

Simulating Meteor Ablation at the Hypersonic Materials Environmental Test System

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The ablation mechanisms of stony meteorite material and a terrestrial analog were investigated at the Hypersonic Materials Environmental Test System (HyMETS) facility at NASA's Langley Research Center. The primary analyte (Tamdakht-H5) and arc-jet test conditions were chosen to simulate the entry of an ordinary chondrite through the Earth's mesosphere.¹ Basalt was selected to compare the meteorite response against material with enhanced polymerization and an elevated concentration of volatile species.

The initial ablation process for each material commences with the vaporization of volatile species and germination of a viscous melt layer on the stagnation surface. However, each material exhibited distinct mass loss mechanisms, with basalt recessing at twice the rate of Tamdakht. Inspection of high-speed video and chemical analysis of the post-test melt layer suggests the dominant mode of mass loss of Tamdakht is expressed through the vaporization of volatile compounds. Vaporization rates of Tamdakht are 18x higher than basalt under the most severe test conditions which provides enhanced thermal shielding. Furthermore, Tamdakht produces a relatively stable melt flow, as evidenced by perpetual growth at the sidewall and the exiguous detachment of molten material into the flow.

The ablation mechanism of basalt is markedly different from Tamdakht and is governed by volatile species in the virgin material. The dominant mode of mass loss for basalt is attributed to the detachment of large sections of the stagnation surface near the edge radius. An additional but subordinate mode of mass loss is assigned to the removal of melt flow as it passes over the edge radius, where shear forces overcome the rheological properties of the molten matter.

Finally, mechanistic details will be discussed in terms of designing future test campaigns, developing meteorite-based materials response models, and impacting the broader scope of the Asteroid Threat Assessment Project (ATAP).

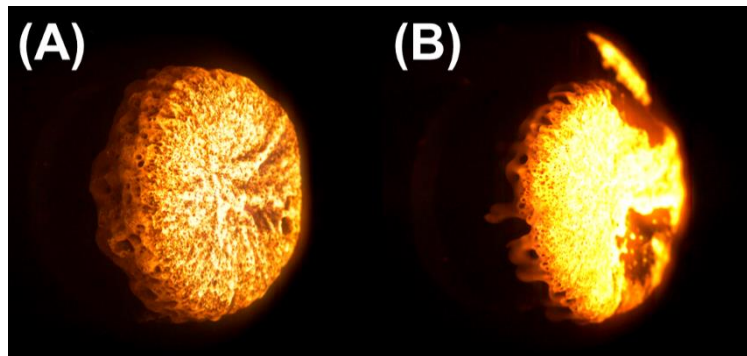


Figure 1. Still images of the stagnation surfaces of (A) Tamdakht and (B) basalt during testing at the Hypersonic Materials Environmental Test System (HyMETS).

[1] Raghunandan, P. et. al. *AIAA Journal*, 60, 4, 2022.