SUBSURFACE BASALT STRATIGRAPHY OF MARE SERENITATIS, Virgil L. Sharpton and James W. Head, Dept. of Geological Sciences, Brown University, Providence, R. I. 02912

Introduction - The results of a multiple orbital correlation technique for processing the Apollo 17 Apollo Lunar Sounder Experiment (ALSE) (HF-1) traverse across southern Mare Serenitatis revealed the existence of two subsurface basin-wide reflecting horizons [1] as shown in Fig. 1b. These horizons have been interpreted to represent either regolith layers or pyroclastic deposits subsequently buried by younger basalts [1,2]. The minimum distance between the surface and subsurface structure resolvable by HF-1 is 400 m [1]. This at least partially accounts for the abrupt, subsurface truncation of the reflecting horizons as they rise toward the surface. We propose that these horizons represent regolith layers developed on regional surfaces due to exposure to extensive impact bombardment rather than regional pyroclastic deposits because: 1) outcrops of pyroclastic material around Serenitatis are restricted to two localities of limited extent (Fig. 1d) whereas the basin-wide extent of the reflecting horizons implies a more regional process, and; 2) two reflecting horizons imply two outcrops of pyroclastics at each end of the traverse.

The best estimate for the thickness of the layers represented by the reflecting horizons is $\sim$ 2-5 m [1]. Monte Carlo models of regolith growth rates [3] suggest it requires on the order of $10^8$ y to develop 2 m of regolith. Time intervals orders of magnitude less than $10^8$ y would probably not be capable of producing a significant regolith. Therefore it appears that the reflecting horizons identify the subsurface traces of the major stratigraphic boundaries and may be correlated with surface unit boundaries.

Fig. 1a shows the surface distribution of the major stratigraphic units mapped by Howard et al. [4]. Table 1 identifies the convention used for denoting stratigraphic units and the age assignments for each unit [5].

Our objectives are as follows: 1) briefly review the current stratigraphic assignment of the reflecting horizons; 2) present an alternative correlation of surface and subsurface stratigraphy across southern Mare Serenitatis, and; 3) use this correlation to reconstruct the pre-mare topography and develop the subsidence history across southern Mare Serenitatis.

Previous Interpretation - The upper horizon has been previously interpreted as the interface between units III and II [1,6]. Likewise the lower horizon has been correlated with a small patch of pyroclastics just east of Abetti making it the unit II-unit I contact. Comparison of Figs. 1a and 1b reveals an important inconsistency at the eastern end of the traverse in the above interpretation. Directly below the point where the surface trace of the unit III-unit II boundary intersects the ALSE groundtrack the upper horizon is still 1 km below the surface and continues for 40 km eastward before its location is no longer traceable on the profile. If the upper horizon represented the unit III-unit II boundary it would have to emerge at the point where the traverse intersects the unit III-unit II surface boundary.

Present Interpretation: Upper Horizon - The surface projection of the upper reflecting horizon in the eastern portin of the traverse intersects the unit II-unit I boundary with only a slight reduction of the slope evident in the ALSE profile. On this basis we assign the upper horizon to the unit II-unit I interface.

Lower Horizon - The reflecting horizons are superimposed on a background of randomly spaced reflectors (Fig. 1b). These horizons serve to

separate the ALSE profile into three zones: zone 1 - above the upper horizon; zone 2 - between the two subsurface horizons, and; zone 3 - below the lower horizon. The density of randomly spaced radar reflections per unit area for zones 1, 2 and 3 are 2.3, 2.4 and 4.4 respectively. The significantly higher density in zone 3 is consistent with a change in material properties across the lower horizon such as between a basaltic unit above and a less coherent material below. We therefore interpret the lower horizon as the interface between unit I volcanics above and the Serenitatis basin material below.

Shallow units - On the basis of the interpretation developed thus far the unit III-unit II interface does not appear in the radar profile. Therefore if a regolith was developed on the unit II surface it is constrained to be <400m below the present surface because of the characteristics of HF-1 previously discussed. We propose that a regolith was developed on unit II and the maximum thickness of unit III basalts is <400 m; based on the following evidence: 1) the crater Bobillier, transected by the ALSE groundtrack is flooded by unit III basalts to a depth estimated to be 150 - 200 m [7]; 2) a linear subsurface feature at a depth of ∿100 m was recognized on HF-2 imagery 150 km along the groundtrack in western Serenitatis [8]. Fig. 1c summarizes the interpretation discussed above.

Pre-mare Topography and Subsidence History - The fluidity of basaltic lavas allows the original depositional surface of a mare unit to be approximated by a horizontal plane. Therefore by reducing the upper horizon to its original planar configuration, the pre-mare configuration of the lower horizon is restored. Similarly the topography developed on unit I subsequent to the emplacement of unit III can also be restored. Analysis of the resulting reconstructions yield the following information:

(1) The large arch-like topographic feature below ALSE intersections with the prominent concentric mare ridge system existed as a major topographic feature prior to the onset of mare volcanism. This precludes an origin for this feature through tectonic processes or igneous intrusion. Head [9] has previously assessed the pre-mare interior basin topography of Serenitatis by comparing it with the Orientale basin. Results indicate that the location of the flooded peak-ring of Serenitatis is surficially delineated by the concentric mare ridge system. Comparison with Orientale basin topography developed from earth-based limb photographs [10] reveals that the dimensions of the subsurface arch are similar to the dimensions of the Orientale peak ring. We conclude that this arch is the intersection of the concentric peak ring structure of Serenitatis with the ALSE groundtrack.

(2) The concentric mare ridge ring does not appear to separate regions of differing basalt thicknesses. However comparison with Orientale topography suggests that a major topographic depression exists just beyond the sampling limitation of the ALSE groundtrack (∿50 km basinward of the peak ring)

(3) The basin-related topography significantly influenced distribution of the volcanic load and the resulting subsidence history. The peak ring has undergone <400 m of subsidence since unit I volcanism whereas the deeply flooded regions between the rings have undergone vertical downwarping >1.2 km.

(4) Maximum subsidence occurred after the emplacement of unit I but before unit III was emplaced.

(5) Unit III is <400 m thick but the maximum structural relief developed after the emplacement of unit III is ∿600 m suggesting that the lithosphere was continuing to adjust to the volcanic load of units II and I beyond the time unit III was emplaced.

(6) The filling of the mare basin appears episodic with extrusion of

large volumes of basalt in very short periods of time, separated by extended periods of volcanic quiescence, characterized by the complete absence of volcanic activity and the development of a regolith layer.

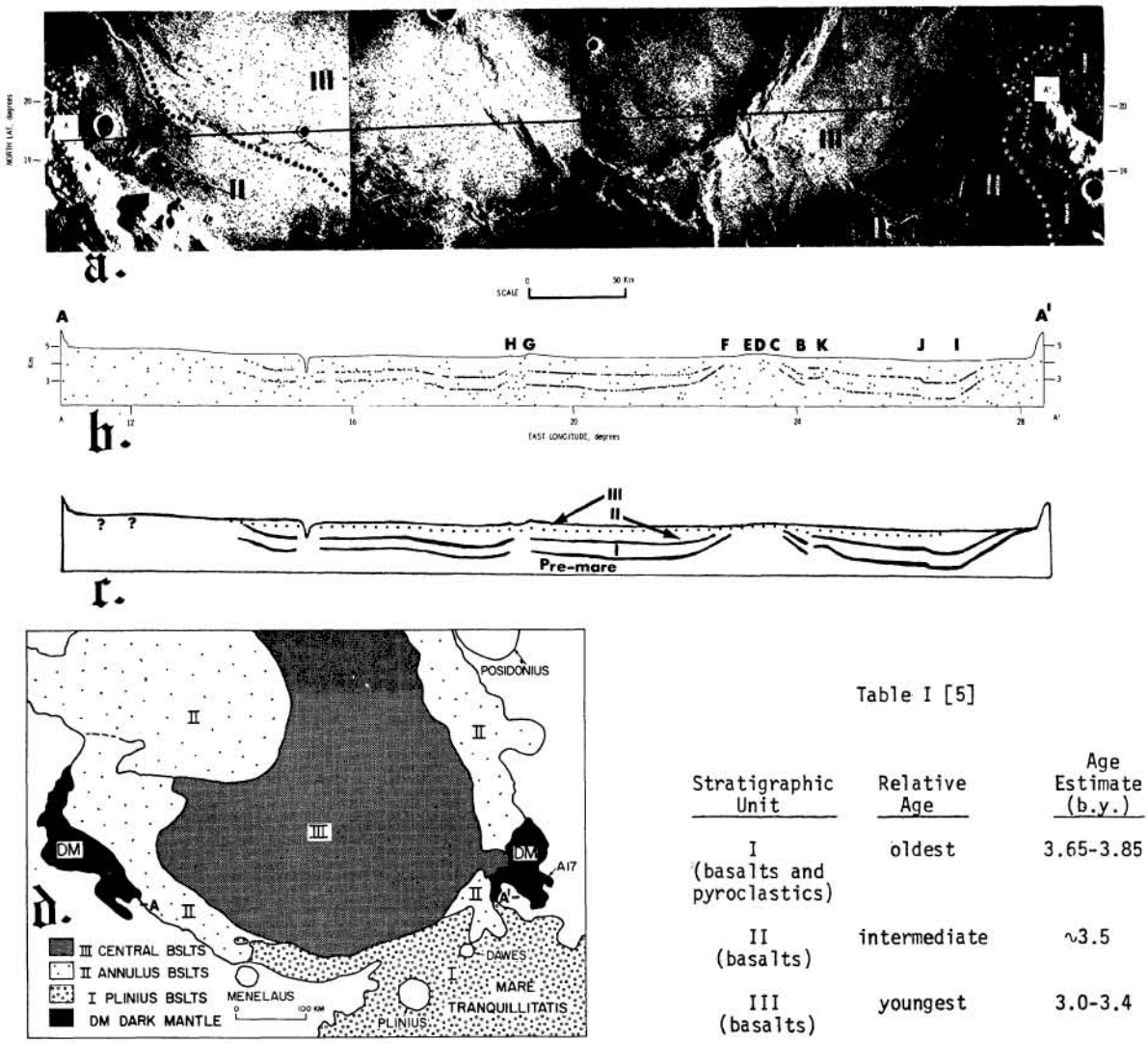


Table I [5]

| Stratigraphic Unit | Relative Age | Age Estimate (b.y.) |
|---|---|---|
| I (basalts and pyroclastics) | oldest | 3.65-3.85 |
| II (basalts) | intermediate | ∿3.5 |
| III (basalts) | youngest | 3.0-3.4 |

Fig. 1: a) ALSE Groundtrack (rev. 16 of Apollo 17) across the sourthern portion of Mare Serenitatis [1] and the major stratigraphic units for this area [4]. b) the coherent ALSE radar returns drawn to the same horizontal scale. c) Summary of the stratigraphic interpretation discussed in text. The dotted unit II-unit III contact is undetectable on ALSE but is constrained to be <400 m. d) Major stratigraphic units for Mare Serenitatis showing areal extent of pyroclastic (DM) deposits.

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