The effect of atmospheric entry heating on micrometeorite volatile composition

Conference or Workshop Item

THE EFFECT OF ATMOSPHERIC ENTRY HEATING ON MICROMETEORITE VOLATILE COMPOSITION.

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Introduction: With estimates of present day mass flux of 40,000 ± 20,000 t/yr [1], micrometeorites (MMs) may have served as a substantial contributor of volatiles and biologically significant molecules to the early Earth (or other young planetary surfaces). These particles have high relative velocities, which dissipate their energy during atmospheric entry. This study investigates the effect of heating during atmospheric entry, on the survival and modification of organic material in MMs, and their involvement in pre-biotic organic chemistry.

Experimental Techniques: Due to the micrometer-sized nature of MMs and their low availability for analysis, compositionally analogous materials are required to represent unmelted MM particles. In this case, 9mg aliquots of the powdered carbonaceous chondrite Murchison are used.

The samples were heated in air to peak temperatures between 400 and 1000^{o}C for the short durations of 5, 10 and 20 seconds, using a platinum filament fitted to a CDS 1000 pyroprobe. A thermocouple was embedded in the sample to quantify the peak temperature experienced by the sample. The heating range is comparable to the peak temperatures experienced by unmelted MMs [2, 3]. Fractions of the heated sample were examined using elemental and thermo-gravimetric (TG) analysers, to assess the percentage carbon loss and volatile and organic survival.

Results: Elemental analysis demonstrates that the shorter the heating duration, the higher the percentage of total carbon surviving any peak entry heating temperature. A minimum of 5% total carbon remains in samples heated to ~900^{o}C for 20s, corresponding to carbonate minerals. A minimum of 30% total carbon remains in samples heated to a similar peak temperature for 5s. The remaining carbon is dominated by carbonate minerals with detectable quantities of organics.

A greater abundance and broader range of organic material survives in samples exposed to higher entry heating temperatures at shorter heating durations. As TG CO_2 profile peaks corresponding to organics are very broad, it is not possible to identify individual organic components. Alternative techniques are required to determine the nature of surviving organic material.

Similarly, at shorter heating durations, a greater abundance of adsorbed and structurally bound water was able to survive, when exposed to higher entry heating temperatures. The structural water peaks are consistent with cronstedtite [4], a dominant phyllosilicate present in Murchison [5].

Implications: The results demonstrate that organic molecules and other volatile components can withstand certain atmospheric entry heating conditions. It is therefore plausible that micrometeorites may have made a contribution to the organic inventory of the early Earth, prior to the evolution of life.

References: [1] Love, S. G. and Brownlee, D. E. 1993. *Science* 262:550-553. [2] Toppani, A. et al. 2001. *Meteoritics and Planetary Science* 36:1377-1396. [3] Love, S. G. and Brownlee, D. E. 1991. *Icarus* 89:26-43. [4] Morris, A. A. et al. 2005. Abstract #1925. 36th Annual Lunar and Planetary Science Conference [5] Buseck, P. R. and Hua, X. 1993. *Annual Review of Earth and Planetary Sciences* 21:255-305.