IMPLICATIONS OF VOLATILES WITHIN LUNAR BASALTS FOR THE ORIGIN OF SINUOUS RILLE SOURCE DEPRESSIONS. D. M. Hurwitz[1] and J. W. Head, [1]Brown University, 324 Brook Street, Providence, RI 02906; debra_hurwitz@brown.edu.

Introduction: Observations of pyroclastic materials in dark mantle deposits (DMDs) have led to the interpretation that explosive volcanism occurred early in lunar history [1-5]. These explosive eruptions were driven by the exsolution of various volatile species [6-9] and in some cases resulted in the formation of unique geologic features, such as source depressions of sinuous rilles [10,11].

New high-resolution image (Lunar Reconnaissance Orbiter Wide and Narrow Angle Cameras, LROC WAC and NAC) and topography (Lunar Orbiter Laser Altimeter, LOLA) data are used to investigate the morphologies of the source depressions of several lunar sinuous rilles with associated pyroclastic deposits. Details in morphology, such as depression shape and width, the continuity of subsurface layers, and peripheral deposits, are investigated to look for evidence of explosive activity and to explore the origin of the source depressions and the associated sinuous channel.

Lunar Pyroclastic Eruptions:

Geochemical evidence for volatile content. Substantial research has been completed in investigating the volatile content of lunar basalts, both from laboratory measurements of returned glass samples [6-8] and from remote observations of lunar surface deposits [12-14]. Initial investigations of Apollo green and orange glasses found volatile-rich coatings that contained Zn, Pb, Cu, S, F, and Cl, among other volatile species. Advances in ion mass spectrometry have led to increased accuracy in measurements of volatile abundances in the cores of lunar glasses, with the most significant volatile species including S, H_2O, F, Cl, and CO_2 [8]. These more detailed analyses lead to the interpretation that lunar magmas contained more volatiles than previously expected, indicating that the Earth-Moon system either retained significant amounts of volatiles after initial formation or that volatile-rich material accreted to both the Earth and Moon shortly after formation but prior to 4.3 Gyr [8].

In addition to laboratory investigations, observations of volatiles on the lunar surface have been made using visible to near-infrared wavelength spectra collected by Earth-based telescopes [3,5,12], Clementine [13] and the Moon Mineralogy Mapper aboard Chandrayaan-1 [14,15]. Pyroclastic materials are observed within DMDs and are characterized by the presence of a significant Fe^{2+}-bearing component consistent with volcanic glasses [3,5,12].

Theory of explosive eruptions. The occurrence of pyroclastic DMDs have been attributed to eruptions similar to terrestrial Hawaiian-style eruptions [1,2]. Magma was likely generated either from a volatile-rich source deep in the lunar mantle [16] or by recycling and remelting a dense, ilmenite-rich layer in the lunar mantle [17]. While the magma was subjected to larger pressures deep in the lunar interior, the volatile elements remained dissolved, but as the magma rose to the lunar surface and pressure decreased, the gas exsolved and formed a foam that accelerated magma ascent until it erupts explosively at the lunar surface [6,18]. Eruption velocities may have been as high as 50 – 100 m/s [9], resulting in a dispersion of pyroclastic materials that cover an area 6x larger than expected for similar terrestrial eruptions due to lower lunar gravity [5]. Such high eruption velocities likely influenced the formation of the vent, and ponding of lava near the eruption source in some cases resulted in the formation of the depressions surrounding the eruption vent [10].

Observations: LROC WAC and NAC images and LOLA topography data are used to observe morphologies of source depressions of sinuous rilles. Observations of both elongate (i.e., Rima Hadley) and circular (i.e., Rima Prinz) source depressions will be investigated as will sources for sinuous rilles that are associated with pyroclastic deposits (i.e., Rimae Hadley and Bode) and that are not associated with pyroclastic deposits (i.e., Rima Prinz) to compare morphologies of sources with interpreted pyroclastic and effusive volcanic eruption origins.

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