ROCK STATISTICS AT THE MARS PATHFINDER LANDING SITE, ROUGHNESS AND ROVING ON MARS. A. F. C. Haldemann, N. T. Bridges, R. C. Anderson and M. P. Golombek, Jet Propulsion Laboratory, California Institute of Technology (JPL 238-420, 4800 Oak Grove Dr., Pasadena, CA 91109-8099, albert@shannon.jpl.-nasa.gov).

Introduction: Several rock counts have been carried out at the Mars Pathfinder landing site [1,2,3,4,5] producing consistent statistics of rock coverage and size-frequency distributions. These rock statistics provide a primary element of "ground truth" for anchoring remote sensing information used to pick the Pathfinder, and future, landing sites [1,6,7]. The observed rock population statistics should also be consistent with the emplacement and alteration processes postulated to govern the landing site landscape [8,9,10]. The rock population databases can however be used in ways that go beyond the calculation of cumulative number and cumulative area distributions versus rock diameter and height. Since the spatial parameters measured to characterize each rock are determined with stereo image pairs, the rock database serves as a subset of the full landing site digital terrain model (DTM) [11]. Insofar as a rock count can be carried out in a speedier, albeit coarser, manner than the full DTM analysis [11], rock counting offers several operational and scientific products in the near term. Quantitative rock mapping (see Figure 1) adds further information to the geomorphic study of the landing site, and can also be used for rover traverse planning. Statistical analysis of the surface roughness using the rock count proxy DTM is sufficiently accurate when compared to the full DTM to compare with radar remote sensing roughness measures, and with rover traverse profiles.

Rock Counts: *MarsMap rock count.* A first rock count was produced using the MarsMap virtual reality software [12] during Pathfinder operations. The analysis was carried out on the Monster pan set of IMP images. One person measured some 2000 rocks in about 1 month. For each rock the position at the left tangent point of the rock's touching the soil, the rock apparent width, and the rock maximum z extent were measured. The map of MarsMap rock positions is shown in Figure 1. A 3 m to 6 m annulus, considered to have been thoroughly surveyed for rock sizes above 3 cm was used to assemble rock statistics. The cumulative area covered within the annulus is 16%, with variation ranging from 11% coverage in the eastern half of the annulus, to 25% coverage within the rock garden (southwest quadrant).

Showstereo Rock Count. This second more detailed rock count consisted of measuring 9 (x,y,z) points on each of some 4400 rocks to define position, apparent width, long axis, short axis, and maximum height. Additionally rock shape (roundness and angularity), texture, and burial were assessed for all sufficiently large rocks. This work was carried out using showstereo display software on stereo image pairs, one pair at a time. The work required the cumulative effort of 6 summer students working for 10 weeks each, or about one person-year. A summary of the rock statistics of this database will be presented at the meeting. Fits of the Golombek and Rapp [8] rock distribution relationships for some 3200 of the rocks within the dataset (from 2.5 to 10 m) yield reasonable results for a cumulative fractional coverage of 12.9% (assuming simple elliptic rock shape) and exponential factor of 2.5. Analyses of whether distinct rock populations can be identified using the rock characterization parameters will also be discussed.

Far field rock count. Rocks in the far field were examined using the vertical IMP stereo pairs produced by pre- and post-mast-deploy panoramas. Rock positions were estimated both by comparison with the horizon position and by triangulation. The horizon method appears sufficiently accurate to produce rock statistics that are in agreement with the size-frequency distributions of smaller rocks closer to the lander.

Surface Roughness: Surface roughness can be estimated using the rms deviation of the proxy DTM corresponding to the cloud of (x,y,z) points of rock positions. An initial conclusion from the MarsMap rock count data is that the surface roughness at the Pathfinder landing site is self-similar at scales from 0.5 to 5.0 m, with a fractal dimension D=2.47+/-0.04. The rock garden is rougher with D=2.2+/-0.7, while the eastern sector is smoother with D=2.55+/-0.05. These observations are also consistent with the rover traverse profiles for which D=2.47+/-0.01 for all the traverse data. The connection to the remotely sensed radar Hagfors rms slope of 4.8 degrees is that this corresponds to a length scale of around 3.5 m at the Pathfinder landing site. This value is some 100 times the radar wavelength used (3.5 cm), and is thus entirely consistent with the assumptions of the Hagfors scattering model used to analyze the radar data.

Outlook: Rock population analysis offers operational opportunities, first for selection of a landing site, then for analysis of the geomorphic information at the landing site. Initial, "by-hand", rock counts can probably be effected in a manner that would support rover traverse planning, especially if some degree of automation can be developed [5]. These data also offer an opportunity to test sampling scenarios, and automation scenarios for future missions; what sort of sample-return target rock would be chosen at the Pathfinder site using the algorithms being developed for Mars '03? Can quantitative rock mapping provide useful information for rover targeting decisions? This may aid Marie Curie on '01. Does our Pathfinder experience with surface roughness lend itself to an improved analysis for '01 and later landing site selection?

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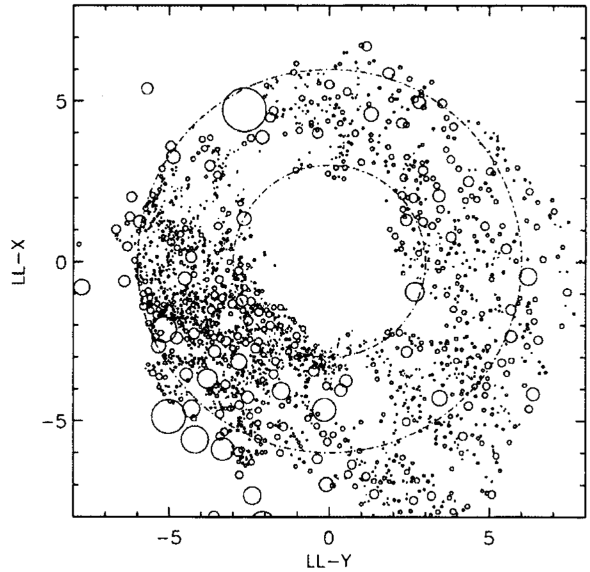

Figure 1. Map of rock positions measured with Mars-map virtual reality software [12]. Coordinates are local lander frame in units of meters. North is at the top, and the rock Yogi is the largest circle centered at approximately LL-Y –2.7 m, LL-X 4.8 m.