GEOLOGIC AND REMOTE SENSING STUDIES OF RIMA MOZART: EARLY RESULTS;

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The nature and origin of lunar sinuous rilles have long been the subject of major controversy. Lunar sinuous rilles typically occur on mare surfaces, though a few cross into highland terrains. They are generally associated with a crater or an elongate depression at their highest elevation and vary in width, depth, length, and degree of sinuosity. Suggested origins for sinuous rilles include: 1) erosion by nuees ardentes,[1] 2) fluvial erosion,[2,3,4,5] 3) tectonic features of tensional origin,[6] 4) formation as lava tubes and channels during lava emplacement,[7,8,9] or, during the draining of a lava lake,[10] 5) incision of channels by thermal erosion and/or turbulent flow through the channels.[11,12]

A number of these possible origins appear to be unlikely at this time. It is unlikely that nuees ardentes would form the smooth sinuous channels on the lunar surface. On the Earth they form hummocky channels and dunes, not smooth curvy channels. Though a morphologic similarity to terrestrial fluvial features has been noted,[2,3,4] a fluvial origin for lunar rilles has long been discounted due to the anhydrous nature of the returned lunar samples (e.g., Taylor, 1975).[13] The similarity of certain lunar rilles to terrestrial channels of fluvial origin merely suggests an origin by fluid flow, though water is not necessarily the erosive agent.[9]

Terrestrial lava tubes and channels commonly originate at vent craters or depressions associated with regional tectonic features such as faults, fissures, or fracture systems that may form concentric to calderas.[8] Similarly, many lunar sinuous rilles are located in areas of structural weakness and often tend to follow pre-existing structural trends. However, the presence of elongate "head" craters, levees, and the fact that lunar sinuous rilles may extend for large distances without offset or mirror images on either side contradicts an origin due to extensional tectonics alone.

Lunar sinuous rilles are also morphologically similar to terrestrial lava channels and collapsed lava tubes in that they commonly originate at irregularly shaped "head" craters, trend down-slope, are discontinuous in areas (tube formation and/or collapse?), taper out at distal ends, and may form distributaries. They are believed to form in several phases, similar to terrestrial tube-fed lava flows .[14] On Earth, a lava flow may extend for large distances under the insulating layer of its cooled surface. A similar insulation process, in conjunction with the high termperatures and low viscosities typical of lunar lavas, may also provide protection for lunar flows, enabling lava tubes and channels of considerable linear extent to form. Although thermal erosion and turbulent flow may help explain the enormous linear extent and depth of lunar sinuous rilles, they cannot explain the formation of meanders that are commonly associated with lunar rilles.

In order to better understand the processes responsible for the formation of lunar sinuous rilles, we have conducted a study of Rima Mozart using a variety of geologic, photographic, and remote sensing data. This paper presents the preliminary results of an analysis of these data.

Rima Mozart is a 40 km-long lunar sinuous rille located near the SE rim of Imbrium basin (25°21"N, 359°03"W) and approximately 100 km southwest of the Apollo 15 landing site. It is 250 to 500 m deep and is incised into the volcanically derived KREEP basalts of the Apennine Bench Formation.[15,16,17] The rille is surrounded by a smooth mare-like, low albedo volcanic unit. While most of this dark unit appears to have been emplaced as voluminous volcanic flows originating at the primary source vent, Kathleen, some of it may represent pyroclastic "dark mantle" material. An anlysis of the high-resolution 3.8 cm radar maps of the Rima Mozart region presented by Zisk *et. al* .[18] indicates that at least some pyroclastic debris is present around Kathleen. The KREEP basalts of the Apennine Bench Formation (~ 3.8 to 3.9 b.y.) are a plains-forming unit of intermediate albedo, with numerous secondary craters and a variety of linear structural features present. Underlying the Apennine Bench Formation is a 3.8 b.y. old unit of extremely fractured, hummocky Imbrium ejecta material.

Adjustment and settling of this unit and/or the draining of the once molten Apennine Bench Formation may explain the presence of the linear structural features seen on the surface.[19] Beneath the Imbrium ejecta is a 3.86 b.y. old unit of Serenitatis ejecta material.

Photographic data indicate the presence of two major volcanic source vents for Rima Mozart. Now girdled by dark mare-type material, these vents appear to have formed in the underlying Apennine Bench Formation. Kathleen, the primary source vent and the largest of the two, is an elongate crater (5 x 3 km) in the Apennine Bench Formation. From Kathleen, Rima Mozart follows a dominant NW/SE structural trend[16] until its terminus 30 km to the east. About 10 km from the terminus of Rima Mozart the second elongate (2 x 1 km) source vent, Ann, is joined to the main channel by a secondary rille. Evidence of spatter surrounding Ann strongly supports a volcanic origin for this feature. Additional evidence for a volcanic origin for Rima Mozart is the presence of what appear to be uncollapsed and partially collapsed tubes along the rille. At the distal end of Rima Mozart, the rille terminates at Michael, an apparent "sink" crater, as suggested by the lack of evidence for fire-fountaining around the vent and the fact that it is topographically lower than Kathleen and Ann. The crater Michael may be connected to the NE-trending Rima Bradley, to the southeast, through a conduit marked by a collapse feature, Patricia. This possible extension of Rima Mozart joins Rima Bradley at a 90° angle, reflecting the dominant NW/SE structural trend of the region.

Near infrared spectra (0.6 - 2.5 μm) recently collected at the U.H. 2.2 m telescope on Mauna Kea indicate that both Apennine Bench material and lesser amounts of mare material are exposed in the interior of the source vent, Kathleen. The surface of "Lacus Mozart", the mare deposit southeast of Patricia, is dominated by mature mare basalt with a minor amount of contamination by highland debris. Further analysis of these spectra as well as those obtained for other geologic units in the region should provide additional compositional information.

We suggest that Rima Mozart, like many other lunar sinuous rilles, was most likely formed by a combination of events. Rima Mozart does follow a pre-existing, dominant, NW/SE structural trend suggesting the influence of structural features on the rille orientaton. The volcanic origin of Rima Mozart is strongly supported by the presence of two volcanic source vents and the spatter present around Ann. We suggest that the formation of Rima Mozart began with an explosive eruption at Kathleen which deposited a blanket of pyroclastic material. The eruption then calmed down to the pulsating, high volume, low-viscosity lava flow which has been inferred to be typical of most lunar effusive eruptions. The rapid effusion rate of the magma as well as its high temperature and turbulent nature helped to erode the sinuous rille into the fractured Apennine Bench Formation underneath. Similar eruptions and flows were also created at Ann and joined to the main channel by a NE-trending secondary rille. Rapid, turbulent lava flows continued to form Rima Mozart through a network of channels and/or tubes that appear to conform to the underlying, pre-existing structure of the Apennine Bench Formation until reaching the terminus at Michael.

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