Size distribution of Antarctic micrometeorites stored in surface snow near Dome Fuji Station

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Introduction Since 2003, we have collected Antarctic micrometeorites (AMMs) preserved in snow from the surface to ~10 cm in depth near the Dome Fuji Station, Antarctica. Because the snow accumulation rate near the Station is ~10 cm/year, the snow and the AMMs included fell within about 1 year before collection. The collected snow (total amount: 1.2 tons) was transferred to NIPR (and further transferred to Ibaraki University until 2010) in a frozen state. The snow was melted to form cold water, that was filtered by Omnipore® filter with 0.2 µm openings in class 1000 clean rooms at NIPR and Ibaraki University. Fine grains on each filter were picked up under stereo microscopes in the clean rooms and examined by SEM-EDS to identify AMMs [1]. Here we report size distribution of the Dome Fuji AMMs and compare them with the AMM preserved in ice at the Tottuki 5 site near the Tottuki Point, Antarctica. In the latter case, ~11-ton ice was melted to form water and water was filtered on site in 2000 [2]. We identified AMMs by SEM-EDS among fine grains picked up from the residue on stainless sieves [1].

Results At the time of April 2019, total number of the Dome Fuji AMMs is 986, which are comprised of 805 unmelted AMMs (82%), 51 scoriaceous (in other words, partially melted) AMMs (5%), and 130 spherules (13%). Their average sizes are 41, 64, and 40 µm, respectively. The linear fits for three types of the Dome Fuji AMMs on the log-log plots of the cumulative size distribution ($N(>d) \sim d^r$) yield exponents r of -3.6 ± 0.2, -2.4 ± 0.3, and -2.5 ± 0.2, respectively. The relative abundances of the three types of the Dome Fuji AMMs contrast starkly with those of Tottuki AMMs. 3162 Tottuki AMMs are comprised of 1132 unmelted (36%), 527 scoriaceous (17%), and 1503 spherules (47%). Their average sizes are 87, 110, and 87 µm, respectively. The linear fits for the three types of the Tottuki AMMs on the log-log plot of the cumulative size distribution yield exponents r of -4.4 ± 0.2, -3.0 ± 0.1, and -4.0 ± 0.2, respectively. These results clearly show the following: (1) Dome Fuji AMMs are considerably smaller but much more abundant per unit weight of snow than Tottuki AMMs, (2) unmelted AMMs are highly enriched in the Dome Fuji collection than the Tottuki collection, and (3) the Tottuki AMMs have steeper negative slopes than those of the Dome Fuji AMMs on the log-log plots of the cumulative size distribution, which means that fine-grained AMMs are proportionally more abundant among the Tottuki collection than those in the Dome Fuji collection.

Discussion The results described above may be related to the different collection methods between these two collections. It is likely that polycarbonate sheet filters effectively collected finer fragile AMMs than stainless sieves did, which resulted in the smaller average size, proportionally higher abundance of unmelted AMMs, and much higher number density per unit kg of snow in the Dome Fuji AMMs. Collection onto polycarbonate filter sheets may have served to preserve finer fragile AMMs during filtering of water, which would give a shallower negative slope on the log-log plot of the cumulative size distribution.

Cumulative size distribution of AMMs have been estimated in the previous studies of AMMs collected by melting of Antarctic ice [e. g. 2-5]. The exponents of AMMs in the previous studies range from -5.3 to -4.5, these values are consistent with the values of the Tottuki AMMs. The unmelted + scoriaceous / spherules ratio of the Tottuki AMMs is 1.13, which is also within the range of the ratios in previous studies [2]. The high unmelted + scoriaceous / spherules ratio of Dome Fuji AMMs (6.69) has not been reported from AMMs recovered from ice and supraglacial moraines [4-7]. These results also support that filtering of water on flat polycarbonate filters have advantages to collect fine-grained fragile AMMs.

In the Dome Fuji collection, the exponent of the unmelted AMMs has steeper negative slopes than those of the scoriaceous AMMs and spherules, which suggests that finer AMMs that experienced enough high temperatures to melt partially or completely during atmospheric entry preferentially decreased. Such a missing fraction may contribute to ions such as Fe in the upper atmosphere [9]. To estimate a recent flux of AMMs, we supposed that the shape of each AMM was sphere and that their density was 2 g/cm^3. The average density of surface snow near the Dome Fuji Station is 0.5 g/cm^3. The flux was estimated to be 4.8 x 10^3 tons/year, which is intermediated between [3] and [8]. These similar values may suggest that micrometeorite flux did not change considerably from tens of thousands of years ago to present.

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References

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