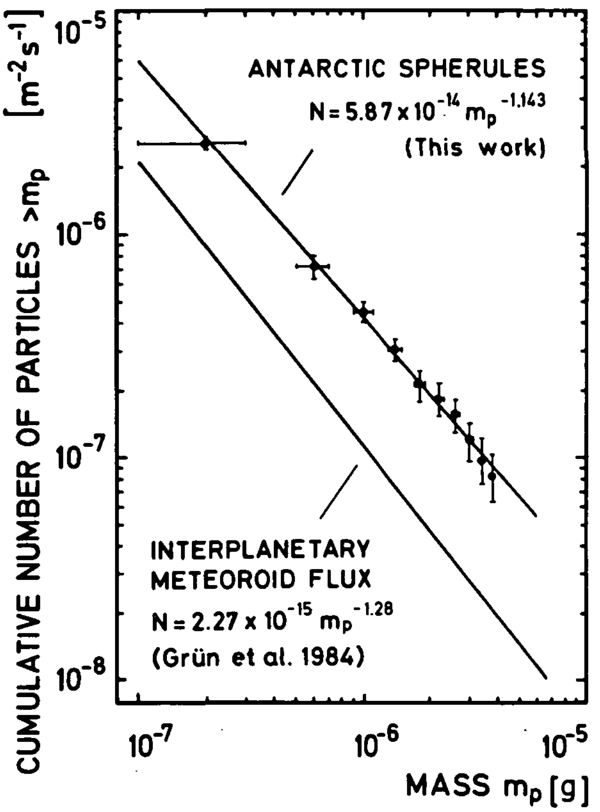

Fig 2. Cumulative particle flux of AAS and interplanetary meteoroids according to Grün et al. (1984)[1]

References

1 Grün, E., H. Fechtig, H.A. Zook, and R.H. Giese, (1984) Lunar Planet. Sci. XV, 333-334