MARS PATHFINDER NEAR-FIELD ROCK DISTRIBUTION RE-EVALUATION. A. F. C. Haldemann[1] and M. P. Golombek[1], [1]Jet Propulsion Laboratory, California Institute of Technology, Mail-Stop 238-420, 4800 Oak Grove Dr., Pasadena, CA 91109-8099, albert@shannon.jpl.nasa.gov.

Introduction: We have completed analysis of a new near-field rock count at the Mars Pathfinder landing site and determined that the previously published [1,2] rock count suggesting 16 % cumulative fractional area (CFA) covered by rocks is incorrect. The earlier value is not so much wrong (our new CFA is 20%), as right for the wrong reason: both the old and the new CFA's are consistent with remote sensing data [1,2,3,4], however the earlier determination incorrectly calculated rock coverage using apparent width rather than average diameter. Here we present details of the new rock database and the new statistics, as well as the importance of using rock average diameter for rock population statistics. The changes to the near-field data do not affect the far-field rock statistics [5].

ShowstereoMap database: The first near-field rock data were limiting in that only two rock population parameters, apparent width and height, were evaluated in addition to rock position. In order to carry out more detailed studies of the rock population in the vicinity of the Pathfinder lander, we built a new rock database with more spatial information for each rock, including nine local-level frame coordinates to evaluate rock position and shape, as well as descriptive parameters like angularity, shape, burial, texture, and color. We used the JPL-developed 'showstereo' image analysis software to determine the spatial parameters for each rock. We thus call these data the '*ShowstereoMap near-field rock database*.' The showstereo software performs user interactive stereo matching of individual image pairs. We chose images pairs from the entire post mast deployment IMP dataset that provided the best available resolution (lowest compression) for that part of the rock field. Generally these are red (670 nm) Superpan images [4], although some blue (440 nm) Superpan images, and even some Monsterpan images were used. Nine local-lander frame (x,y, z) locations were measured for each rock with showstereo: (1) rock position is the leftmost point where the rock touches the ground, (2) leftmost point on the rock, (3) rightmost point on the rock, (4) left end of rock long axis, (5) right end of rock long axis; (6) left end of rock short axis, (7) right end of rock short axis, (8) topmost point on rock, and (9) lowest point on rock. Five shape categories (discoidal, sub-discoidal, spherical, sub-prismoidal, and prismoidal) and the six angularity categories (very angular, angular, sub-angular, sub-rounded, rounded, and well-rounded) were measured for each rock following accepted sedimentological grain shape studies. Burial was a qualitative assessment, assigning a value from 0 (perched) to 3 (near-complete burial) to each rock. Texture followed *Parker et al.*'s[6] criteria for bumpy, pitted, knobby, smooth, and lineated textures [7] in images. Rocks were allowed more than one texture type. All data were hand-entered via a web-interface into a mySQL database [8].

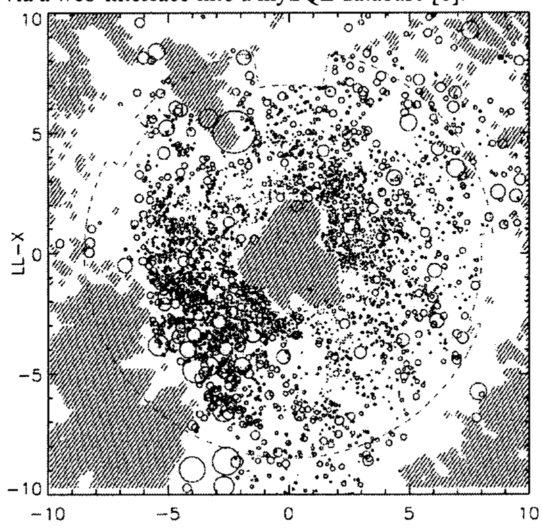

Figure 1. Map of Pathfinder near-field rocks

The final ShowstereoMap database includes 4456 rocks. For the vast majority of these rocks (4309) the showstereo software generated the spatial information, and the dataset is thus consistent for statistical mapping purposes. Corrections were made for about 75 large rocks that fall across image boundaries. Also, position measurements using a vicar software routine [9] called 'mpfview' were made for some dark near-field images (147 rocks in 17 images). Mpfview, unlike showstereo, allowed for image processing in addition to stereo analysis, however its interface was less conducive to database entry and so it was not used more extensively. Of all the measurements, 24 rocks measured in a single image pair with mpfview could not be reconciled with the image pointing and are removed from the mapping and statistical analysis that follows. A map of the 4432 measured rocks is shown in Figure 1. We derive the rock field statistics in an annulus from 2.5 m to 8.5 m radius. The discrepant mpfview image lies beyond this annulus. Notches in the annulus are locations not explored by the rock counters. Taking into account shadows as determined from the Pathfinder landing site digital terrain map [10], the measured area of the annulus is 186.4 m^2.

Rock statistics: Figure 2 shows the ShowstereoMap CFA. We calculate the statistics versus average rock diameter. The cumulative area covered by rocks within the 2.5-8 m annulus is 20%, with variations ranging from 7% coverage in the southeastern portion of the annulus, to 50% coverage within the southwest quadrant. The average rock abundance is consistent with expectations prior to landing. These values correct previously published values of 16%, 11%, and 25% respectively.

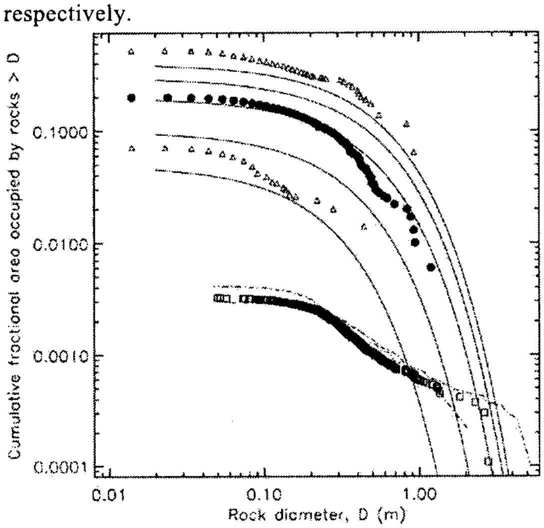

Figure 2. New Pathfinder near-field rock CFA shown by dots. Triangles show range. Open boxes show far field [4]. Solid lines are 5%, 10%, 20%, 30% and 40% CFA models [13].

Database uncertainties Average rock diameter, D, is the average of the length of the rock long axis and the length of the rock short axis [11, 12, 13]. It is a more correct representation of rock size than apparent width, W (the distance between leftmost and rightmost points on a rock), and D ~0.75 W is reported [13]. Additionally, the ShowstereoMap manual method of picking stereo points in image pairs will have a tendency to bias both W and D high, with perhaps more bias on W. This is because of the possibility of picking a point beyond the rock for stereo matching when trying to pick the edge of a rock. Long and short axes picks on most (decimeter-sized) rocks will fall on a rock face or near the top rear of the rock rather than a tangent edge. Clearly discrepant picks (i.e., 5 m rocks near the lander) have of course been corrected in the ShowstereoMap database. The stereo point picking bias also tends to flatten rocks: there is the possibility that points picked near the top of a rock may fall on the ground behind the rock generating a smaller difference between rock top and bottom.

The importance of the distinction between rock apparent width and average rock diameter is most clear when we compare the ShowstereoMap results with the earlier near-field results. The first near-field rock count was produced using the MarsMap virtual reality (VR) software [14] during Pathfinder operations, so we call these data the '*MarsMap near-field rock dataset.*' The MarsMap VR display interface relies on three dimensional models of the Martian surface that are generated from stereo MonsterPan image pairs [15, 4]. The terrain model contains minor offsets at image boundaries, which produce uncertainties on rock position of less than a few percent of the range [14], and less than 1 cm for rock size. For each of 2035 rocks we measured (i) location in local lander coordinates, (ii) rock apparent width, and (iii) rock maximum height. The position of the left tangent point where the rock touches the soil was chosen as the rock location, except for the first 115 rocks of the dataset for which a point somewhere near the middle of the IMP-facing portion of the rock was picked. Rocks 3 cm and larger were thought to be thoroughly surveyed within a 3 m to 6 m annulus (1472 rocks). MarsMap rocks are mapped in Plate 5 of [1] and statistics shown in Plates 8, 9 and 10 of [1], and in Figure 2 of [2]. It is now clear that the 3 m to 6 m annulus was not thoroughly surveyed for the MarsMap database: the same annulus in the ShowstereoMap contains 2504 rocks! This difference may be due to the difference in resolution of the MonsterPan and the SuperPan. The discrepancy was not discovered because (i) we insufficiently appreciated the importance of the difference between rock apparent width and average rock diameter, and (ii) the cumulative fractional area result obtained using apparent width was so close to the predicted result [3,4]. Since the older data are clearly in error we do not plot them for comparison.

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