A LOW PRESSURE EJECTION MECHANISM FOR MARTIAN METEORITES?

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Introduction: Over 40 years ago, Gene Shoemaker, Don Gault, and Paul DeCarli discussed the possibility that a large impact could accelerate Martian rocks to escape velocity. If the shock in near-surface rocks were relieved by planar release waves from the surface, the rocks might be ejected by spalling at a free-surface velocity of 5 km/s, corresponding to a shock pressure of about 65 GPa. Don convinced us that planar stress release was improbable and that it was much more likely that Martian rocks would be ejected at a particle velocity of 5 km/s, corresponding to a shock pressure in excess of 100 GPa. The rocks would be molten on release of pressure.

However, there is very strong evidence that certain meteorites did originate on Mars. There is also strong evidence that some of these Martian meteorites were not shocked to pressures as high as 65 GPa, the minimum pressure implied by the spall mechanism. Measurements of the magnetic field of Martian meteorite ALH84001 imply that the ejection event did not heat it above about 40 C [1], corresponding to a maximum shock pressure during ejection of < 13 GPa.

Further Constraints: The primary problem is to avoid tensile (and shear) stresses that fragment the meteorite. Dynamic (microsecond-duration stress) tensile failure of compact rocks begins in the range of about 100-250 MPa, and complete fragmentation is observed at tensile stresses above 500 MPa [2]. The fact that Martian meteorites have dimensions of centimeters implies acceleration by pressures less than 500 MPa.

Low-Pressure Acceleration of Meteorites: If we have correctly identified the Martian meteorites, there must be a mechanism for low-pressure acceleration. The high-velocity guns used in experimental impact studies use modest pressures, less than 300 MPa, to achieve projectile velocities as high as 6 km/s. Vickery's calculations indicate that Martian surface rocks could be accelerated to escape velocity by entrainment in an impact-generated vapor cloud [3] The calculations indicate that rocks having a crush strength of 100 MPa could be as large as large as 10 m diameter and survive acceleration to 5 km/s. Weaker rocks, with a crush strength of 10 MPa, would have to be smaller, ca. 1 m diameter, to survive acceleration to 5 km/s.

New Results: We present the results of current studies of Zagami. Our interpretation of its thermal and pressure history implies that its shock history predated its ejection from Mars. Our calculations are in agreement with Vickery's.

Conclusions: The fact that a meteorite is identified as Martian does not imply a high pressure, ca 65 GPa, ejection event. Observations on Martian (and even Lunar) meteorites are consistent with a low-pressure mechanism for accelerating the meteorites to escape velocity.

References: [1] Weiss B. P. et al 2000 *Science* 290:791-795 [2] Ai H. A. and Ahrens T. J. 2004 *Meteoritics and Planetary Science* 39: 233-246 [3] Vickery A. M. 1987 International Journal of Impact Engineering 5:655-661