ONSET OF TECTONIC RILLE DEVELOPMENT IN SOUTHERN MARE SERENITATIS: EVIDENCE FOR INCOMPLETE PRE-MARE ISOSTATIC COMPENSATION? V.L. Sharpton, Lunar and Planetary Institute, Houston, TX 77058

Introduction. The stratigraphic relationships between tectonic rilles and the major volcanic units exposed in southern Mare Serenitatis (Table 1) were determined in order to constrain the timing of deformation within that portion of the basin. The following images were examined: Apollo 17-1819 (metric), Apollo 17-0808 (metric), Apollo 17-2102 (metric) covering the southwestern flank of Mare Serenitatis; Apollo 17-0939 (metric), Apollo 17-2882 (metric), Apollo 17-2884 (metric), Apollo 17-2420 (metric), Apollo 17-2416 (metric), Apollo 17-1660 (metric), and Apollo 17-150-23069 (Hasselblad) covering the south-central portion of the basin; Apollo 17-0449 (metric), Apollo 17-0796 (metric), and Apollo 15-1115 (metric) covering the southeastern regions; and Apollo 17-0939 (metric) covering the eastern margin of Mare Serenitatis.

Table 1: Volcanic Stratigraphy of Mare Serenitatis

Volcanic Units [1]	Major Stratigraphic Unit	Estimated Age, b.y.
Basalt of Mare Serenitatis	Unit III	3.0 - 3.4 [2]
Basalt of southwestern Mare Serenitatis Eastern Ring basalt Basalt near Dawes	Unit II	ca. 3.5 [3]
Basalt of Plinius area Dark mantle of Sulpicius Gallus Formation Dark mantle of Littrow	Unit I	3.65 - 3.84 [4]

Observations. Linear and arcuate rilles in southern Mare Serenitatis occur on highland and unit I surfaces. There is no indication of the unit I volcanics flooding or embaying any of these rilles nor is there indication of rille truncation at unit I/highland boundaries. No noticeable variations in rille width or floor depth were observed at unit I/highland boundaries. Some concentric rilles are located beyond the extent of the mare deposits. As these features do not intersect unit I surfaces, their ages are uncertain. Rilles which intersect unit II surfaces are consistently truncated and embayed by unit II lavas. Elongate collapse features, indicative of buried rilles, are observed on unit II surfaces in the southeastern portion of the basin but no such features are evident on exposed unit I surfaces.

Analysis. Tectonic rilles which occur along the flanks of southern Mare Serenitatis developed after unit I was emplaced but prior to the emplacement of unit II lavas. The occurrence of older rille structures which have been buried by subsequent unit I volcanics cannot be ruled out; however collapse features were not found on exposed unit I surfaces similar to those observed on unit II associated with buried rilles. Conceivably the earlier rilles could be deeply buried with no surface expression remaining. If this were the case it would appear that the early deformation of southern Serenitatis must have been distinctly episodic, with the first discrete period of rille formation occurring during the relatively early stages of unit I emplacement. As there is no evidence of rilles either shallowly or partly flooded by unit I, this early episode of rille formation must have been followed by a period of

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tectonic stability prior to the initiation of the post-unit I episode of intense faulting and downwarping which produced the rilles observed along the flanks of the basin. Current models of thermal evolution and lunar mascon deformation [5] show lithospheric thickness and mantle viscosity increasing throughout early mare evolution and do not favor multiple episodes of extensional deformation during mare infilling (at which time the load would be increasing).

Conclusions. The most straight forward and consistent interpretation of the stratigraphic relationships examined in this analysis appears to be that the development of linear and arcuate rilles along the flanks of southern Mare Serenitatis began after the unit I surfaces were deposited in this region. Thus if rille formation were caused by subsidence of the basin floor [6] and associated flexure [7], this deformation appears to have begun primarily after the majority of unit I volcanics had been emplaced. This does not rule out deformation unaccompanied by rille formation, nor are constraints placed on the timing of deformation in areas of the basin other than those examined. It would be difficult, nonetheless, to defend appreciable deformation in response to, and occurring during, the emplacement of unit I that was not accompanied by rille formation [5].

Implications. The post-unit I onset of rille formation appears to signal a relatively slow response of the lithosphere to the increasing volcanic load in the Serenitatis Basin. One possible explanation for this apparent lag could be that the unit I volcanics were emplaced rapidly enough to be virtually complete by the time significant deformation began. However, given that isotopic ages of unit I material span a range of approximately 0.2 b.y., this seems unlikely. A second explanation could be related to the relative age of the unit I volcanics on the basin margins vs. those in the basin center where the load is greatest. If the margin volcanics were emplaced relatively early in the unit I sequence, then significant loading (and concurrent deformation) associated with filling the central basin regions may have followed their emplacement, as the surface observations indicate. While this scenario is possible, again, the ages of samples returned from the Apollo 17 site, suggest the unit I volcanics in this region cover a broad age range. The most likely explanation involves the isostatic state of the Serenitatis Basin during early mare emplacement. It is conceivable that appreciable quantities of the unit I volcanics would be required to offset the mass deficiency created during impact basin formation. If unit I emplacement began shortly after the impact event then compensation of the basin topography may have been incomplete at the time of unit I volcanism. In this case, a substantial portion of the unit I mass may have been required to offset the negative load. The results of the analysis presented here suggest that in the southern portion of Mare Serenitatis volcanic infilling did not reach superisostatic levels until the majority of unit I was emplaced.

References. [1] Howard et al. NASA SP-330, 29-1--29-12, 1973. [2] Neukum et al., Moon, 12, 201-229, 1975. [3] Muehlberger, Proc Lunar Sci. Conf., 5th, 101-110, 1974. [4] Wasserburg et al., Philos. Trans. R. Soc. London, Ser. A, 285, 7-22, 1977; Geiss et al., Philos. Trans. R. Soc. London, Ser. A, 285, 151-158, 1977. [5] Solomon and Chaiken, Proc. Lunar Sci. Conf., 7th, 3229-3243, 1976; Kuckes, Phys. Earth Planet. Inter., 14, 1-12, 1977; Solomon, Phys. Earth Planet. Inter., 15, 135-145, 1977; Melosh, Proc. Lunar Planet. Sci. Conf., 9th, 3513-3523, 1978; Solomon and Head, J. Geophys. Res., 84, 1667-1682, 1979. [6] Bryan, Proc. Lunar Sci. Conf., 4th, 93-106, 1973; Runcorn, Proc. Lunar Sci. Conf., 8th, 463-469, 1977. [7] Solomon and Head, Rev. Geophys. Space Phys., 18, 107-141, 1980.