NEW SIZE DISTRIBUTION AND MASS FLUX ESTIMATES FROM THE TRANSANTARCTIC MOUNTAINS MICROMETEORITE COLLECTION L. Folco[1,2] and M.D. Suttle[1,3]. [1]Dipartimento di Scienze della Terra, Università di Pisa, 56126 Pisa, Italy (luigi.folco@unipi.it) [2]CISUP, Centro per l'Integrazione della Strumentazione della Università di Pisa, Lungarno Pacinotti 43, Pisa, Italy. [3]Planetary Materials Group, Department of Earth Sciences, Natural History Museum, Cromwell Road, London, SW7 5BD, UK

Introduction: Micrometeorite collections provide a natural sampling of the cosmic dust flux falling to Earth over the recent and geological past [1], [2], [3]. [4]. Constraining the composition, source bodies and quantity of cosmic dust arriving on Earth has significant implications for Solar System science, including:

(1) Providing ground-truth data for dynamical modelling studies [5],

(2) Resolving the composition of the inner Solar System's interplanetary dust complex [6],

(3) Defining the extraterrestrial contribution to Earth's geochemical budget for elements that are otherwise rare at the Earth's surface [7],

(4) Identifying periods with enhanced dust flux that are associated with catastrophic minor body collisions and thus asteroid family formation events [8] and

(5) Increasing the geological diversity of extraterrestrial materials through the sampling of new and otherwise unrepresented parent bodies [9],[10].

Here, we provide a comprehensive characterization of the Transantarctic Mountains (TAM) micrometeorite accumulation dynamics and resulting micrometeorite collection. This is achieved through the case study of a single (loose) sediment trap (termed TAM65), located at the top of Miller Butte (72˚ 42' 03.30"S, 160˚ 15' 34.20"E), a glacially eroded nunatak within the Victoria Land Transantarctic Mountain range, Antarctica. We provide new size distribution estimates and mass flux estimates, as well as data on the relative abundance of different unmelted micrometeorites and textural types of cosmic spherule.

Methods: We investigated approximately 2540g of sediment (<5mm). This was washed, dried and size-sorted using a set of clean cascade sieves. Each size fraction was then magnetically separated and both the magnetic and non-magnetic aliquots investigated in an exhaustive picking effort. Potential micrometeorites were imaged both optically and under SEM-BSE. Micrometeorite identification was based on criteria listed in Genge et al., 2008 [11].

Results: In total, we recovered 1643 micrometeorites, 69 microtektites and 1 meteorite fragment (an equilibrated high-metamorphic grade ordinary chondrite). Unmelted and scoriaceous particles represent 7% of the total collection at a ratio of 1:14 (0.07 – unmelted micrometeorites to cosmic spherules), among these fine-grained precursors are overwhelmingly dominant (~75%).

Among completed melted particles (termed cosmic spherules), 95.6% are silicate-dominated S-types, which are further subdivided into porphyritic (16.9%), barred olivine (19.9%), cryptocrystalline (51.6%) and vitreous (7.5%). The remaining 4.4% are equally split between iron-rich (I-types) and particles of intermediate composition (iron-rich silicate) G-types.

We also report the relative abundances unusual S-type cosmic spherules:

- Approximately 3.2% are tailed, their shapes deviating significantly from the ideal spherical morphology, owing to the presence of a single tapering extension of melt. Tailed micrometeorites were first reported by [3] and later found among the TAM collection by [4], their formation mechanism remains unresolved.

- Metal beads, formed by the segregation of immiscible Fe-Ni metal (or Fe-Ni sulfides) from silicate melt [1], [2] were found in 20.4% of S-type cosmic spherules.

- Hollow spherules occur at a frequency of 1.6% and contain a single large off-centre vesicle (>40 vol%). They were first reported in [13] and later suggested by [14] to form by rapid spin rates (of several thousand radians/s), potentially representing immature dust, recently released from their parent body and whose fast rotation have not yet been slowed by magnetic dampening.

Size distribution: The size distribution for TAM65 (Fig.1) is segmented, showing a short head and a long tail, both with distinctly different slopes. The main population, between 200-700µm can be accurately modelled by a power law (with a slope of -3.91, R^2=0.98). Meanwhile, the small size fractions (100-200µm) are fitted against a power law with a slope of -0.227 (R^2=0.87). Micrometeorites >700µm number only 22 particles – insufficient for a meaningful statistics.

Micrometeorite abundance peaks at 250µm (±40µm), consistent with data from other collections (e.g. 210-330µm [15]; 200-250µm [3], and 265µm ±92µm[16]). Meanwhile abundances <200µm have a distinct abundance profile which appears unrelated to the larger size fractions.

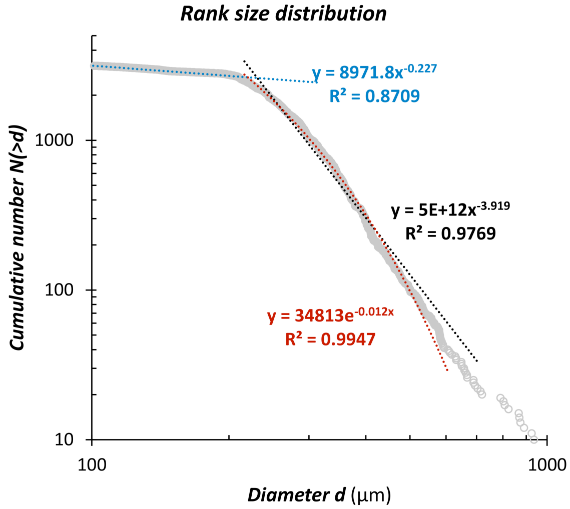

Figure 1. Rank-size distribution for the TAM65 micrometeorite collection.

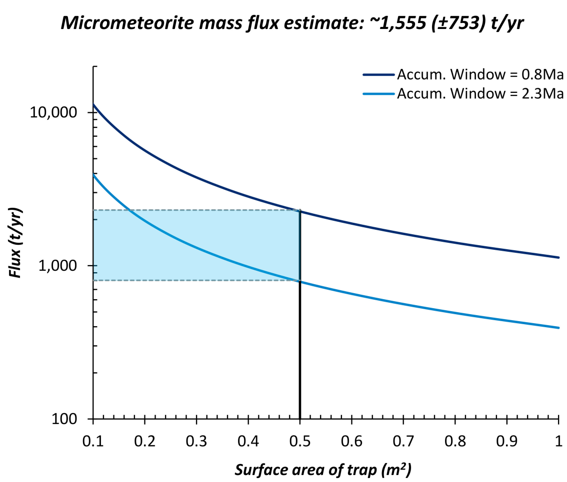

Figure 2. Mass flux estimate (in t/yr) based on the TAM65 data. Our estimate varies significantly, dependent on two factors: the size and age of the collection site.

Discussion – size distribution: The TAM65 size distribution is bimodal, with peaks centered at ~145µm and ~250µm. On reanalyzing the published Larkman Nunatak size data by [15] we identified remarkably similar peak positions (155µm and 243µm). These observations suggest that the micrometeorite flux reaching Earth is composed of multiple dust sources with distinct size distributions. We envisage three probable explanations that could be responsible for the two main size distributions: (1) asteroidal vs. cometary parent bodes, (2) hydrated vs. anhydrous chondrites or (3) constituent components of chondrites: fine-grained matrix vs. coarse-grained chondrules and CAIs.

Discussion – Mass flux (Fig.2): The estimated total extraterrestrial mass within the TAM65 trap is ~1.772g. Assuming negligible secondary effects (accumulation or loss by terrestrial processes) and 100% efficiency in micrometeorite recovery, we estimate a total mass flux of cosmic dust to Earth between 803 and 2,308 t/yr. This estimate is based upon a collection area of 0.5m^2 and an accumulation window between 0.8 and 2.3 Ma.

Uncertainty on the duration of the accumulation window introduces a factor of three error in our flux estimate. Likewise, constraining the surface area of the trap, and the effects of no accumulation (during strong winds or snow cover) are difficult to quantify, thereby precluding a more precise flux estimate.

Given the above limitations we conclude that the order-of-magnitude, time-averaged flux of cosmic dust (within the 100-2000µm size range) arriving on Earth over the last 0.8-2.3 Ma lies at approximately 1,555 (±753) t/yr – consistent with previous micrometeorite abundance estimates and almost identical to the South Pole Water Well estimate (~1,600 t/yr)[3] and potentially indicating minimal variation in the background cosmic dust flux over the Quaternary period.

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