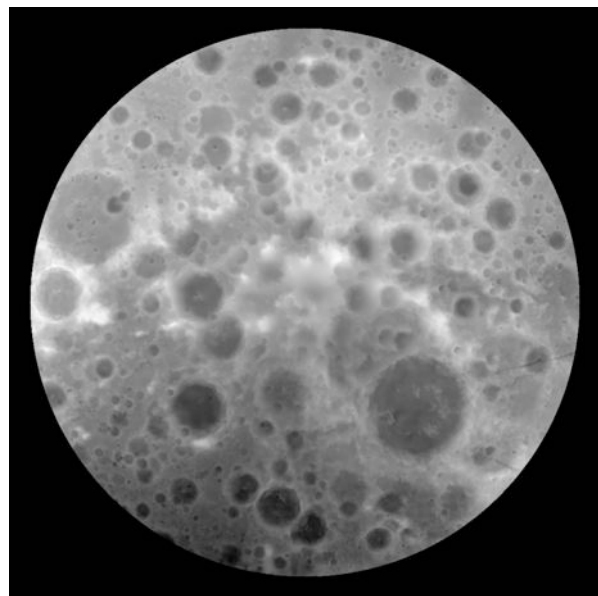


**LUNAR TOPOGRAPHY FROM STEREOPHOTOCLINOMETRY.** R. W. Gaskell<sup>1</sup> and N. Masroderos<sup>2</sup>,  
<sup>1</sup>Planetary Science Institute, 1700 E. Fort Lowell, Suite 106, Tucson, AZ 85719, rgaskell@psi.edu, <sup>2</sup>JPL/Caltech.

**Introduction:** In the last few years, techniques have evolved [1-3] for constructing shape and topography of small bodies directly from imaging data, at a resolution comparable to that data. The basic data product is a set of overlapping digital topographic/albedo maps (L-maps) which tile the surface of the body. The slopes and albedo at each pixel in an L-map are determined by an estimation procedure called stereophotoclinometry (SPC) that minimizes the residuals between predicted and observed brightness in multiple images. The slopes are then integrated to produce the heights relative to a local coordinate system.

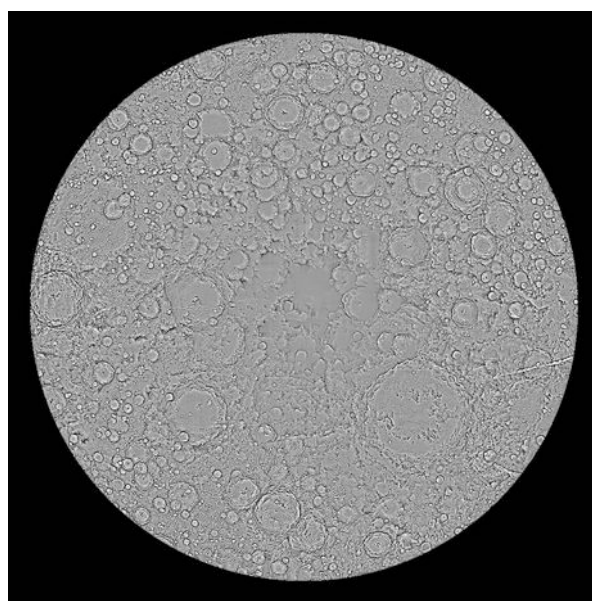
The central pixel of an L-map represents a control point whose body-fixed location is determined in a simultaneous estimation with the camera location and orientation, constrained by apriori information, that minimizes the residuals between predicted and observed image space locations, limb locations and correlations between overlapping L-map topography. These techniques are now being applied to larger bodies such as the Moon, necessitating many more L-maps and involving much larger data volumes.

**Lunar Mapping:** About 6% of the Moon has been mapped in our initial studies, mainly near the south pole, but also near the north pole and other areas. Over 14000 L-maps have been constructed using SPC, and their central control points determined from over 360000 measurements in 15000 Clementine images.



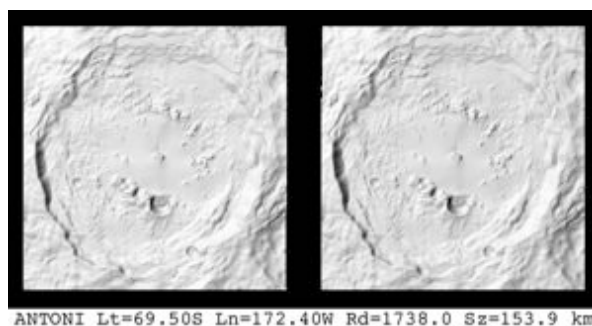
**Figure 1: Lunar South Pole DEM**

The current digital elevation map (DEM) for the Moon south of 62.5° S is shown in Figure 1. It has a horizontal resolution of 1.7 km, and elevations relative to a 1737.4 km sphere range from -8.4 km to 7.8 km. Shadowed regions near the pole and in areas of rough terrain are interpolated smoothly rather than left blank. These are even more evident in the Laplacian filtered version of Figure 2 that plots  $\nabla^2 h$ , where  $h$  is the topographic height. This filter shows the fine structure much more clearly.



**Figure 2:  $\nabla^2 h$  near Lunar South Pole**

**Local Topography:** The vast majority of our L-maps have a resolution of 220 m/pixel with some overlapping 500 m/pixel maps for context. In order to represent the data properly, it is best to concentrate on a local region. Figure 3 is a stereo pair of crater Antoniadi, just above the lower edge of Figure 1. This has

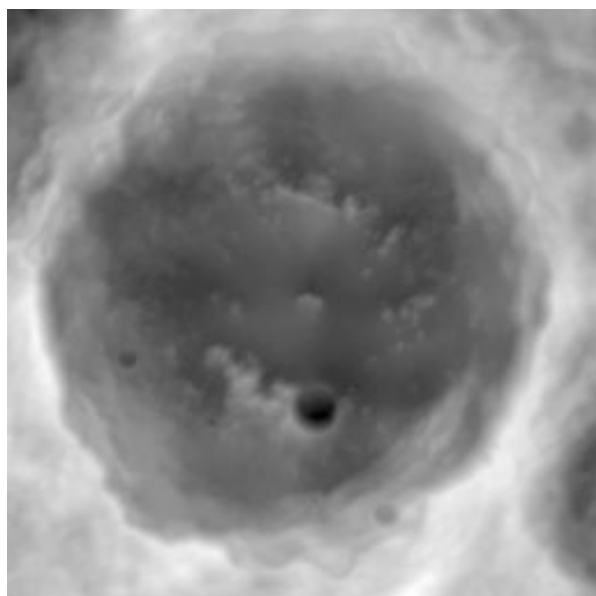


ANTONI Lt=69.50S Ln=172.40W Rd=1738.0 Sz=153.9 km

**Figure 3: Stereo Pair of Antoniadi Crater**

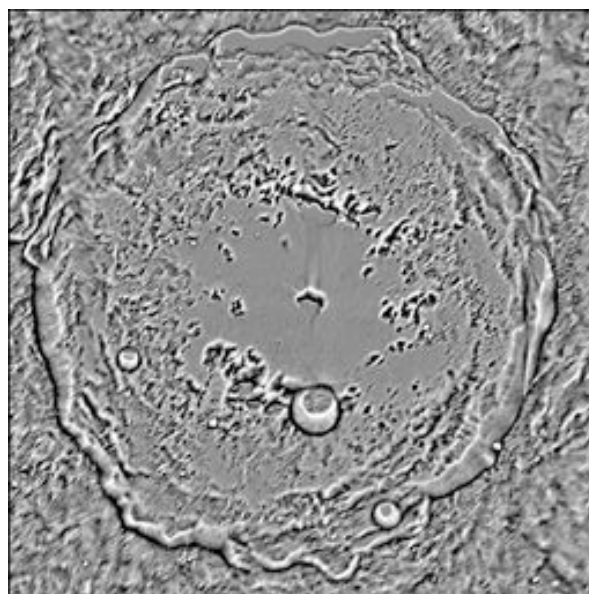
a peak ring structure probably due to the collapse of an original central peak [4,5].

The DEM for Antoniadi is shown in Figure 4 with elevations ranging from -8.8 km to -0.7 km and a horizontal resolution of 300m. The central plain shows more height variation than is apparent in the images. This is an artifact due to the very limited variation of illumination directions in the data set, which translates into a large formal uncertainty on the L-map single pixel slope solutions of about  $6^\circ$ . The slope uncertainties are reduced for longer L-map baselines and in the aggregate DEM.



**Figure 4: DEM of Antoniadi Crater**

Here again, there are areas which are not illuminated and which show up as flat due to interpolation. In particular, the northern floor of the large deep crater south of the central peak is dark in all images as is an area just south of the peak and some areas of the outer rim. Since the crater represents the topographic low in the region, the -8.8 km lower limit given above is somewhat uncertain. The Laplacian-filtered height distribution in Figure 5 shows the artifacts of shadowing at the crater bottoms very clearly as well as the smooth areas in the outer rim where there is no data. It also shows the distribution of rocks and craters and clearly delineates the peak ring structure and flatness of the central plain.



**Figure 5:  $\nabla^2 h$  in Antoniadi Crater**

**Ongoing Work:** The purpose of this work is to generate as complete map of the Moon as possible using Clementine and Lunar Orbiter data. The L-maps will primarily have resolutions of 500 and 220 meters. When new data become available, the images can be registered quickly to the ensemble of L-maps, the spacecraft state can be refined and the topography made more precise with very little additional effort. New images with different illumination will allow us to eliminate many of the artifacts discussed above. With this topography as a context, successively higher resolution mapping can be accomplished.

**References:** [1] Gaskell R. W. et al. (2006) AIAA-2006-6660. [2] Gaskell R. W. et al. (2006) *LPS XXXVII*, Abstract #1876. [3] Gaskell R. W. (2005) *AAS 05-289*. [4] Hartmann, W. K. and Wood, C. A. (1971) *Moon: Origin and evolution of multi-ring basins: The Moon*, v. 3, no. 1, p. 4078. [5] Williams, K. K. and Greeley, R. (1997) *LPS XXVIII*, Abstract #1080.