

**THE GEOLOGY OF SMYTHII AND MARGINIS BASINS USING INTEGRATED REMOTE SENSING TECHNIQUES: A Look At What's Around The Corner.** Jeffrey J. Gillis<sup>1</sup>, Paul D. Spudis<sup>2</sup> and D. Ben J. Bussey<sup>2</sup>, 1. Dept. of Geology and Geophysics, 6100 South Main Street, MS-126, Rice University, Houston, Texas, 77005. Gillis@lpiip2.jsc.nasa.gov 2. Lunar and Planetary Institute, 3600 Bay Area Blvd., Houston, Texas, 77058.

As part of our ongoing study of volcanism on the far side of the Moon, we are studying the geologically diverse eastern limb of the Moon. Crustal thickness in this area, 60 - 75 km, [1, 2] approximates more closely the average crustal thickness of the far side of the Moon (100 km) than the crustal thickness beneath the near side, Apollo sites (40-60 km). Moreover, the eastern limb region has been documented by a variety of remote sensing techniques: Lunar Orbiter and Apollo images, Apollo X-ray and gamma-ray data, and Clementine gravity, topography and multispectral images.

A comprehensive study of the geology of the eastern limb of the Moon, 10°-30° N latitude and 70°-100°E longitude, was conducted using Clementine, Lunar Orbiter, and Apollo data. Prominent features within this region are the Smythii (2° S, 87° E; 750 km diameter) and Marginis (20° N, 84° E) Basins. Highlands dominate the exterior of the two basins, while mare is concentrated within the basin interiors and in depressions produced by the large impact craters Neper (2° S, 85° E; 140 km diameter), Hubble (22° N, 87° E; 85 km diameter), Joliot (25° N, 94° E; 170 km diameter) and Lomonosov (27° N, 98° E; 95 km diameter).

Smythii is a pre-Nectarian basin composed of three recognizable ring structures 370, 540 and 740 km in diameter [3]. The mare occupies the northeast region of the basin floor, within the 370 km ring of Smythii. These lava flows appear to be among the youngest on the Moon; crater densities relative to the lava flows at the dated Apollo sites indicate that the Smythii flows may be between 1 to 2 b.y. old [1].

The volcanic deposits in Smythii have average iron and moderate to high titanium content compared with typical lunar basaltic regolith (Table 1). The disagreement in measured FeO content between Clementine and Apollo gamma-ray data may be attributable, in part, to the resolution of the data. The Clementine data has a resolution of 250 meters per pixel, whereas the resolution of the orbital gamma-ray data is about 100 to 200 km [4]. Mare Smythii is about 200 km in extent. Therefore, the Apollo gamma-ray data must average the signal of mare and nonmare material across much of the basin. In addition, the main mare deposit is covered only by the northern edge of the Apollo 15 and 16 command module ground tracks. These factors suggest that for Mare Smythii, the iron abundance values calculated using the new method of Lucey et al. [8] with the Clementine multispectral images are more accurate.

We have estimated the thickness of the basalt deposits in Mare Smythii by bracketing the depths at which craters have excavated highlands material and the depths at which they have not. For simple craters, typical excavation depths are on the order of one-tenth their apparent diameter [9]. Craters less than 300 meters deep (e.g. an unnamed crater 3 km in diameter located at 0.7° N, 87.1° E) have not excavated

highlands material while craters greater than 350 meters deep (e.g. unnamed crater 3.5 km in diameter located at 0.6° N, 86° E) have excavated highlands material from beneath the mare. Thus, we estimate that the basalt is approximately 325 meters thick at most.

A unit with intermediate albedo and iron values (10 - 12 wt. % FeO) occupies the southwestern central area of the Smythii basin. Topographically higher, this unit forms an elongate arch that stretches from northwest to southeast and divides the main basalt deposit to the northeast from two isolated basalt patches to the south and southwest. Along this isthmus are a number of floor-fractured craters; Haldane, Kiess, Purkyne U, Runge, Schubert C, and Warner. These floor-fractured craters represent pre-mare impact craters whose floors have been uplifted tectonically and modified volcanically during mare flooding [5]. The genesis of this basin floor unit is uncertain. Fire-fountain type eruptions discontinuously mantle this region with pyroclastic material. Subsequent uplift of the basin floor preserved this intermediate unit from burial by an ensuing eruption of lava. A mixture of basin floor material and pyroclastics would produce the chemical and albedo signature that we observe. An alternative explanation is that this unit is a complex mixture of impact melt, fallback breccia, and mare material.

Clementine color data support the finding by Spudis and Hood [1] of anorthositic material in the northwest corner of the 370 km ring structure of Smythii. Images of this area in the 950 nm band show no significant absorption caused by the presence of iron-rich silicates. Low iron soils, 2-6 wt. % FeO, are also detected outside the 370 km ring to the southeast of the crater. The central peaks of Neper, Hubble and Joliot also display low iron concentrations, suggesting anorthositic rocks. Thus, we see evidence for anorthositic rocks within both the inner basin ring of Smythii (as seen elsewhere on the Moon [10]) and within the central peaks of large, complex craters in the region. We infer that the crust in this area is anorthositic at depths between those sampled by crater central peaks (~10 km; [7]) to those sampled by basin inner ring structures (~30 km; [9]).

Mare Marginis, north of Smythii, may or may not occupy an impact basin [3]. There is no indication of an anorthositic ring within the basin in the Clementine imagery. Furthermore, the topography derived from Clementine altimetry shows only a shallow, irregular depression. Marginis also lacks the strong (> 200 mGal), circular positive gravity anomaly displayed by many impact basins. These attributes are characteristic of a very old degraded impact basin, a coalescence of large craters, or a structural trough exterior and concentric to Smythii basin.

Mare Marginis is older than Mare Smythii, as suggested by higher crater densities. Further evidence to support a pro-

## GEOLOGY OF SMYTHII AND MARGINIS BASINS: J. J. Gillis, P. D. Spudis, &amp; D. B. J. Bussey

longed volcanic history is found in the craters Neper, Hubble, Joliot and Lomonosov, which also contain deposits of basalt. Basalt flows in the craters Hubble and Joliot are older than those in Neper and Lomonosov [6]. Therefore emplacement of basalt occurred over a period of time and not in one discrete episode. Volcanism was probably occurring in Smythii, Marginis and these large craters concurrently. In time, eruptions were less voluminous and concentrated in only Mare Smythii and Lomonosov.

The iron and titanium abundance in Mare Marginis is equivalent to that in Mare Smythii (Table 1). Estimated minimum thickness of the basalt is 350 meters based upon crater excavation depths. This estimate lacks an upper defined limit because no large craters that have excavated highlands material. We attribute the low iron and titanium content of Neper, Hubble, Joliot and Lomonosov (Table 1) to age and their relative thinness. Hubble and Joliot have the lowest concentration of iron and titanium while Neper and Lomonosov are somewhat higher.

The surfaces of Mare Smythii and Mare Marginis are 5 and 3 km, respectively, below the mean lunar radius of 1738 km [2,6]. The mare within Smythii is concentrated in the north-eastern corner of the basin. Geophysical characterization of the subsurface density under Smythii basin [2,6] suggests the presence of a concentration of mass, or mascon, underneath the area where the mare is the deepest. The basalt flows are too thin (~300 m) to be the cause of the mascons. If the mascon were the result of the mare basalt, then it should be found that Mare Marginis possesses a greater mascon be-

cause of its thicker basalt flows. Instead there exists only a moderate (125 mGal) mascon beneath the Marginis basin [2].

The eastern limb of the Moon offers a diverse grouping of geologic features and a variety of remote sensing information with which to study them. Comprehension of the interrelationship between mascons, crustal thickness, elevation, duration of volcanism, and basalt composition, volume and age is important to understanding the geologic processes that influence lunar volcanism. Preliminary observations of the eastern limb region reveal the complex interplay between these factors. The youngest basalt deposits occur in the lowest and highest elevations occupied by mare in this region, and they are associated with the weakest and strongest mascons in the area (e.g. Lomonosov and Smythii basin). In the case of Smythii Basin, the production of floor fractured craters seems influenced by the magnitude of the mascon. These craters are only found in close proximity of the mascon within Smythii Basin. Further study of the Smythii-Marginis region and other far side basalt deposits will be conducted with the aim of identifying controlling factors behind lunar volcanism.

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oxide	Smythii Clem.	Smythii Apollo	Marginis Clem.	Lomono. Clem.	Neper Clem.	Joliot Clem.	Hubble Clem.
FeO	14 - 16	7.2 - 9.5	14 - 16	10.5-12.5	12.5-14.5	9 - 11	9.5 - 11.5
TiO <sub>2</sub>	3.5 - 4.5	4.2 - 5.8	2.6 - 3.6	0.5 - 1.5	2.2 - 3.2	<0.5 - 1	< 0.5
MgO		8.3 - >12.3					
Al <sub>2</sub> O <sub>3</sub>		16.1 - 18.9					

Table 1. Comparison of geochemical data compiled from Apollo gamma ray and Clementine UVVIS data for Smythii and Marginis Basins. Clementine iron and titanium abundance calculated using equation of Lucey et al. [8]. Apollo chemical data from La Jolla Consortium [e.g., 4]. (Clem. = Clementine, Lomono. = Lomonosov)