CHARACTERIZATION OF MARTIAN ROCK SHAPE FOR MER AIRBAG DROP TESTS.

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Introduction: Mars Exploration Rover airbags, like those for Mars Pathfinder, were designed to encapsulate and cushion the lander when impacting the Martian surface. It is necessary to test the strength and durability of these airbags against analog Martian rock distributions in order to observe damage that could effect the airbags performance. Airbag tests are conducted at the largest vacuum chamber in the world in Plum Brook Station of NASA's Glenn Research Station in Sandusky, Ohio. A full scale lander with airbags is suspended with a bungee cord above 60° , 30°, 45° and 0° dipping platforms to simulate different landing angles and are pulled down at landing velocities. The airbags have four, six-lobed tetrahedral faces each covering an area of approximately 8.95m^2. Attached to the platforms are chalked sharp andesite rocks in distributions similar to or worse than the martian surface. Chalked rocks are re-arranged on the platform to target distinct areas on the airbags so that specific damage can be assessed.

Because MER is more massive than Mars Pathfinder, airbag drop tests have shown that as an airbag conforms around triangular rocks >0.2 m high, the tensile stress can exceed the strength of the inner bladder and cause failure. Angular rocks also cause greater abrasion of external layers. The burial of a rock (perched, partially buried or buried) was also considered because perched rocks may pose less of a threat to the airbags than those buried because perched rocks can be dislodged and roll during impact resulting in less stress to the interior bladder and less abrasion of outer layers. Susceptibility to failure against triangular rocks has also been largely ameliorated by the addition of a second interior airbag bladder.

Using the Viking and Mars Pathfinder landing sites as a guide, this study assessed rock shapes, sizes and burial so they could be compared with rocks on the test platforms. This work allowed comparison of the severity of the rock distributions on the test platforms with the 3 landing sites and helped guide the rocks used on the test platforms during the final airbag qualification tests.

Rock Shape and Burial: For Viking Lander 1 and 2 (VL1 and VL2), rock data sets included rock height, width, location, and burial of all rocks in an area of approximately 80 m^2 and include 425 and 499 rocks respectively [1]. Burial of rocks at VL1 and VL2 has been estimated as perched, partially buried or deeply buried [2]. Triangular rocks >0.2 m high are potentially hazardous to the airbags. There was only one rock >0.2 m high in the Viking Lander 1 data set, so rocks >0.1 m high were included for a total of 44 rocks. At Viking Lander 2 a total of 28 rocks >0.2 m high were evaluated. The Mars Pathfinder near field data set includes 1472 rocks that extend from 3-6 m around the lander for a total area of 85 m^2 [3]. There were only 14 rocks >0.2 m high so rocks >0.1 m high were included. There are 61 total rocks in the Mars Pathfinder data set.

Rocks were classified into three categories, round, square or triangular. Round rocks were those that appeared to be weathered, hemispherical or smooth. Rocks classified as square had large flat tops or had flat distinct linear features. Triangular rocks were distinctively angular or pyramidal in shape. There were a total of 46 rocks >0.2 m high with burial data at the three landing sites. Classifications of each rock were made by three independent observers using the same lander images. Final rock shape characterizations were determined by a two thirds majority. MER airbag test platforms were characterized so a comparison of rock distributions could be made with those determined at the 3 landing sites. Photographs of 16 test platforms were used to characterize rock shape of 126 rocks and all of these rocks were considered deeply buried as they are firmly attached to the platform.

Conclusions: On average ~33% of all rocks analyzed at the three landing sites are triangular. Approximately 14% of all rocks that are >0.2 m high are buried. Approximately 19% of all rocks at the three landing sites >0.2 m high are triangular and buried or partially buried and 7% are triangular and deeply buried. Rock distributions on MER airbag platforms show that a greater number, ~25% of triangular rocks are >0.2 m high and all of these rocks are considered deeply buried as they are firmly attached to the platform. This indicates that rocks on MER airbag test platforms have more hazardous rocks and thus represent a greater hazard to the airbags than the rocks at the three landing sites.

References: [1] Moore, H. J. and Keller J. M. (1990) NASA Tech. Mem. 4210, 160-162, (1991) NASA Tech. Mem. 4300, 533-535. [2] Baron J. E. et al. (1998) *JGR, 103,* 22,695-22,712. [3] Haldemann et al. (2000) LPS XXXI, Abstract #1846.