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AUTOMATED SEM-SEARCH FOR MICROMETER-SIZED ANTARCTICA MICROMETEORITES FROM EAST ANTARCTICA (DOME B) ICE CORE SAMPLES.

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We try to recover Antarctic micrometeorites (AMMs) smaller than a few micrometers from ice cores drilled in the central regions of Antarctica. Such tiny micrometeorites cannot be collected in the stratosphere like SIDPs with U2 collector plates because they get deflected by air turbulences. We search for differences in the "pristine" characteristics of the grains acquired before capture by the Earth, as a function of both their sizes and time of "rendez vous" with the Earth (i.e., depth in the ice core). We might both find new populations of Interplanetary Dust Particles, including very rare interstellar dust grains, and monitor the past activity of the micrometeorite flux reaching the Earth surface over a time scale of ≈ 250,000 a, which is possibly affected by "Super-Tunguska" events, corresponding to collisions of NEOs (Near Earth Orbiting bodies) with sizes up to a few hundreds meters in diameter with the Earth.

In 1982-1983, one of us (MM) collaborated with M. de Angelis at LGGE, to look for "chondritic" particles with sizes ≈ 1-5µm in about 20 successive annual ice layers formed around 1908 in the Dome C ice core (74° S, 124° E, 3240m, a, s, l), both searching for ashes from the Tunguska event, and assessing the feasability of investigating changes in the past activity of the micrometeorite flux over a time scale ≥ 100,000 years. All grains with size ≥ 0.1µm from ≤ 100g aliquots of melt ice water from each annual ice layer were collected on a nucleopore filter. About 300 grains were analyzed on each filter with a SEM equipped with an EDS, which was run very slowly in a "manual" mode of operation, and no "chondritic" particle was found in 10 annual layers. But 6 months later it was realized that all sections were "just below" the 1908 horizon! Nevertheless, we discovered micrometer-sized volcanic glassy lamellae and demonstrated their usefulness to monitor the history of cataclysmic volcanic eruptions (1).

We have recently "rejuvinated" these studies, using an automated SEM (available at MVA, Inc.) to search for ≤ 10µm sized chondritic grains in annual ice layers from one of the 900m deep ice core drilled in Central East Antarctica at Dome B (77°S, 95°E, 3600m a, s, l). This ice core which spans about 30,000 a (2), was drilled by the Arctic and Antarctic Research Institute (St. Petersburg) during the 1988-1989 field season, in one of the dryest place in the world (precipitation rate ≈ 3cm water equivalent per year). We first selected a favorable ice layer showing one of the lowest volcanic dust background, and collected ≈ 200,000 grains (size 0.1-10µm) from ≈ 20g of melt ice water (figure 1). This sample was run with a Jeol 6400 SEM equipped with a Noran system of automated microanalysis, including a thin window EDS and a SUN workstation were all data are loaded and analyzed in an Excel tabler.

We have only run 4400 grains in ≈ 8 hours of operation (using 5s counting time for each grain), and 8 "favorable" grains with known coordinates were sorted out from the list, just setting the conditions that Mg count rates are at least 3 times higher than those of Al, and that both Fe and Ni should be observable in the EDS spectra. But when these grains were repositioned for more accurate analyses, we observed that the Ni "counts" were artefacts in grains with sizes ≤ 0.3µm, which cannot thus be reliably analyzed in the automated mode of operation. So only one "good looking" grain with a size ≈ 1µm, showing both an aggregate texture and a "favorable" EDS spectrum (Mg> 3Al, with Fe) was finally sorted out. Unfortunately, the undetectably low abundances of both S and Ni prevent an unequivocal identification of its extraterrestrial origin, even so the leaching of micrometeorites by melt ice water during their recovery can lead to a selective depletion of these two elements (3).

Supposing that this grain is an AMM, we get a lower limit of the flux of ≥ 0.5µm-sized micrometeorites in central Antarctica of about 1000 AMMs per m^2 per day, as compared to one SIDPs with a size of ≈ 10µm per m^2 per day (D.E. Brownlee, personal communication). These preliminary results confirm our previous (1982) observations of low concentrations of AMMs in the ice (relative to terrestrial grains).

The upper limit (≤ 0.02%) of the abundance of ≤ 10μm size micrometeorites in two favorable ice cores is ≈ 2,000 times smaller than the value of ≈ 10% observed for both SIDPs collected in the stratosphere (size 10-30μm), and AMMs found in the 50-100μm size fraction of the glacial sand recovered from Cap-Prudhomme, Antarctica.

However, the amazing power of automated SEM microanalyses, when coupled with the use of ice layers where the concentration of terrestrial grains is about 10 times lower than in the first sample investigated in this work, should help to successfully tackle the objectives listed in the first paragraph of this paper. Furthermore, the use of dry lyophilization techniques to collect the grains should allow the study all soluble particles trapped in the ice, including very tiny sulfates possibly deposited on particle surfaces during the scavenging of atmospheric aerosols (see fig.1, in reference 3). Such a set up could provide us with a new method to investigate aerosols from the past.

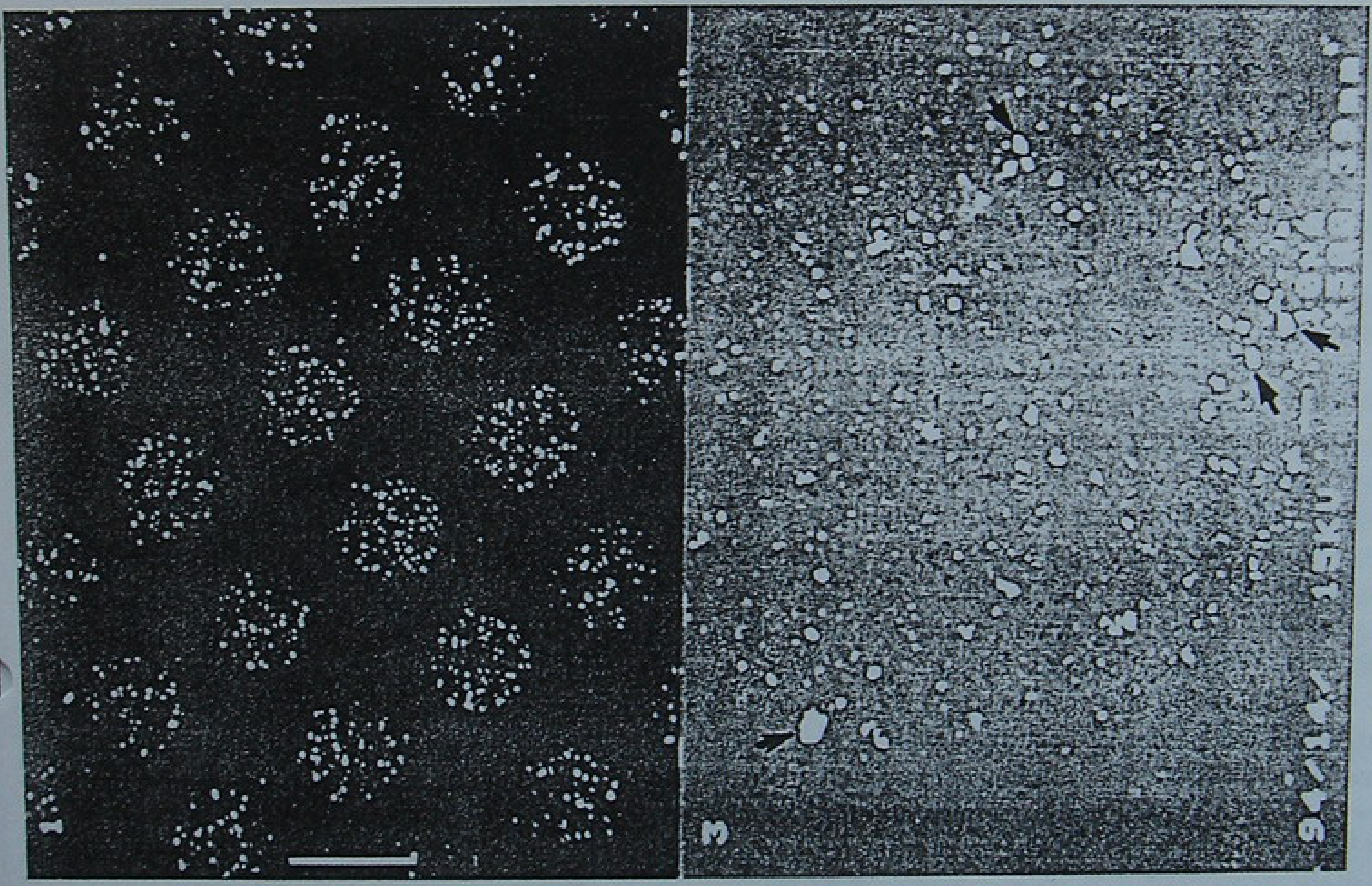

Figure 1. Scanning electron microscope pictures of dust grains extracted from the Dome B ice core in central Antarctica. By relying on optical microscope observations, a 1cm diameter nucleopore filter, with openings of 0.1 μm, was appropriately loaded with ≈ 200,000 dust grains initially trapped in ≈ 20g of melt ice water, and distributed over 1000 circular areas with a diameter of about 120μm (see micrograph on the left; scale bar = 200μm). In the magnified area shown at right the arrowed grains satisfy the criteria "Mg> 3Al with Fe", but they correspond to single crystals of a likely terrestrial origin. Only Mg-rich fine-grained aggregates could be chondritic micrometeorites.

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References: (1) M. de Angelis et al, Nature 317, 52 (1985); (2) J.Jouzel et al, Climate Dynamics, in press (1995); (3) M.Maurette et al, in Analysis of interplanetary dust, AIP Conf. Proc. 310, 277 (1994).