MARS SPHERULE SIZE DISTRIBUTION FROM PANORAMIC CAMERA IMAGES. Denis Royer[1] (Aix-en-Provence, France, droyer@club-internet.fr), James Nelson[1] (San Diego, Ca) and Henry C. Wallace[1] (Panama City, Fl), [1]Mars Forum collaboration, http://www.markcarey.com/mars/mars-forum/forum.html.

Introduction: At the very beginning of the rover Opportunity mission on Mars in January 2004, it has been obvious that one of the most striking features of the landscapes at Meridiani Planum is the presence of billions of spherules of sub-centimeter size scattered on the soil and on the rocks. Their shape is nearly spherical. The question arose of their origin and of the processes of their formation. Soon, work began on the Mars Forum [1] to measure the size distributions (SD) of the spherules. Using close-up images from the Microscopic Imager (MI), it rapidly appeared that the SD is narrow and asymmetric with a tail towards lower sizes. This is an unexpected feature; on Earth, geological analogs show a right-tailed distribution while in biological structures the logistical growth curve has some similarities to the Mars spherules distribution [2]. It was then desirable to confirm these findings with an independent approach. It is the scope of this paper to report on the use of larger field Panoramic camera (Pancam) images from NASA [3] to determine the SD.

Pancam images processing: Suitable Pancam images have a resolution of about 0.5 mm/pixel, and a spherule is no more that 10 pixels wide. With thousands of spherules on an image it is very difficult to measure them by hand. We have investigated the use of ImageJ software [4] to measure the diameters of a great number of spherules on an image.

The use of 4x to 8x enlarged and interpolated images have been proven necessary in order to avoid aliasing effects. The software provides automatically a list of the spherules with the area of their illuminated portion. As the work on the MI images features the diameters, for the convenience of the comparisons we have converted the area into equivalent diameter (i.e. the diameter of the circle with the same area).

The effect of perspective, defined as the maximum of the difference of the apparent diameters of identical spherules in different locations on the image is calculated as 18 % for sol 188 and 3 % for sol 202. The effect has been taken into account in both images and the individual diameters corrected.

The measurements obtained that way suffer from two difficulties. First, the automated process selects only the illuminated portion of the sphere, and the resulting area is lower than the full hemisphere area. The error in relative terms is the same for all the spherules, being dependant only on the sun incidence angle.

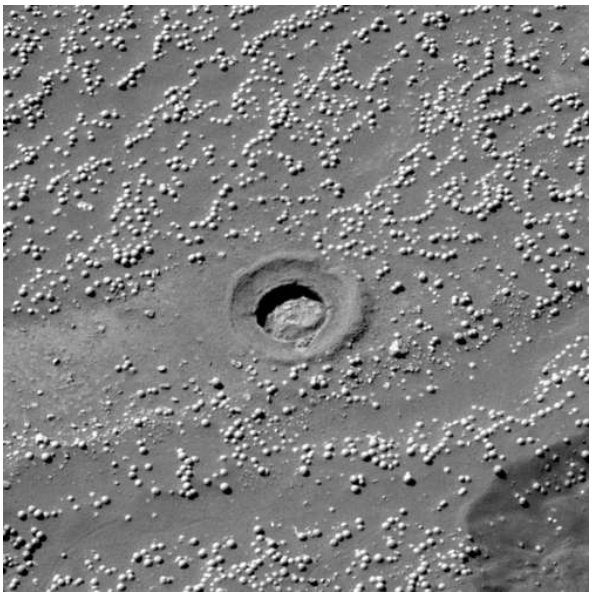

Figure 1: Image 1P144875265ESF3416P2547R1M1-BR taken with the R1 (436 nm) filter on sol 188. The RAT hole provides an absolute size calibration of the image. The camera axis intersects the ground at an incidence angle of 36 degrees. The resolution is 0.75 mm per pixel and the sun incidence angle correction factor (see text) is 1.10.

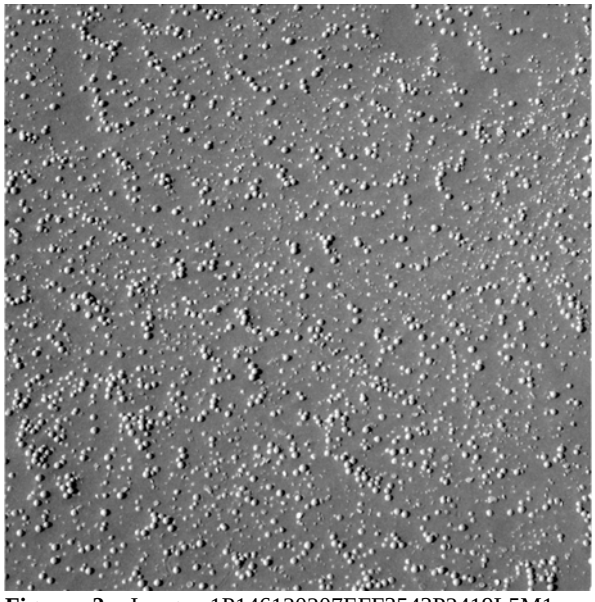

Figure 2: Image 1P146120207EFF3543P2419L5M1 on Endurance Crater taken with the L5 (535 nm) filter on sol 202. The line of sight is nearly perpendicular to the soil and the camera distance is 1.39 m above the surface. The resolution is 0.39 mm per pixel and the sun incidence angle correction factor is 1.12.

A correction coefficient is determined for each image by measuring manually a set of 50 spherules (Figure 3). The correction factor is close to 10% in this study.

Second, lots of spherules appear to interfere or to be buried in the substrate layer. It is essential to remove these spherules from the data. A selection of "valid" particles is operated manually for particles which are well isolated from their neighbors and which project a distinct shadow on the ground.

Together, these corrections are applied to the raw software measurements to provide corrected data.

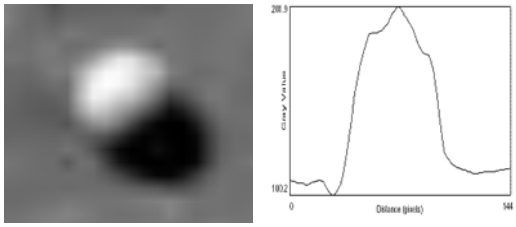

Figure 3: Magnified view of a spherule (left) and intensity profile along its largest diameter (right). The "sun incidence angle" correction factor is determined by measuring the width at half maximum on the intensity profile after background substraction and comparing it to the radius as given by automatic image processing.

Results: The size distribution parameters for the two spherule samples in Endurance Crater are summarized in Table 1.

	Sol 188	*Sol 202*
Number of spherules	*407*	*562*
Median (mm)	*3.95*	*3.76*
Mean (mm)	*3.88*	*3.73*
Standard deviation of mean (mm)	*0.03*	*0.03*
Standard deviation of distribution (mm)	*0.62*	*0.61*
Skewness	*-0.76*	*-0.48*

***Table 1**: Size distribution parameters for sol 188 and sol 202 samples.*

The values for the mean of the two samples are 0.15 mm apart. The standard t-test for two independent samples show that the datasets have significantly different means.

Both sol 188 and sol 202 distributions are asymmetric as can be seen on median, mean and skewness values. On both samples the ratio between the skewness statistic and the standard error on skewness show that the asymmetry is significant.

Discussion: These results from Pancam images show an asymmetry that has already been demonstrated with the analysis of MI images [2]. Pancam images being snapshots on unique locations, this asymmetry cannot be an effect of geographical variations and is then a property of spherules populations.

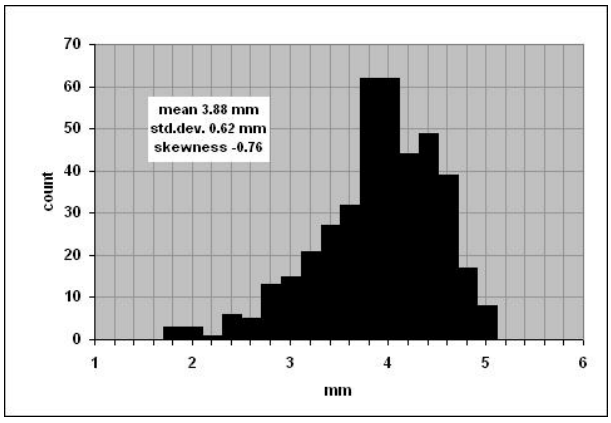

Figure 4: Spherule size distribution from sol 188 data. Bin size 0.20 mm.

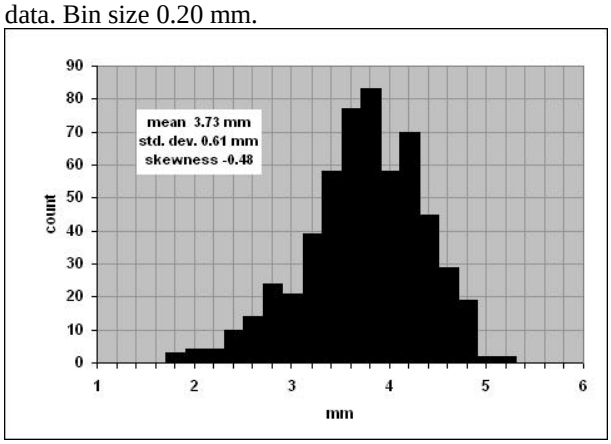

Figure 5: Spherule size distribution from sol 202 data. Bin size 0.20 mm.

Conclusion: Those Pancam results together with Microscopic Imager results establish the atypical shape of the size distribution of the spherules at Meridiani Planum. Whereas this is an indication on the biological origin of the spherules should be addressed to geologists and exobiologists and should encourage further research on Earth analogs.

References: [1] Mars Forum Discussion, http://www.markcarey.com/mars/discuss-17077-go-measure.html. [2] Measuring the Meridiani blueberries, H. C. Wallace, 27 mars 2005, http://abcsite1.com /statistics_paper.html. [3] Mars Exploration Rover Mission, http://marsrovers.nasa.gov/home/. [4] National Institute of Health, http://rsb.info.nih.gov/ij.

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