SIMULATION OF THE ATMOSPHERIC ENTRY OF MICROMETEORITES THROUGH THE MARTIAN ATMOSPHERE.

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Introduction: The main source of extraterrestrial material on Earth is micrometeorites (MMs) and interplanetary dust particles (IDPs). These sub-millimeter particles are thought to contribute 20-40 kt of material to the Earth annually [1]. All MMs experience some degree of heating during atmospheric entry depending on their initial velocity, entry angle and size. Using a model based on that of Love and Brownlee (1991), this study models the atmospheric entry of MMs entering the terrestrial and Martian atmosphere to compare the abundances of unmelted and melted particles.

Method: Simulations of ~29000 particles with radii ranging from 10-500 µm and entry angles ranging from 5-90° were run for both entry conditions on the Earth and Mars. The entry velocities range from the escape velocity of Earth and Mars (11.2 and 5kms^{-1} respectively) to the solar system escape velocity at the planets distance from the sun (72 and 32.4 kms^{-1} respectively). All particles are assumed to have a chondritic composition and an average density of 3 gcm^{-3}. The probability of a particle having any combination of entry parameters was also calculated for the Earth and Mars. This allows the proportion of the extraterrestrial dust flux reaching a given temperature range to be predicted.

Results: *Peak Temperature:* The average peak temperature reached by a particle is higher on Earth than on Mars, 1950±80 K and 1700±100 K respectively. The error accounts for grazing incident particles as the model only considers the first pass through the atmosphere. Some MMs will be lost to space and some will re-enter the atmosphere and reach higher temperatures on their second/third entry, especially particles with higher initial velocities. It is clear that more particles will survive atmospheric entry without melting on Mars compared to Earth. Assuming a solidus temperature of 1573 K [2], simulations suggest 63.6±3.2% of MMs falling on Mars will survive unmelted, whereas only 29.7±1.5% of MMs falling on Earth survive unmelted.

Mass Loss: The mass loss of an MM during entry is directly related to the temperature the particle reaches. Particles falling on Earth lose more mass than those falling on Mars with ~9.1% compared with ~3.5% of particles being completely vaporized during entry. However, this is restricted to those particles with the highest entry velocities. Of those particles that are not vaporized, a large proportion falling on Earth (~40.7%) still lose >90% of their original mass but only 12% of particles falling on Mars lose this amount.

Discussion: At escape velocity, a particle with initial radius ≥110 µm requires a grazing incidence to survive without melting on Earth. However, at escape velocity on Mars a particle as large as 500 µm can survive without melting and does not require a grazing incidence. Larger MMs seem to have affinities with ordinary chondrites and smaller particles with carbonaceous chondrites [3, 4, 5]. Due to larger MMs surviving on Mars more easily than on Earth it is possible that MMs on Mars could provide samples of other parent bodies not seen in current collections. As well as other asteroidal parent bodies, it is also likely that more particles with a cometary origin will survive entry on Mars. MMs with possible cometary origins on Earth are very rare due to their higher entry velocities, whilst those on Mars survive owing to lower gravitational acceleration.

Organic survival: Extraterrestrial organic material has been found in MMs in several studies e.g. [6, 7] however, most of these organics decompose at ~473 K with some surviving up to ~823 K. On Earth, only ~0.8±0.8% of particles remain below 823 K, however, on Mars, ~13.2±2.2% of MMs remain below this temperature. Also, [8] found that a few percent of some types of organic material in MMs can survive up to 1173 K. A similar trend is seen with ~4.3±1.3% of MMs remaining below this temperature on Earth and ~37.8±2.8% of MMs remaining below this temperature on Mars. This suggests that significant extraterrestrial organic material could accumulate on areas of the Martian surface with low sedimentation rates.

Conclusion: These simulations show a much higher survival rate for MMs on Mars compared to Earth. Therefore, large quantities of MMs could have built up on the Martian surface. They may also provide samples of MM parent bodies not yet studied. Future Martian rover missions could incorporate instruments capable of finding and studying MMs on the surface with the hope of gaining a wider understanding of the population of meteorite parent bodies.

Although it is difficult to estimate the amount of organic material surviving entry on Mars, it is still possible to say that some will survive. If there were locations on Mars which naturally enrich the soil in MMs, it is possible that a significant amount of extraterrestrial organic material could have accumulated, potentially providing a suitable habitat for microbial life.

References: [1] Love. S. G and Brownlee. D. E. 1993. *Science.* 262: 550-553. [2] Genge. M. J. 2016. *MAPS*. 51: 1063-1081. [3] Flynn. G. J. 2009. 40th *LPSC.* Abstract #1164. [4] Suavet. C. 2010. *Earth and Planetary Science letters.* 293: 313-320 [5] Prasad. M. S. 2013. *Journal of Geophysical research.* 181: 2381–2399. [6] Matrajt. G. 2005. *A&A*. 433: 979-995. [7] Clemett. S. 1993. *Science*. 262: 721-725. [8] Matrajt. G. 2006. *MAPS*. 41: 903-911.