CONSTRAINTS ON THE SPATIAL ORIGINS OF INDIVIDUAL MICROMETEORITES: EVIDENCE FROM COSMOGENIC RADIONUCLIDES ^{26}Al AND ^{10}Be.

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Introduction: The study of cosmogenic radionuclides in meteorites for the determination of cosmic-ray exposure duration in space has been well-established for meteorites. For micrometeorites (MMs), this approach has rarely been applied [1-5]. The small size of MMs (30-1000 µm [6]) poses the challenge of being able to experimentally measure the trace amount of radionuclide atoms contained in individual MMs. This quantity decreases with increasing terrestrial age, which in many cases is not known. Because the precise origin of individual MMs (as either asteroidal or cometary) is still under debate, the study of their cosmic-ray exposure ages represents an important step towards identifying their heliocentric distance of origin within our Solar System.

Methods: We measured long-lived ^{26}Al and ^{10}Be in twelve silicate-type MMs collected on urban rooftops and Antarctic moraine sediments [1,7]. While the urban MMs are not older than the rooftops from which they were collected (i.e., insignificant terrestrial ages for ^{26}Al and ^{10}Be [8]), the terrestrial ages of the Antarctic MMs potentially exceed 780 kyr [7]. The individual MMs with diameters of 90-500 µm were dissolved and, after stable carrier addition, ^{26}Al and ^{10}Be were chemically extracted and measured by accelerator mass spectrometry (AMS) at the Vienna Environmental Research Accelerator (VERA), Austria. The experimental data were compared to the results of a model that calculates the build-up of cosmogenic radionuclides in MM precursors in space. Briefly, this model simulates the travel of the MM precursors on spiral trajectories towards the Sun due to the Poynting-Robertson drag while being irradiated by solar and galactic cosmic rays with non-isotropic flux profiles producing ^{26}Al and ^{10}Be [1]. The number of cosmogenic radionuclides increases with the time the MM precursors reside in interplanetary space, providing the opportunity to estimate their heliocentric distance of origin in the Solar System. The model considers a variety of orbits, precursor particle sizes, compositions, and densities, depth-dependent production rates, as well as spherical evaporation during atmospheric entry.

Results & Conclusions: Individual MMs contained ~10^4-10^7 ^{26}Al and ^{10}Be atoms. Comparison of the experimental radionuclide concentrations (Fig. 1) with the modelled data revealed a wide range of exposure durations in space reaching from near 0 up to 5.8 Myr, and similarly a wide range of heliocentric distances of origins from Near-Earth orbits to the Kuiper Belt. Therefore, the origin for six MMs remains enigmatic. However, two MMs show a preferential bias towards an Inner Solar System origin (Near Earth Objects to the Asteroid Belt) and four towards an Outer Solar System origin (Jupiter Family Comets to the Kuiper Belt). Our results show that dust originating from the Outer Solar System may be able to survive prolonged transport and arrival to the terrestrial planets.

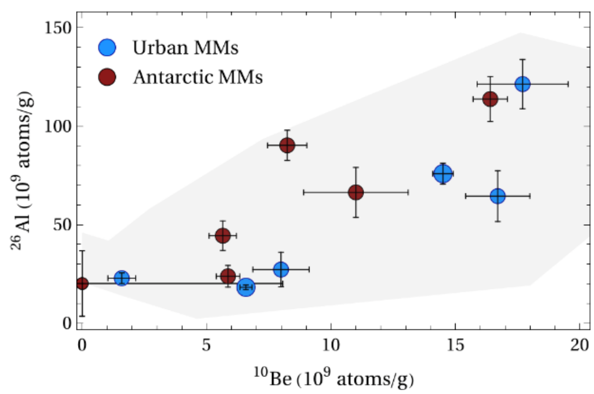

Figure 1: ^{26}Al and ^{10}Be data of urban and Antarctic MMs [1]. The gray region enveloping the data corresponds to measurements from other studies [2-5].

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