LUNAR SINUOUS RILLES: ANALYSIS OF MORPHOLOGY, TOPOGRAPHY, AND MINERALOGY, AND IMPLICATIONS FOR A THERMAL EROSION ORIGIN. D. M. Hurwitz[1], J. W. Head[1], L. Wilson[2], and H. Hiesinger[3]; [1]Dept. of Geological Sciences, Brown University, Providence RI 02912, debra_hurwitz@brown.edu; [2]Lancaster Environment Centre, Lancaster University; [3]Institut für Planetologie, WWU Münster

Introduction: Sinuous rilles are most commonly observed within the maria regions of the Moon, with sources that range in morphology from elongate- or irregularly-shaped depressions (e.g., Hadley Rille) to large crater-like depressions (e.g., Rima Prinz). Sinuous rille termini are typically indistinct and gradually disappear in surrounding mare deposits..

Post-Apollo studies link sinuous rille formation with the emplacement of lava flows, and a growing appreciation of the ascent and eruption of lunar magma has led to hypotheses consistent with very high effusion rates of low-viscosity lava [1]. The characteristics of the proposed lavas involve high Reynolds numbers, suggesting that turbulent flow and thus thermal erosion of the substrate has occurred [2, 3]. More recent numerical/analytical models have therefore modeled the formation of sinuous rilles as thermally erosive channels that generate a crust at the flow surface [4-7]. The latter study [7] demonstrates that rille length, width and depth variations as well as regional slope are the primary rille characteristics that are needed to deduce all of the characteristics of a rille-forming event, including Reynolds number (i.e. flow regime and thus potential for thermally erosive flow), flow velocity, and vertical/lateral erosion rates.

To apply updated models for thermally erosive lava flows [5-7], we have been examining properties of sinuous rilles, including 1) source region topography and morphology to assess implications of source geometry for thermal erosion theories [8, 9]; 2) lengths to assess possible flow durations; 3) slopes in order to assess important parameters associated with thermal erosion; 4) marginal deposits in order to distinguish between wide leveed lava flows and narrow thermally erosive flows; and 5) spectral properties of units in which sinuous rilles occur in order to assess the units that they may be eroding and to detect the presence of possible distal deposits. These properties will be used to assess and update theories of thermal erosion as an origin for the formation of sinuous rilles and to distinguish between those features associated with thermal erosion and those formed by other processes.

Preliminary Results: Kaguya topography data (LALT) were used to supplement Lunar Topographic Orthophotomaps (LTO) and Lunar Orbiter (LO) images to make detailed observations of morphologic and topographic trends for Rimae Prinz and Hadley Rille, shown in Figure 1, as well as Schroter Vallis, Herigonius Rille, Marius Rille, and two rilles within the Orientale basin.

Our initial studies have focused on Hadley Rille and Rimae Prinz, including Prinz, Beethoven, Handel, for the lengths of these rilles (Figure 1) using high resolution Kaguya topographic data (16 ppd spatial resolution, 5 m vertical resolution), and characteristic properties of the rilles are displayed in Table 1. Morphologic observations indicate that while the average widths of lunar rilles are fairly constant regardless of rille length, rille depths vary, though it should be noted that available topographic data rarely resolves the maximum depths of the rilles. Further analysis using Lunar Orbiter Laser Altimeter (LOLA) data will be used to supplement these measurements. Topographic observations using averaged LALT data and detailed LTO profiles indicate that a majority of the rilles analyzed are associated with a regional slope of ~ -1.0%, though exceptions include Rima Prinz, which begins flowing down a steeper grade (slope of -1.9%) before turning to follow a more gradual slope of -0.41%, and Hadley Rille, which begins flowing across anomalously positive terrain (+0.36% slope) before turning to follow a more gradual -0.51% slope into Palus Putredinis. The anomalous positive slope may indicate that mare subsidence occurred after the emplacement of the rilles.

Table 1: Properties of Lunar Rilles

Rille	Length (km)	Ave Width (km)	Depth (m)	Δ Depth (m)	Regional Slope (%)
Hadley	123.9	1.6	87	-36	+0.36 to -0.51
Prinz	83.5	1.0	35	11	-1.9 to -0.41
Beethoven	71.1	1.6	16.5	unresolved	-0.84
Handel	32.2	1.1	unresolved	unresolved	-1.3
Telemann	25.3	1.3	unresolved	unresolved	-1.4

Future Work: Future analysis of the various morphologic, topographic, and compositional properties will be used to further enhance our understanding of the origin of sinuous rilles. Major outstanding themes include: 1) analysis of topographic and morphologic characteristics of rille sources and investigation into how these properties relate to the thermal erosive capabilities of the lava, 2) use of very high resolution altimetry (LOLA) to assess levee presence and character, 3) further analysis of sinuous rille and regional slopes and determining implications for the thermal erosivity of the lava, 4) observations of spectral properties of sinuous rille substrates and possible distal deposits, and 5) comparison of the origin of lunar sinuous rilles and the origin of sinuous rilles found on Venus, Mars, and beyond.

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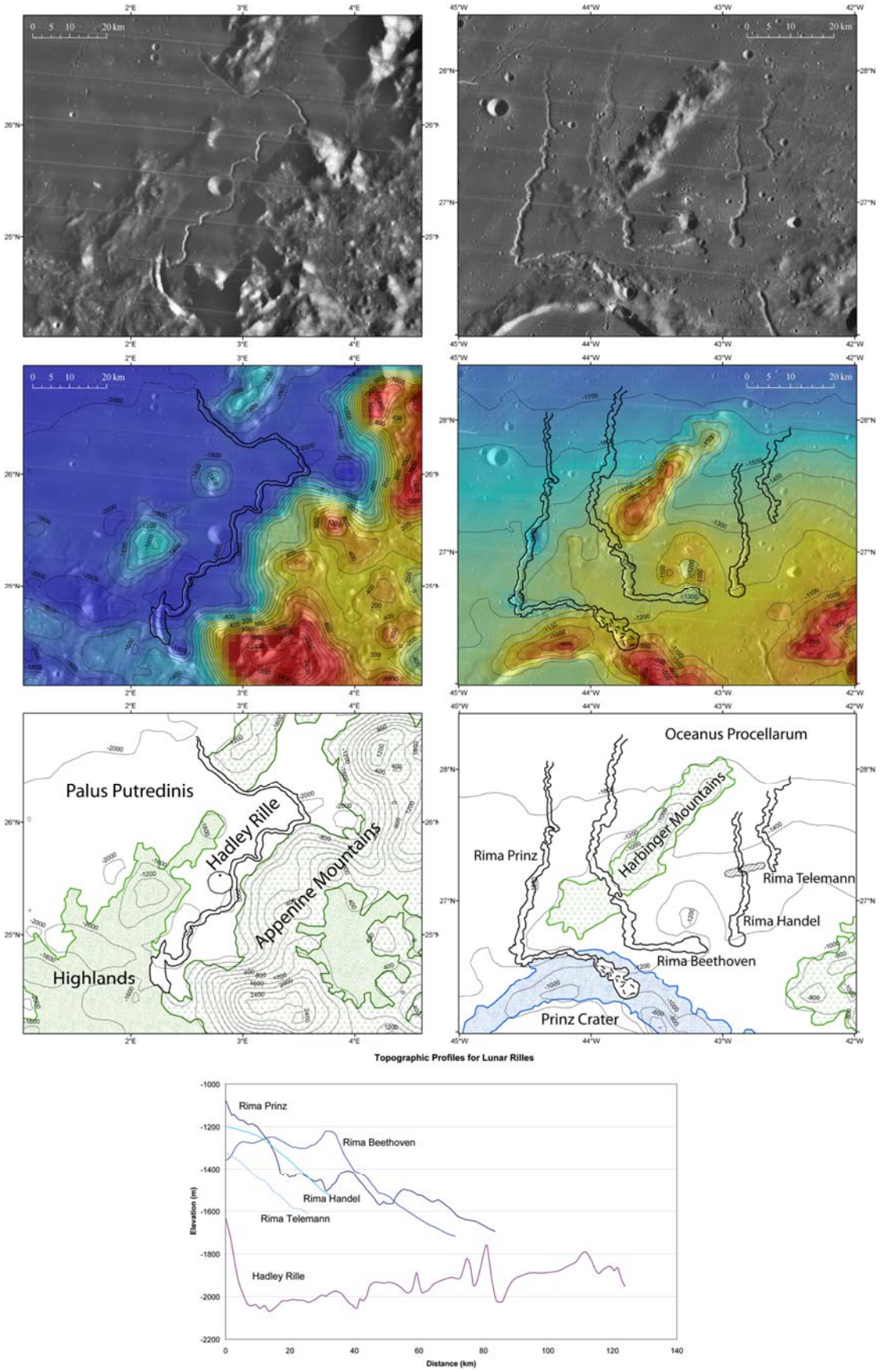

Figure 1: Lunar Orbiter (LO) images, Kaguya Laser Altimeter (LALT, vertical resolution of 5m, spatial resolution of 16 ppd), and schematics of Hadley Rille and Rimae Prinz, including Prinz, Beethoven, Handel, and Telemann. Topographic profiles were obtained using both LALT and Lunar Topographic Orthophotomap (LTO) data, and while down-grade trends are observed as expected for the latter four rilles, Hadley Rille flowed slightly uphill, a trend observed in both averaged LALT data and detailed LTO profiles, suggesting that mare subsidence occurred after rille emplacement. Additional analyses using LROC and LOLA data to resolve the depths of the rilles will help us confirm these trends.