PRELIMINARY MEASUREMENT OF LUNAR PARTICLE SHAPES. Doug Rickman[1], [1]NASA/MSFC/Earth Science Office (320 Sparkman, Huntsville, AL 35802 doug.rickman@nasa.gov).

Introduction: Particle shape is a basic parameter and essential for many engineering applications. Very little data is published on the shape of lunar particles. [1-15] An unpublished review found that even where the same samples were studied the results were contradictory, probably because of extremely small sample sizes. Other workers have made fundamental errors in algorithms.

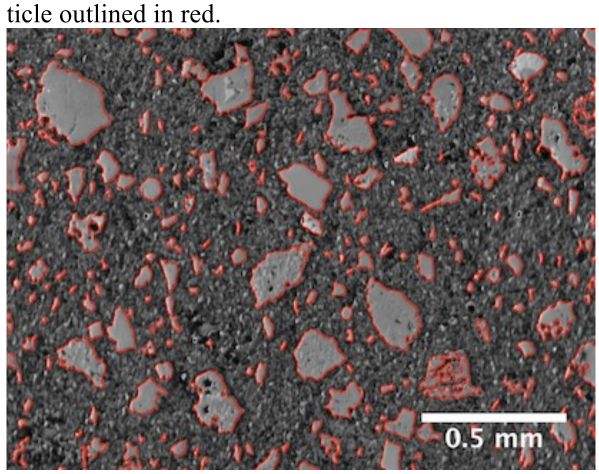
There are many ways to measure particle shape. One common approach is to examine the particles as intersected by a plain, such as a thin section. If discrete particles can be segmented from the image, programs such as ImageJ [16] can readily obtain shape measurements for each particle.

Method: Three thins sections of Apollo 16 core were photographed using refelected light and a petrographic microscope. The pixel resolution was set to 0.00148 mm/pixel and spectral resolution was done at 16 bits/pixel in three colors. The imagery for each thin section had to be acquired in 74 – 96 tiles. The tiles were assembled into whole using the photomerge function in Photoshop. This approach is extremely sensitive to imperfections in alignment of illumination and viewing; it was therefore necessary to model this and apply a per tile correction to reduce unwanted unevenness in lighting.

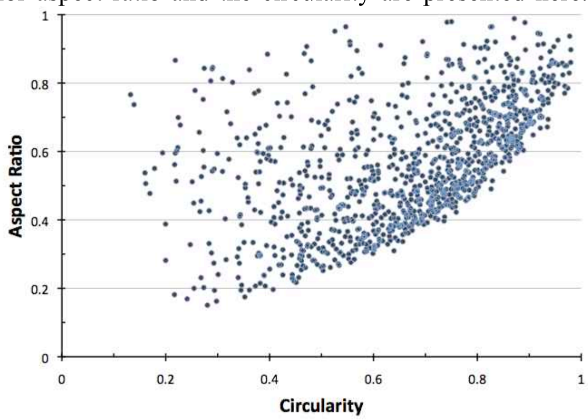
The resulting imagery can then be processed such that regolith particles at the front surface of the polished thin section are distinctly brighter than particles immersed in the epoxy. In principle simply thresholding the grey level values of the imagery will therefore distinguish between particles and non-particles. The software can then isolate individual patches above the threshold.

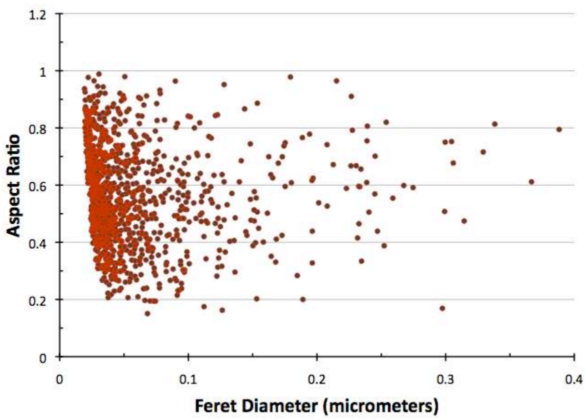
However, there are several significant problems which must be overcome to actually obtain valid shape measurements. (1) At the level of individual pixels there is a noise component. This has the effect of increasing the boundary length between particle and background. This can be addressed by either filtering the data or by adusting the smoothness of the polygon defining the particle boundary. (2) There are a very large number of particles just emerging from the epoxy. These cause the background to be highly heterogeneous. Because these are small compared to the particles of interest for this research, filtering can also be used here to subdue this problem. Shape preserving median filters are useful for both problem 1 and 2. (3) There are a large number of wholes in the particles. There are several causes for these. Some holes are caused by mechanically plucking of the particles during thin section preparation. Some are due to voids in the particles. ImageJ provides a function specifically to fill the holes within closed features. There is also the capability to fill only holes of specific shape or size, neither of which was done for this report. (4) Many lunar particles have major mechanical fractures. These are especially common in the larger particles. At present the only option for these is to interactively edit the imagery to connect the pieces. (5) Some of the particles are little more than relatively unconsolidated aggregrates of very fine "soil". These are not as reflective as the other types of particles. To the extent these are important, manual editing is also required to retain them.

Analysis: For this report an area 4mm x 3mm was extracted from the complete image of 68001 6031 processed according to the preceding protocols. Because smaller particles are sensitive to the pixilated nature of their boundary with the background, only particles having an area greater than 100 pixels were retained for analysis. A subset taken from the 4x3 area is shown below with each automatically identified particle outlined in red.



For the entire 4X3 region 1033 particles were defined. Once defined, a vast number of measures can be obtained for each particle. Following Rickman et al. [17] work on 6 simulants of the lunar regolith, results for aspect ratio and the circularity are presented here.





Conclusions: It is definitely practical to obtain statistically robust measurement of lunar particle shapes from thin sections of the Apollo cores. A 4 X 3 mm region yielded just over 1000 particles sufficiently large to provide good measurements. The total area of each thin section is over 100 times greater.

With appropriate development it should be possible to process such imagery to extract information such as the frequency of vesiculated particles, statistically defensible statements about particle shape and orientation (if any), and to quantify spatial variations within and between thin sections. If images are also acquired of plain polarized light and under crossed nicols, with spatial co-registration, particle composition versus shape and size will also be obtainable. Data from other modalities, such as BSE can also be integrated and used.

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