A NEW LOOK AT OLD DATA: THE APOLLO 17 LUNAR SOUNDER EXPERIMENT.
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Introduction: Data from the Apollo Lunar Sounder Experiment (ALSE) represent the only direct view to date of the near-surface substructure across a lunar mare. Analysis of the subsurface geology of the maria provides information on the volcanic and tectonic evolution of the Moon(1). Some of the holographic-format data for this area was interpreted in earlier studies(3,4), and yielded the cross-section shown in Fig. 1. A strong correlation between subsurface reflectors was suggested, and was presented as evidence for subsurface regolith/pyroclastic layers that had been buried beneath younger lava flows(1,2,3).

However, the vast majority of the ALSE data have never been processed or interpreted. A new study has been undertaken in an effort to supplement the work which was begun some time ago(4). We report our preliminary results here.

Current Analysis: We have initiated a three-step investigation to extract subsurface information from available lunar sounder data. The first phase of this project is an evaluation of the subsurface information contained in optical data products, which are being studied using digital image-analysis techniques. This method is analogous to that used previously for the holographic-format data(2,3), in that a move-out correlation technique is used. In this way it is possible to determine whether time-delayed radar returns represent subsurface features rather than off-nadir surface backscatter. If the reflection is caused by an off-nadir surface reflector, then the arrival times for the reflector will vary from one orbit to the next, because the orbits are 3 to 4 km offset from one another in the Mare Serenitatis area. If, on the other hand, the return is caused by a horizontal subsurface reflector, then the arrival time will be the same from one orbit to the next.

A disadvantage of the optical-format data is that it has been compressed horizontally such that one pixel in the image represents about 1.5 km across the lunar surface. An advantage of using the optical data is that it is readily available, it can be digitized by standard digital image-analysis techniques, and logistical problems are avoided (the holographic viewer is in Utah). Dark areas in the image suggest strong radar returns, whereas bright areas suggest weak ones. We developed a computer routine to select the darkest pixels from each vertical sequence, an operation that results in a noise-reduced profile of the lunar surface as well as time-delayed reflectors which might be located underground. To relate results from the different orbits and to eliminate surface clutter noise, a computerized correlation technique was developed. Dark pixels with identical or adjacent x and y values in both images produce a dark pixel in the resulting image (Fig. 2). The optical data contain indications of orbitally correlated reflectors analogous to the results of (2) and (3). We always found evidence for a single partial horizon below the mare. However, the current study never produced a result identical to that achieved by previous workers(2,3). In the image shown in Fig. 2, there is evidence for two partial reflectors in the eastern part of the basin and one partial reflector in the western part of the basin. We have also included Fig. 3, in which we went one step beyond computer analysis and manually connected the subsurface reflectors into a horizon. We calculate the average depth of the westernmost reflector to be 1100 m, while the two eastern reflectors have calculated average depths of 1100 and 1600 meters. For comparison, previous calculations suggested depths of 900 m and 1600 m(2). For six cases, we calculated the locations of any off-nadir surface reflectors which could have caused a correlated and time-delayed return on the image, and plotted their positions on a map of Mare Serenitatis. In only one case was a surface feature located which could have caused a similar time-delayed return in both images. Therefore we have confidence that at least 80% of the correlated returns in Mare Serenitatis represent subsurface features.

Conclusions: The optical data analyzed for Mare Serenitatis indicate that the subsurface horizons found previously were not totally artifacts of processing or of subjective interpretation. The calculated depths of these features are in good agreement with calculations given by previous workers(4). However, our results do not show that these layers drape over a subsurface high in the Dorsa Lister area, as previously suggested, nor is there clear-cut evidence for constantly increasing depth toward the basin center or significant shallowing near the basin margins(2,3). Nevertheless, it should be recalled that the optical data is highly reduced in resolution in comparison to the holographic data, because (a) the holographic data has greater dynamic range, and (b) the optical data has been greatly compressed in the horizontal plane. The strongest advantage of this new technique is that it allows for rapid analysis of the remaining data which have until now suffered from neglect.

Because a computer technique now exists which gives some degree of confidence as to the validity of the results, it can next be applied to the remainder of the HF1 (60 meter-wavelength) data. The same technique can also be applied to the HF2 data (20 m wavelength), which will allow resolution of other possible horizons closer to the surface. The HF2 data may reveal the draping high over Dorsa Lister and the shallowing of layers near the basin margins that were not seen in this study.

(1) Sharpton, V.L., and Head, J.W.III (1982), Jour. Geophys. Res., V. 87 no. B13, pp. 10,983-10,998. (2) May, T.M. (1976), Master's Thesis, Univ. of Utah. (3) Peeples, W.J. et al. (1978), Jour. Geophys. Res., V. 83 no. B7, pp. 3459-3468. (4) Phillips, R.J. et al. (1973), Apollo 17 Prelim. Sci. Rept., NASA, Washington D.C., pp. 22.1-22.226.

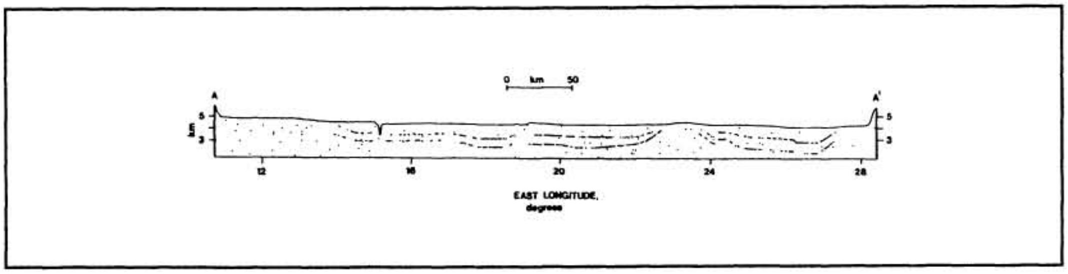

Figure 1. Results of correlation done by previous workers (2,3) for the Mare Serenitatis data. The above image was interpreted from holographic-format rather than optical-format data, and has been reduced to roughly the same horizontal scale as the other images shown in the following figures. The vertical scale is compressed as compared to the following figures. The final result is noticeably different from that obtained in our analysis (figures 2-3), especially in the area near Dorsa Lister Wrinkle Ridge.

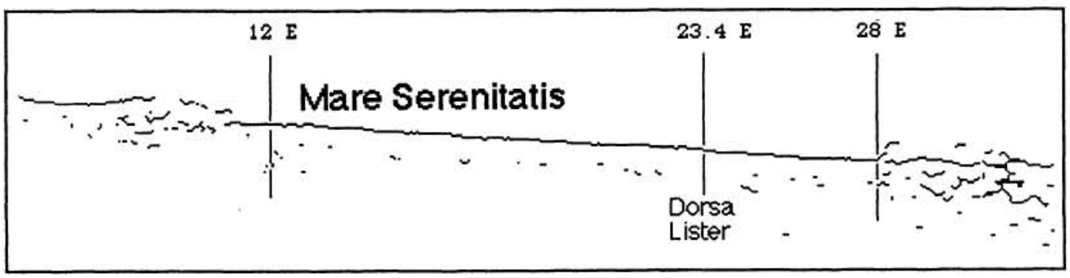

Figure 2. Correlation of two plots from two different orbits covering the same area of Mare Serenitatis. A computerized correlation technique was used in which pixels from two images were compared. Dark pixels with idential or adjacent x and y values in both images produce a dark pixel in the resulting image.

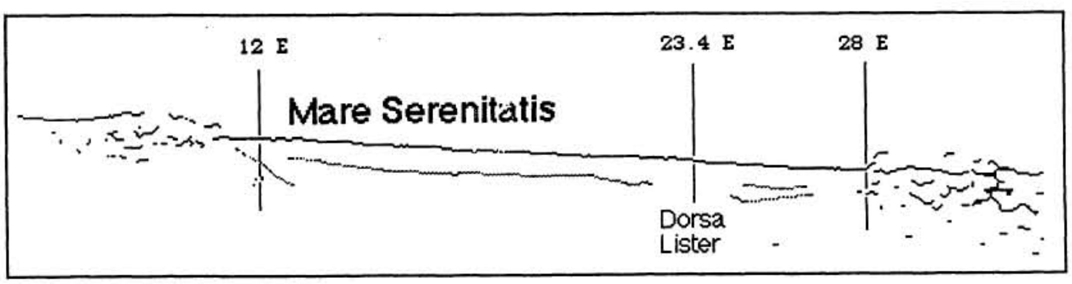

Figure 3. Geologic interpretation of the data shown in Fig. 2. We did a linear interpolation between points. Although the results are somewhat similar to those of previous workers as shown in Fig. 1, we do not find evidence for draping of layers over the Dorsa Lister Wrinkle Ridge. This may be a result of the decreased dymanic range of the optical-format data.