MARE VOLCANISM IN THE HERIGONIUS REGION OF THE MOON. Ronald Greeley and Paul D. Spudis, Dept. of Geology and Center for Meteorite Studies, Arizona State University, Tempe, Arizona 85282.

The geological history of mare emplacement on the Moon is much more complex than generally considered prior to the Apollo missions, particularly with regard to styles of volcanism and sequences of eruption. As part of a general study of modes of mare emplacement (1) the region in the vicinity of the crater Herigonius was studied in detail because it appears to be a vent area for mare basalts and may have contributed flows to two provinces, southern Oceanus Procellarum and Mare Humorum. The part of the study reported here is restricted to the region near and west of Herigonius (Fig. 1), covered by LO IV frame 137 H-2; Apollo 16 metric, panoramic and Hasselblad frames were used for the study.

Pit craters and numerous sinuous rilles (Rimae Herigonius, identified for convenience as RH 1 through RH 7 on Fig. 1), many of which originate in the area, demonstrate that the region was the source for at least some of the mare basalts. Photogeology and remote sensing spectral data (2) show several different basalt units in the area, ranging from high titanium to low titanium lavas. Some of the units have prominent mare ridges of the classic, multiple profile form (a broad arch, with a crenulated upper element). The mare ridge-sinuous rille-mare contact relations show a complex volcanic history and eruptive sequence, tentatively interpreted as follows:

STAGE 1. Earliest recognizable volcanism produced mare lava interpreted as low titanium basalts (2), shown as L on Figure 1; these are relatively high albedo and moderately cratered mare units that occur most commonly at the contact with the highlands. Some parts of the unit contain vestiges of sinuous rilles; one area in the northwest contains large (4 km) "dimple"-shaped craters that may be endogenic. Light plains units (Fig. 1) may represent eruptions of pre-mare volcanics earlier than unit L, although the origin as volcanic is questionable.

An elongate zone some 35 km by 50 km is the main vent area for the prominent rilles and has been mapped by Pieters and others (2) as low titanium basalt; examination of color difference images of Whitaker (per. comm.), however, shows that this unit has a different signature than the other low titanium units in the area which suggests a different composition.

STAGE 2. Superposition and cross cutting relations show that the next oldest recognizable volcanic unit is a high titanium (H on Fig. 1) mare basalt. This is the most extensive unit in the area mapped. Early eruptions of this unit may have been confined to the north, outside the third ring of the Humorum basin. Examination of high resolution, low sun angle panoramic frames fails to reveal hummocky surfaces, ring moat structures and other small scale features; their absence may signal the presence of flood-type lavas (3) that are thick and which were perhaps ponded in topographically low areas. At least some of the lavas, however, were emplaced by lava tubes and channels, indicating lower rates of effusion than flood-type eruptions. RH7, RH4, RH5 and numerous other small, shallow segments of rilles may represent an early network of conduits for the emplacement of these lavas.

STAGE 3. The southern part of Oceanus Procellarum continued filling with mare lava until the topographic high of the third Humorum basin ring was breached through "gaps" in the highlands separating Procellarum and Humorum. This breach focused lava flow southward and led to the development of well defined lava channels (RH1, RH3, RH6); drainage of lava through these channels may have lowered the surface of still-molten lavas. Evidence of lowering is indicated by low albedo, mare-draped hills, ring-craters, and numerous mare benches along some mare-highland contacts, interpreted as high lava marks. Their presence in only some mare areas and absence in the adjacent highlands argues against a debris-flow origin for the benches (as proposed in other areas

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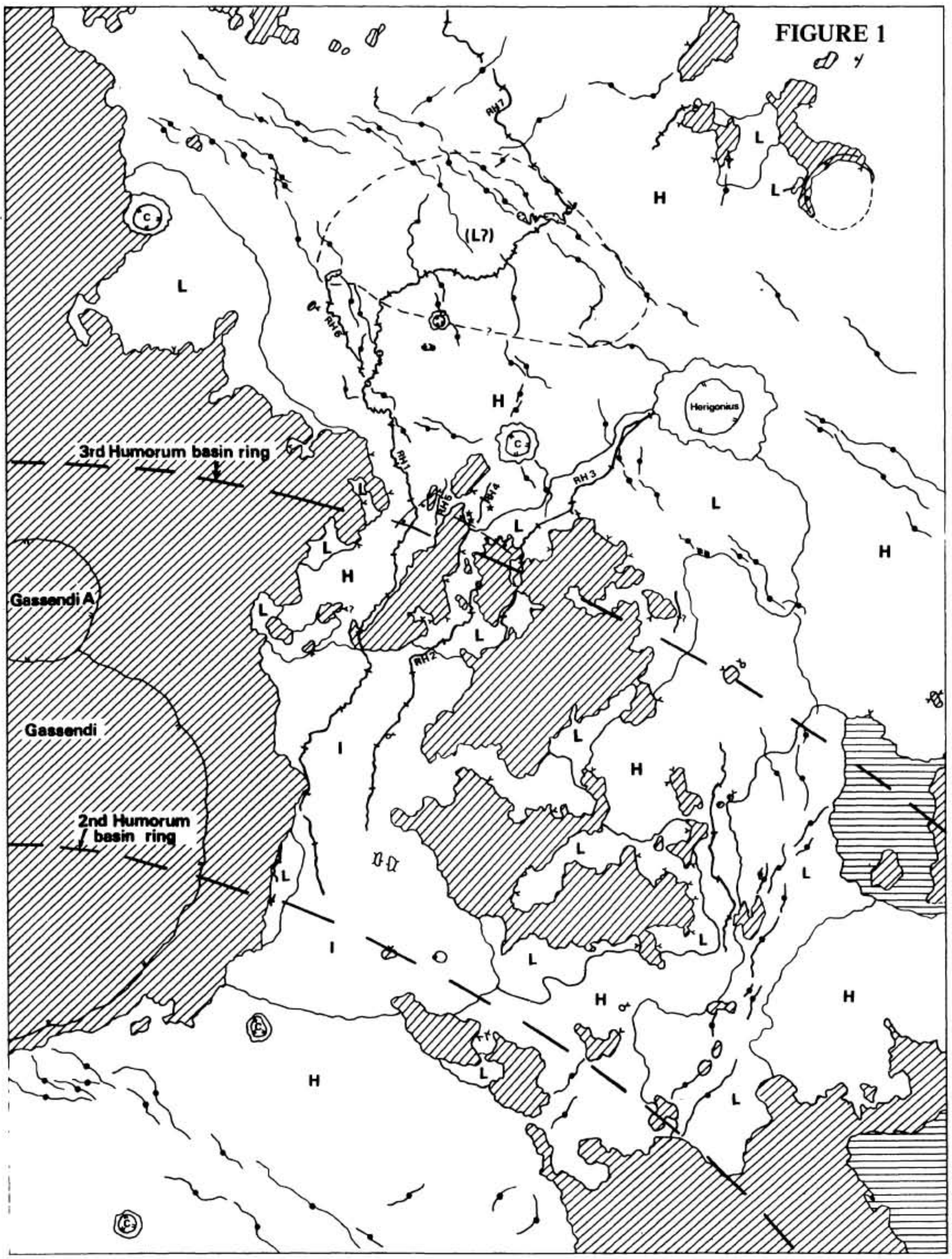

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of the Moon (4). Subsidence of the lavas was accompanied by deformation of the mare surface to form mare ridges. The location of the ridges may be partly controlled by underlying topography such as buried crater rims, and perhaps the proposed "Gargantuan" basin (5, 6). Transected impact craters show that at least some ridges and ridge elements are tectonic in origin, as proposed by many investigators (7, 8, 9); a mare arch superposed on RH7, and flow units making up a mare arch suggests a probable volcanic origin for some mare ridge elements (as suggested by other investigators, 10, 11, 12) and demonstrates the complex sequence of rille-flow ridge formation, etc., in the area. During the episode of major ridge formation, continued eruptions focused lava through the main rilles, enabling the rilles to be maintained by lava erosion as the ridges rose around them. Erosion by lava tubes has been demonstrated on Earth (13, 14) and suggested for the Moon (15, 16).

STAGE 4. The youngest mare lavas in this region are the intermediate titanium composition (2) lavas situated primarily between the second and third rings of the Humorum Basin. Pieters and others (2) interpret the composition of this unit to be the result of vertical mixing of a thin surface lava with an underlying unit. Since this mare unit contains two median sinuous rilles, a more likely hypothesis is that with time the magma evolved to an intermediate titanium composition that was erupted and flowed down the established lava channels (RH1) and was emplaced. Because it was restricted to the vent and channel (RH1, beyond the third ring), this unit does not show in the spectral data due to insufficient spatial resolution.

In summary, the Herigonius region is complex, involving a multiple stage tectonic and eruption sequence of different composition lavas. The study shows that the Humorum basin was at least partly filled with lava originating outside the outer basin ring.

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FIGURE 1. Geologic map of the Herigonius region of the Moon. Highland materials are shown by cross-ruled lines; pre-mare light plains by the horizontal ruling. Line and ball symbol represents mare ridges; line and cross hatch are sinuous rilles; "Y" symbol locates mare benches. The letters L, I and H are mare units as defined by Pieters and others (2) with modification of contact placement by photogeologic study. Star symbols represent possible volcanic constructs; C shows post-mare crater deposits. Basin ring locations taken from (17). Map area approximately 270 km by 350 km; mapped on LO IV - 137 H_2.

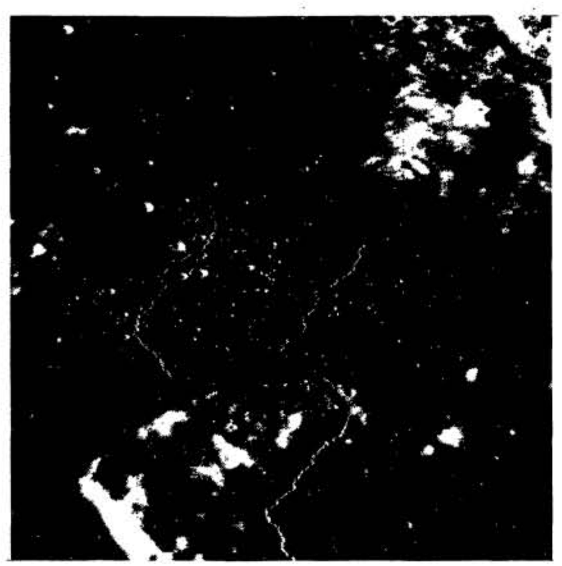

FIGURE 2. Oblique view (near field width approx. 50 km) looking south toward Mare Humorum. Note sinuous rille (RH 1 in Fig. 1) has cut into terra materials in near field, probably by lava erosion, but is controlled by topography further south; here the basalts have intermediate Ti content. Relations observed here suggest differential subsidence of mare lavas in this region (AS 16 - 19169).