

MARTIAN MICROCRATERS AS EVIDENCE FOR OBLIQUITY-DRIVEN PRESSURE VARIATIONS. R. G. Nuno¹ and D. A. Paige¹, ¹University of California, Los Angeles, CA, 90095 (rgnuno@ucla.edu).

Introduction: Mars' axial obliquity undergoes quasi-periodic oscillations that change the latitudinal distribution of solar radiation on Mars' surface [1-4]. At low obliquity high latitudes receive less incident sunlight. Climate models show that during these times of low obliquity almost all CO₂ condenses into permanent polar caps leaving only the non-condensable N₂ and Ar components of the atmosphere [5]. This decrease in atmospheric mass should affect production rates of impact craters by allowing small impactors to reach the surface. At present atmospheric conditions the smallest impact craters estimated to form have a diameter of about 25 cm [6]. Therefore observations of centimeter-sized and smaller craters can be used as evidence for past low-pressure atmospheric conditions [7].

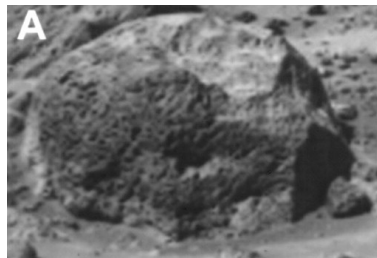


Figure 1. 25 cm impact crater on boulder on Mars' surface taken by the Pathfinder rover [6].

In this work we quantitatively assess atmospheric effects due to deceleration and ablation on a sample carbonaceous chondrite entering the Mars atmosphere at a range of entry velocities. Our model calculates impact velocities, and final crater diameters over a range of impactor masses, and atmospheric pressures (6 mbar and .1 mbar). Our eventual goal for this work is to develop a model to fully characterize obliquity-driven climate variations on small and micro impact crater production rates, and to correlate those results with a search in images taken by rovers on the surface of Mars for evidence of small craters preserved on surface rocks (Fig. 1).

Methods: Impact velocities and mass loss were calculated by solving ablation and atmospheric drag equations, with the assumption that impactors were non-fragmenting as in [8]:

$$\frac{4\rho_e r_e}{3\rho_o H} \sin(\theta) e^{-\left(\frac{\sigma v_e^2}{\rho_e}\right)^{1/6}} \int_{\left(\frac{\sigma v^2}{\rho_e}\right)^{1/6}}^{\left(\frac{\sigma v_e^2}{\rho_e}\right)^{1/6}} \frac{e^u}{u} du - 1 + e^{-Z_e/H} = 0$$

and $m = m_e e^{\frac{\sigma}{2}(v_e^2 - v^2)}$ where ρ_e is the density of impactor, r_e is the impactor radius, ρ_o is atmospheric density, H is the atmospheric scale height, θ is the angle of impactor's trajectory with respect to the surface normal, σ is the ablation coefficient (Table 1), Z_e is the height at which impactor enters the atmosphere, m_e is the mass at entry, and V_e and V are the entry and final velocities, respectively.

Impactor Type	Density [kg m ⁻³]	Ablation Coefficient [s ² m ⁻²]
Carbonaceous Chondrites	2000	4.2 x 10 ⁻⁸

Table 1. Parameters used for calculations.

Crater diameters were calculated using an energy-crater relation as in [9] based on experimental results:

$$D = 10^{-2.823} \times \rho_e^{\frac{1}{6}} \times \rho_T^{\frac{1}{2}} \times \left(\frac{1}{2} m v^2\right)^{0.37} \times (\cos\theta)^{0.86}$$

where ρ_T is the target density assumed to be 2.8 g cm⁻³ which is appropriate for crystalline rocks.

Results: Results of our modeling show that our model works as expected. Meteorites traveling through a denser atmosphere will decelerate (Fig. 2a) due to drag and will lose more mass through ablation (Fig 2c) than those traveling through a less dense atmosphere (Fig. 2b and Fig. 2 d).

Discussion: We are currently expanding our model to include other types of impactors (irons, ordinary chondrites, and cometary material) and greater range of impactor masses to accurately describe the types of impactors that can generate centimeter and smaller craters on the surface of Mars. We will use a Monte Carlo simulation to generate a robust crater model for hypervelocity impacts.

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