SURVIVAL OF LARGE MICROMETEORITES ON ATMOSPHERIC ENTRY: IMPLICATIONS FOR THEIR SOURCES AND THE FLUX OF COMETARY DUST.

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The distribution of peak temperatures reached by small micrometeorites ($\leq$ 100 μm in diameter) on atmospheric entry has been used as an indicator of their sources [1]. The recent recovery of larger unmelted particles from the Greenland and Antarctic ices [2] raises two questions:

1) how large a particle can survive entry unmelted, and,
2) does unmelted survival constrain the possible sources of these particles.

ATMOSPHERIC ENTRY HEATING: The heating experienced by micrometeorites on atmospheric entry can be calculated using the model developed by Whipple [3]. A computer simulation has been developed to determine the entry heating temperature profiles and fraction of particles heated above any temperature for micrometeorites with a range of densities, diameters, initial velocities, and impact parameters [4]. The results are shown in Figure 1, where the peak temperature reached on entry is plotted against impact parameter for initial velocities of 1, 5, 10, and 20 km/sec (prior to gravitational infall acceleration). Even for particles as small as 200 μm in diameter, only those having geocentric velocities (prior to earth infall acceleration) less than 3 km/sec reach peak temperatures below 1600K (the melting point of the dominant silicate phases) on entry. Though this simulation overestimates the peak temperature for particles which melt because it does not include the heat of fusion, it should accurately predict the onset of melting for the dominant mineral phase(s).

EVIDENCE FROM RADAR METEORS: The validity of the Whipple entry heating model cannot be experimentally verified since the deceleration destances are typically tens of kilometers. However, the observation of radar meteors provides direct evidence that particles which the Whipple model predicts will be severely heated do, indeed, vaproize on atmospheric entry. Micrometeorites as small as 10^{-6} grams (~100 μm in diameter) are detected by radar [5]. Recent radar meteor observations show the mass influx of 10^{-6} to 10^{-3} gram micrometeors [6] to be consistent with the flux of 10^{-6} gram particles measaured by satellites. Thus, only a small fraction of the particles larger than 100 μm survive entry without vaporizing (presumably the lowest velocity fraction.)

IMPLICATIONS FOR SOURCES: Geocentric velocities less than 3 km/sec are characteristic of particles derived from main-belt asteroidal parent bodies and evolved to earth under Poynting-Robertson (PR) drag [1]. Thus most large ($\geq$ 200 μm) unmelted micro-meteorites are likely to be asteroidal, consistent with the conclusion, based on chemical associations, that the large unmelted particles from the Antarctic ices are asteroidal [2].

FLUX OF COMETARY DUST: The contribution of main-belt asteroids to the flux of large ($\geq$ 200 μm) particles at earth has

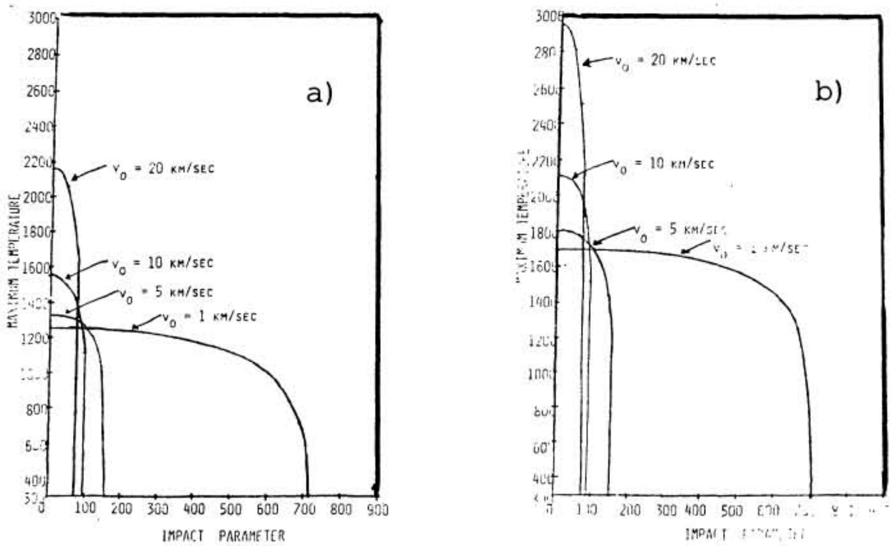

FIGURE 1: Peak temperature versus impact parameter for particles of 1 gm/cc density, geocentric velocities (before earth infall acceleration) of 1, 5, 10 and 20 km/sec, and diameters of a) 60 μm, or b) 200 μm.

previously been assumed to be small [1, 7] since the time required for the orbit of a large dust particle to evolve under PR drag from the main belt to earth intersection is significantly larger than its calculated catastrophic collision lifetime [8]. If, as the unmelted entry survival suggests, these particles are asteroidal, then the catastrophic collision lifetimes accepted in the literature must be questioned. Dohnanyi [8] notes that, even within the asteroid belt, catastrophic collisions between two asteroidal particles are very rare compared to those between an asteroidal and a cometary particle. Thus the survival of large asteroidal particles long enough to evolve to an earth intersecting orbit suggests the flux of cometary particles in the inner solar system is significantly less than previously assumed. This is consistent with the conclusion that much of the smaller cosmic dust collected at earth is asteroidal [1].

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