LTVT EVALUATED AT GASSENDI

By Steve Boint

Recently, I've become aware of new FREE software for the lunar enthusiast: Jim's Lunar Terminator Visualization Tool. While capable of many interesting tasks, it was the promise of easy photo scaling and calculation of relative lunar heights that most interested me. I decided to test the software on an image I had taken of Gassendi both because the image was not beyond the capability of amateurs with small telescopes and because Gassendi has a number of features whose heights are known to within 500 m and one whose height is fully established. Gassendi also happens to be an interesting feature on its own.

From the Imbrium era, 3.6 billion-year-old (plus or minus 700 million years)[1] Gassendi sits on the northern edge of Mare Humorum. Since it overlaps Humorum, it must post-date the basin and may even have formed partly on the slope of the old basin wall, although the vast majority of the crater appears to have fallen on the basin's top edge.

As Mare Humorum filled with lava, some appears to have flowed through a collapsed part of Gassendi's southern wall and covered the crater's floor along the south-eastern edge. However, this region of the crater's floor may have an internal origin. The lava pool appears, in the Clementine ratio image, to be highlands material suggesting a possible origin as impact melt[2]. Other spectroscopic analyses have shown this area to have a high maffic (iron, titanium) and pyroxene content, suggesting an extrusive volcanic nature akin the that of the maria[3]. The many cracks in Gassendi's floor, not all concentric with the crater's rim, suggest an upwelling of lava beneath

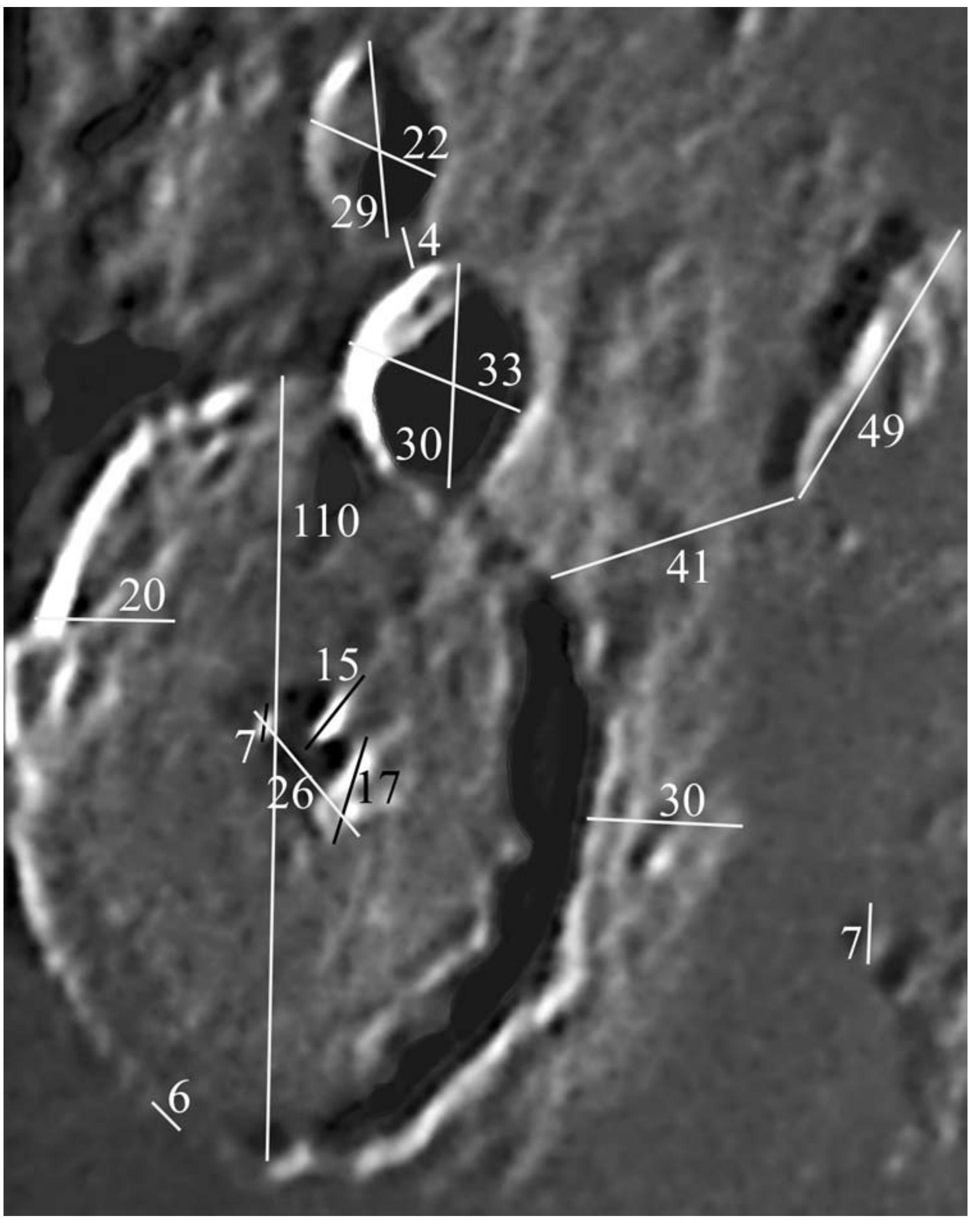

Fig. 1: Horizontal Distances In The Gassendi Area. All values are in km. Photo taken at 2:24 on 6-11-03 UT using a 10" f/4.5 Newtonian with 5x Barlow and a SBIG 237a CCD camera.

the surface[4]. All hinting that this relatively smooth area has an origin within the crater. Where exactly these flows and those of Humorum meet is unknown. As more spectroscopic studies become available, it will be interesting to study the intersection between Gassendi and Humorum in the southern gap.

LTVT allows the user to place a photo they have taken onto a globe of the moon. From there, the user can measure horizontal distances (it automatically scales the photo) and vertical displacements. Its ability to measure horizontal distances is truly enthralling. Measurement is as easy as clicking on one spot and then holding the cursor over another. A readout is provided that gives the distance between the two points. This was so simple and so accurate that it is nothing less than a video game for the lunar enthusiast (but a game with valuable results). But can it really be that easy? As with anything there is a catch. In order for LTVT to correctly scale the photo, the user must first provide the latitude and longitude of two features on the photo. The more accurate these values are, the more accurate the results. While tables of crater depths are readily available, the coordinates given are for the center of the crater. If two small craters are available, this could work. However, finding lunar coordinates for features will not be easy. I used a copy of *The Orthographic Atlas Of The Moon,* long out of print. Rukl's atlas might be usable to a tenth of a degree, the LAC and LTO maps are certainly capable of this. Still, none compare to the Orthographic Atlas. So, in the next installment of this article, accurate lunar coordinates will be provided for a number of interesting features.

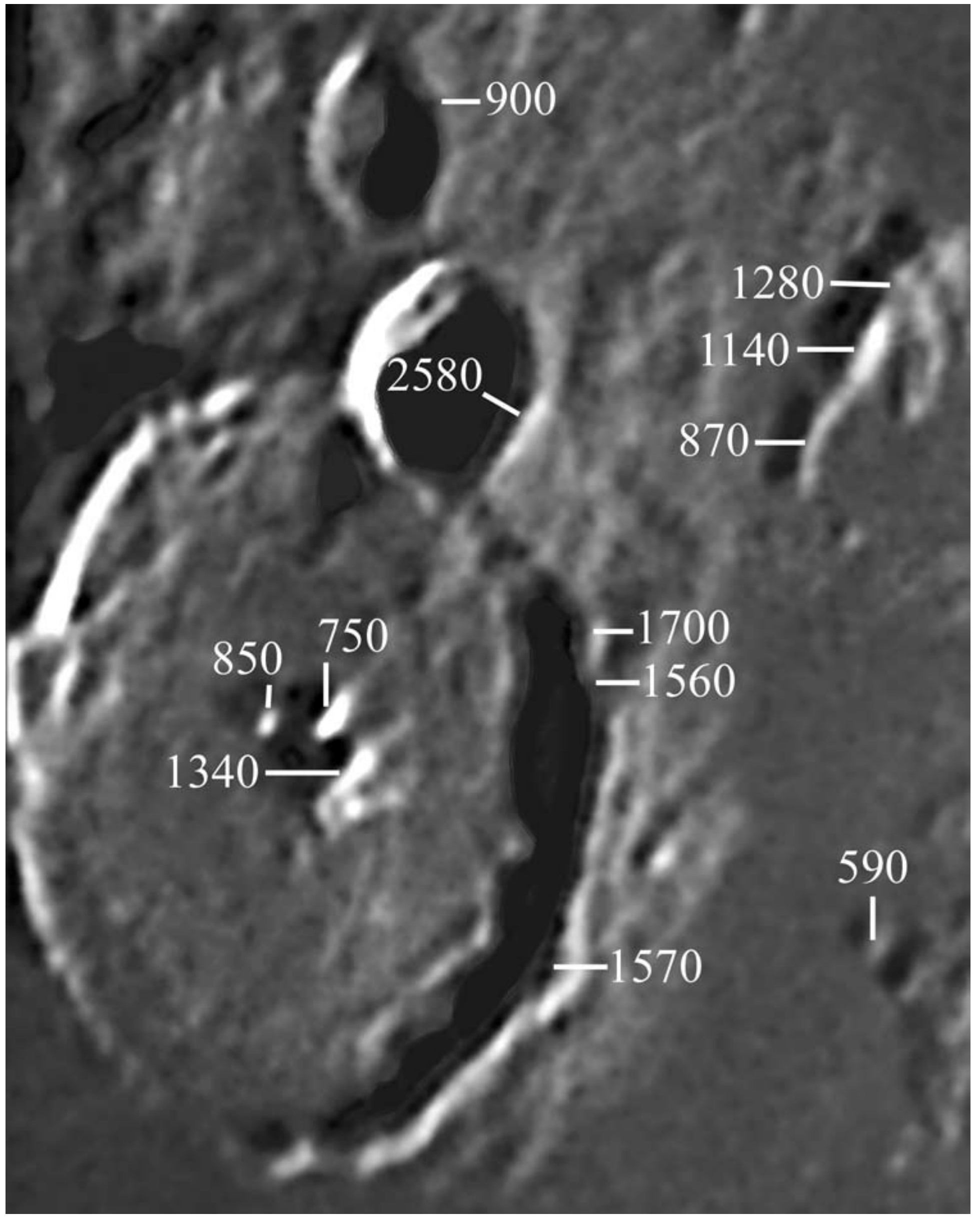

Fig. 2: Vertical Displacement Of Features In The Gassendi Area. All values are in m. Photo taken at 2:24 on 6-11-03 UT using a 10" f/4.5 Newtonian with 5x Barlow and a SBIG 237a CCD camera. This version of the photo has been processed more fully than the one which was used for the measurements.

Using the LTVT on my photo of Gassendi, it correctly gave the crater's diameter as 110 km, whether measuring north to south or east to west, in spite of my photo showing foreshortening. Gassendi A had a diameter of 30 km east to west and 33 km north to south. Was this an indication of a slightly elongated character? To test this I measured a second photo from a different night and found the east/west diameter to be 31 km and north/south 32. Given the limits of photographic resolution I faced, this result was close enough to round to satisfy me. However, Gassendi B clearly has an elongated shape, measuring 14 km by 29 km on my original photo and 14 by 25 on the second. Does this indicate it is a secondary crater? Given its size with respect to Gassendi, it is more likely that it was an oblique strike (less than 10 degrees) or that its shape was controlled by underlying faults (preferential elongation does occur along a fault)[5].

Other distances of interest were measured. It appears that Gassendi's walls have slumped creating 20 km of rubble against the inner wall. Gassendi Beta is 15 km in diameter. Gassendi Epsilon is 17 km. The smaller peak to the west is only 7. The cluster of central peaks has a diameter of 28 km. The gap in Gassendi's southern walls is 6 km. 30 km separate Gassendi from the mare on its east. 41 km separate it from the small mountain range of which Phi is the highest peak. This range runs for 49 km. The small peak on Gassendi's southeast is 7 km in diameter. A little less than 4 km separate Gassendis A and B. (Fig. 1) Measurement of distances with LTVT was as easy as promised.

The only caveats for using LTVT: accurate coordinates for two features on the photo must be available and a feature whose height is known must also be available on the photo.

It was different with the measurement of heights. To evaluate the new software, measurements were first made using an approach to the shadow method which has proven reliable (to about 20% accuracy) in the past. The length of the shadow was measured as the distance between the peak and the shadow tip. The peak was determined as the tonal halfway point between the brightest pixel in the area chosen and the beginning pixel of the shadow. The shadow tip was determined as the tonal halfway point between the darkest pixel and the pixel just beyond the apparent end of the shadow. Calculations were done using Harry Jamieson's *Lunar Observer's Toolkit* software. These results are reported in figure 2 and fall close to the known values, perhaps lending detail to the contour lines of the LAC. A few measurements need explanation. Rukl lists the depth of Gassendi A as 3600 m.[6] This is significantly beyond the value determined here, but an inspection of the photograph shows that the shadow has not left the rim of the crater. The smallest peaks measured (western central peak, small peak east of Gassendi) did not cast deep shadows. This is a problem

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Table 1 (opposite page): Comparison Of Height Measurements. All LAC values except for that of Gassendi Epsilon (a value derived from shadow measurement on orbital photos) are from contour lines. 300 m separate the contour lines and on steep slopes the lines are often confusing. This leads to an estimated plus or minus value of 500 m. The "Toolkit" measurements are plus or minus 20%. The LTVT measurements appear to fall within the same range. The "Toolkit" and first LTVT measurements were made from a photo taken at 2:24 on 6-11-03 UT. The second LTVT measurements were on a photo taken at 2:08 on 12-13-05 UT. The observer's location was: longitude 96.73133, latitude 43.52933, height above sea level 434.64 m. The average shadow length is for the photo from 6-11-03. The telescope used for both was a 10" f/4.5 Newtonian with 5x Barlow. The 6-11-03 image was taken with an SBIG 237a CCD camera. The 12-13-05 image was taken with a Toucam Pro II and stacked in Registax. Both were taken during poor to mediocre seeing.

Name or description	Average Shadow Length (seconds of arc)	LAC Vertical Displ.	Toolkit Vertical Displacement (m)	LTVT Vertical Displ. (m)	Second LTVT Vertical Displ. (m)	Xi	Eta
Gassendi B depth from east rim	4.029557	none	-900	-1200	-800	-.627	-.247
Gassendi Phi	3.720789	none	1280	1000	1000	-.588	-.247
mountain southwest of Gassendi Phi	3.385207	none	1140	750	1100	-.589	-.251
mountain far southwest of Gassendi Phi	2.572864	none	870	500	900	-.588	-.260
Gassendi A depth from east rim	10.232682	none	-2580	-2900	-2400	-.610	-.268
eastern rim, northern-most peak	5.827325	1200-1500	1700	1600	1300	-.597	-.280
eastern rim, dip between northern-most peaks	5.273238	1200-1500	1560	1400	1400	-.595	-.284
small peak east of Gassendi	1.551215	600	≤590	≤600	≤700	-.566	-.294
Gassendi Beta	3.186147	700-900	750	700	900	-.613	-.295
western central peak	3.806949	600-900	≤850	≤600	≤400	-.617	-.296
bend in southeastern rim	5.040605	1100-1300	1570	1300	1500	-.587	-.298
Gassendi Epsilon	5.638677	1370	1340	1300	1300	-.610	-.300

for the method. To get some idea of their height, the end of the faint shadows was used, producing a maximum height for the features. These values should be taken with a grain of salt.

Originally, the vertical displacements produced by LTVT were absurdly high (even following the directions in “help” which indicate that only the umbra of the shadow should be measured). To get past this, several features were measured and these values were divided by the LAC values to get a “screw constant”. These values were averaged, producing an average screw constant of 1.73. After all the features were measured, the displacements were divided by the average screw constant to get the final result. Results were impressive.

To check whether LTVT always required this amount of work or whether it was only this picture which was problematic, a second photo was measured (the same as was used to double check horizontal measurements). Shadows were of different length and since these calculations produce relative values of vertical displacements (the distance between the terrain on which the shadow tip lies and the peak casting the shadow) the values would differ slightly. This time, the known LAC value of 1370 for Gassendi Epsilon was referenced and I played around with where to position the pixel on the shadow tip to get a similar value (without violating the photo’s data). All shadows were then measured in identical manner. The values produced this way were solid.

In all cases, an attempt was made while processing to keep the photos to be measured as close to their “raw” state as possible since all processing has an effect on the image. While images taken with a webcam require stacking and even sharpening, it was assumed best not to change the gamma or brightness/darkness settings since these can have a profound effect upon shadow length and the ratio of umbra to penumbra.

Table 1 compares the results of the traditional method and the two LTVT attempts against the LAC values. LTVT is a resounding success. I’m sure that better photos would produce better results. Even here, the results fall within reasonable limits of variation. The only caveats for using LTVT are: accurate coordinates for two features on the photo must be available and a feature whose height is known must also be available on the photo. This leaves many, many opportunities for useful measurement. Perhaps it will even open up a new era in amateur study of the moon.

LTVT software is available at: http://inet.uni2.dk/~d120588/henrik/jim_ltvt.html.

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