Simulating Ordinary Chondrite (Tamdakht) Ablation at the Hypersonic Materials Environmental Test System (HyMETS) Facility. Brody K. Bessire[1], Francesco Panerai[2], Peter E. Marshall[3], Adam Caldwell[3], Eric C. Stern[1]. [1]NASA Ames Research Center (brody.k.bessire@nasa.gov), [2]University of Illinois Urbana-Champaign, Analytical Mechanical Associates NASA Ames Research Center[3].

NASA's Science Mission Directorate (SMD) created the Asteroid Threat Assessment Project (ATAP) to inform decision-makers of risks associated with Potentially Hazardous Objects (PHOs), which may pose an existential threat to human civilization. ATAP assesses risk, in part, by developing analytical physics-based damage models which draw upon data collected during material property characterization efforts, entry simulations, hazard simulations, and ground-based arc-jet testing.

Therefore, a pathfinder test campaign was conducted at the Hypersonic Materials Environmental Test System (HyMETS) at the NASA Langley Research Center to investigate the ablation mechanisms of an ordinary chondrite (Tamdakht H5) and a terrestrial analog (basalt). The HyMETS facility is a 400 kW constricted arc heater used to screen material performance under simulated aerothermal conditions of hypersonic flow.[1] Facility conditions were chosen to simulate Earth entry conditions between the upper-mesosphere and the lower thermosphere.[2]

The ablation mechanisms of Tamdakht and basalt are illustrated with still images collected from high-speed video cameras (fig. 1, Tamdakht). Tamdakht produces a relatively stable melt flow, as evidenced by the perpetual growth of a flange at the sidewall and the exiguous detachment of molten material into the flow. Furthermore, an inspection of high-speed video and chemical analysis of the post-test melt layer suggests that the dominant mode of mass loss for Tamdakht, at these test conditions, is expressed through the vaporization of volatiles (e.g., iron, potassium, sodium, phosphorus, and sulfur). The vaporization rates of Tamdakht are greater than basalt under the most extreme test conditions, which leads to an enhanced blowing layer, increased thermal shielding, and reduced recession.

The ablation mechanisms of basalt are markedly different from Tamdakht and are attributed to the presence of hydrated minerals dispersed at irregular intervals throughout the silicate matrix. Rapid decomposition of secondary minerals and the subsequent formation of water lead to the ejection of the subsurface and overlying melt layer. Furthermore, the presence of water is suspected of lowering the viscosity of the melt layer resulting in increased mass loss near the edge of the test article where drag forces overcome rheological properties (fig. 1, basalt).

Finally, the results will be discussed in the broader context of meteorite-based material response model development and the potential impact on the Asteroid Threat Assessment Project (ATAP).

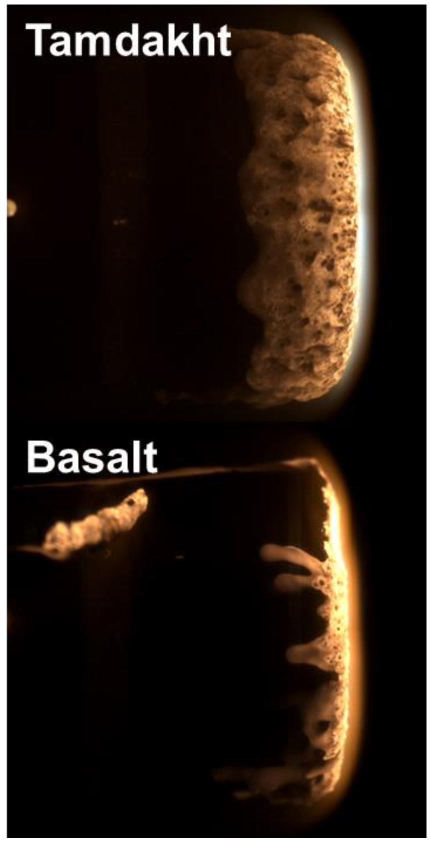

Figure 1: Still images from high-speed videos collected during arc-jet testing of Tamdakht (upper photo) and basalt collected from the Columbia river plateau (lower photo).

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References:

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