A DETAILED MORPHOMETRIC STUDY OF AN ABSOLUTELY UNREMARKABLE CRATER ON MARE SERENITATIS USING THE FREE SHADOWFRONT METHOD

J. E. Chappelow[1]
[1]Meteorifics Inc., Fairbanks, AK, USA (john.chappelow@saga-inc.com)

Introduction: In previous work [*1,2*] I used a shadow measurement technique (the free shadowfront method, FSM) to determine the depths (*d*), diameters (*D*) and shapes of 117 simple craters (~0.5 km < *D* < ~6.0 km) on Mare Serenitatis. I found that a good estimate for the actual mean shape of these simple craters is given by a conic section of eccentricity *e* ~ 2.1 and *d*/*D* ~ 0.174 (and not by an ideal parabola, of *e* = 1, *d*/*D* = 0.20). Here I report a detailed analysis of the morphology of a single crater from that sample, selected mostly because it is completely ordinary.

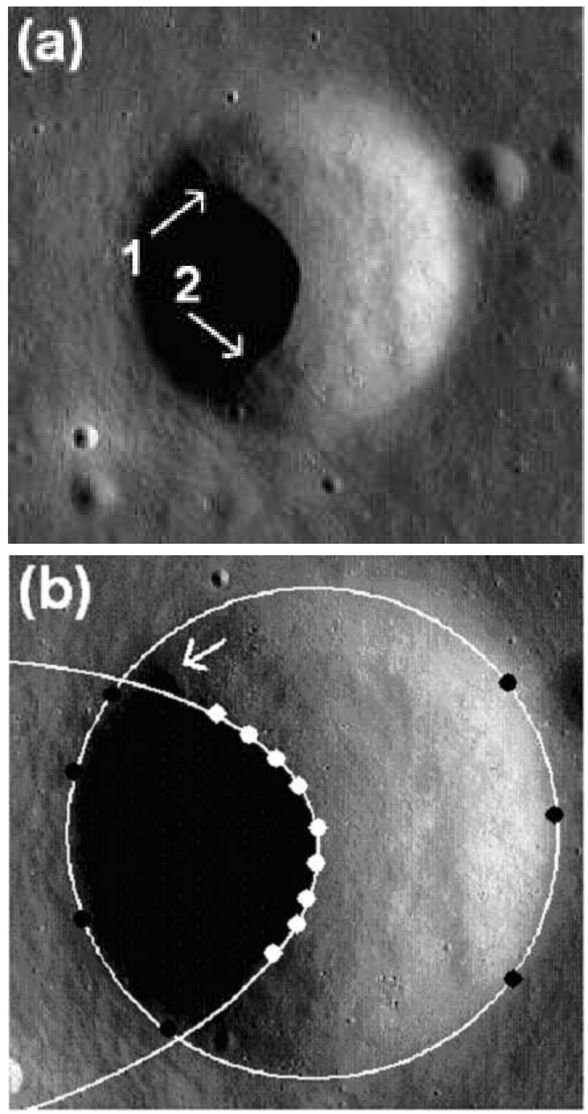
Rather than just to report the results themselves, the larger purpose of this abstract is to demonstrate the utility and accuracy of the FSM. The crater in question was chosen in part because it contains a somewhat non-ideal shadow shape, and it is also crossed by a nearly bisecting LOLA elevation profile.

Methods: Given a generally conic-section-like cross sectional crater shape, it can be shown that the shadow cast within it must be an arc of an ellipse [*3,4*]. This relationship can be exploited to compute the crater shape conic section from the shape of the shadow. The FSM uses the shadow cast within a crater to determine its depth and the eccentricity of its cross sectional profile from measurements of the shadow-bounding ellipse and the crater rim [*2,4*].

The subject simple crater is located at 33.75°N, 21.41°E in northeastern Mare Serenitatis (Fig. 1a). Inspection shows that the crater is has undergone significant modification: its rim is softened, ejecta features are modified, and its interior and ejecta are somewhat recratered. At least two deviations in the shadowfront shape from the elliptical are evident (arrows, Fig. 1a), one of which (arrow 2) may be due to a slide.

The FSM was applied to this crater by least-squares fitting of a circle to seven rim points and an ellipse to nine shadowfront points (Fig. 1b), using a computer implementation of the FSM. All points were selected as far apart as possible, while avoiding areas where the rim and shadowfront are poorly defined or where the deviations noted above occur. The solar incidence angle was 71.44° and the solar azimuth 189.05° (both calculated from the crater center and sub-solar point latitudes and longitudes). The emission angle was 1.23°.

Results: Ten trials of the FSM were conducted with the following results and standard deviations: *D* = 2010 m (σ = 10 m), *d* = 343m (σ = 3m), *e* = 2.01, (σ = 0.03), and *d*/*D* = 0.171 (σ = 0.001). These results are very close to the means found by [*1*] for 117 simple craters on Mare Serenitatis, so this is quite a typical crater for this region of the Moon. The value of *e* shows that the crater is hyperbolic in shape.



Figures 1: (a) An image clip from LRO_NAC image M181030991R (north is up) of the example crater showing two small deviations of the shadowfront from an elliptical shape (arrows). (b) One of ten trials of the Free Shadowfront Method. Seven rim points (black) and nine shadowfront points (white) were used to fit figures to these (white lines). A small section of the shadow diverges significantly from the fitted shadow ellipse (arrow).

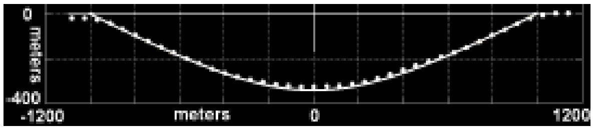
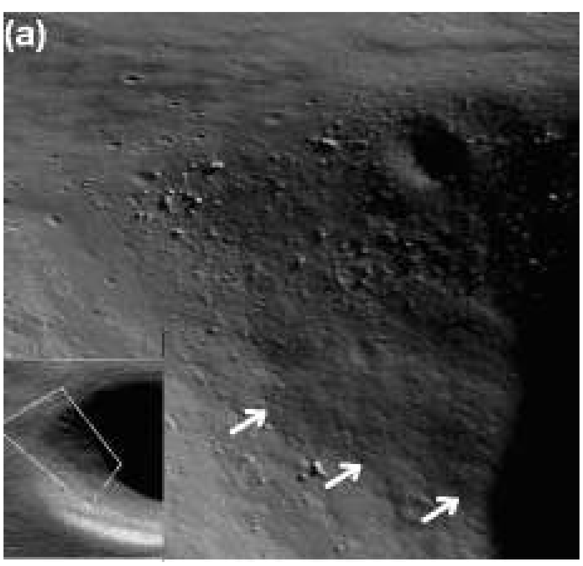
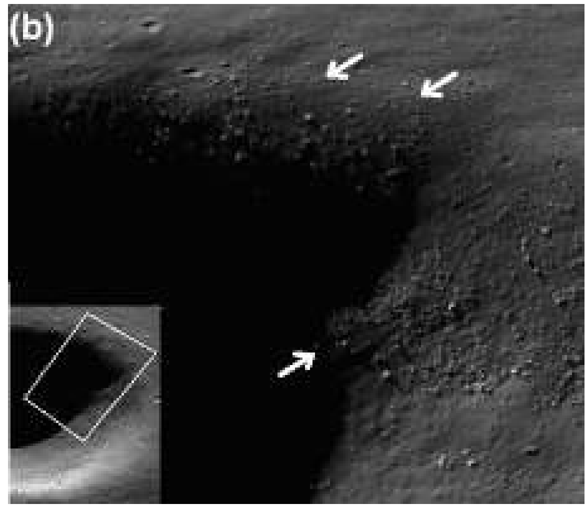


Figure 2: The FSM result obtained herein (solid curve) plotted over the data from a nearly bisecting LOLA traverse. The systematically shallower LOLA results near the bottom are probably due to the slight offset of the LOLA track from the crater center.

The crater is also nearly bisected by a LOLA ground track which is plotted together with the FSM result on Fig. 2 for comparison. The slightly shallower LOLA result is probably due to the slight offset of the LOLA transect from the crater center. The figure also demonstrates the potential difficulty in locating a crater rim from the LOLA data alone.

Obtaining this shape model allows projection of the original image (or any other image of the same crater) onto this surface without major distortion to the shadow or the crater interior. Here, various views of this model (Fig. 3) allow for a few observations about the details of this crater. First, the excursion of the shadowfront near its south end is due to a slide, possibly caused by the small impact crater just under the rim above it (Fig. 3a). The smaller deviation on the north end of the shadow seems to be another small slide, or possibly simply an outcrop (Fig. 3b). The more significant departure of the actual shadowfront from the best-fit ellipse above this (see Fig. 1b) is due to a higher section of the crater rim above it. None of these features is readily apparent in the original image (Fig. 1).





Figures 3: Views looking down on the ends of the shadowfront. (a) The excursion of the shadowfront near its south end is due to a slide, possibly caused by the small impact crater under the rim above it; arrows mark its approximate left-lower margin. (b) The smaller deviation on the north end (arrow) seems to be simply an outcrop or another small slide. The significant departure of the shadowfront from the best-fit shadow ellipse above it (see Fig. 1b) appears due to a higher section of the crater rim above it (two arrows), which is not apparent in Fig. 1. Insets: approximate context for each close-up, as viewed from the west.

Conclusions: Herein the FSM was used to derive a shape model for a very typical simple lunar crater on Mare Serenitatis. Deviations from the idealized elliptical shape for the shadowfront are evident in the image. However, crater shape and dimensions determined via the FSM still agree excellently with those derived from the LOLA pass; and at least some of the small difference is attributable to a slight offset in the LOLA transect from the crater center. When the original, full resolution image is 'draped' onto the FSM-derived shape model the physical features of the crater responsible for these deviations become more apparent. The darkened areas that occur on the sunlit side, at the ends of the shadow boundary (Fig. 1) are a common feature of shadowed craters and are caused at least in part by the very oblique lighting and rough surfaces at these locations.

References: [1] Chappelow (2014), *Proc. 5th Planetary Crater Consortium Meeting*, Abstract #1416. [2] Chappelow (2015), 46th LPSC, abst #1079. [3] Chappelow and Sharpton (2002), *MAPS*, 37, 479-486. [4] Chappelow (2013), *MAPS*, 48, 1863-1872.