

# THE COMPOSITION AND ORIGIN OF THE DEWAR GEOCHEMICAL ANOMALY.

S. J. Lawrence<sup>1</sup>, B. R. Hawke<sup>1</sup>, D. J. Lawrence<sup>2</sup>, J. J. Gillis<sup>1</sup>, P. G. Lucey<sup>1</sup>, G. A. Smith<sup>1</sup>, and G. J. Taylor<sup>1</sup>,

<sup>1</sup>Hawaii Institute of Geophysics and Planetology, School of Ocean and Earth Science and Technology, University of Hawaii at Manoa, 1680 East-West Rd, Honolulu, HI 96822 (slawrenc@hawaii.edu), <sup>2</sup>Los Alamos National Laboratory, Los Alamos, NM, USA, 87545

**Introduction:** Dewar is an Imbrian-aged crater located on the lunar farside (2.7° S, 165.5° E). Recently, D. Lawrence et al. [1] reported a thorium enhancement centered northeast of the crater and used the FeO mapping algorithms of [2] to determine that the position of the thorium enhancement correlates with an area of relatively high FeO values. Here, we report the results of a remote sensing investigation of the Dewar crater area, and place new constraints upon the probable modes of origin for the Dewar geochemical anomaly.

**Methods:** Elements of the calibrated Clementine five-channel ultraviolet/visible digital image model for the Moon were used to create an image cube centered on Dewar crater in simple cylindrical projection at a resolution of 100 m/pixel [e.g., 3-5]. This five-channel image cube was used as the basis for a variety of data products. Five-point spectra were extracted from areas of geologic interest and interpreted according to the procedures set forth in [6] and [7]. The calibrated image cube was used to generate FeO and TiO<sub>2</sub> abundance maps using the techniques recently presented by [8] and [9], which evolve the technique of [2] by including empirical calibrations to Apollo landing sites. Optical maturity images (OMAT) were created using the method of [10]. The half-degree LP-GRS thorium abundance map generated using LP-GRS data from the low-altitude portion of the mission and described in [1] was used to make determinations about the thorium concentrations in the study area.

**Results:** Dewar crater is an Imbrian-age crater with a diameter of approximately 50 km, located north of South Pole-Aitken (SPA) basin [11]. An anomalous area that exhibits a relatively low albedo is visible adjacent to Dewar crater in both Lunar Orbiter and Clementine imagery. This anomalous area can clearly be seen in Figure 1.

As described in [1], the measured thorium concentrations in the anomalous area range from 2-2.5 µg/g. The centroid of the thorium anomaly is directly northeast of Dewar crater. An analysis conducted as a part of the current study showed that the location of the enhanced thorium area correlates with the low-albedo area visible in the Clementine imagery.

FeO and TiO<sub>2</sub> mapping showed that both FeO and TiO<sub>2</sub> enhancements correlate with the low-albedo area, as well. FeO values within the anomaly range from 9-16.6 weight percent. TiO<sub>2</sub> values range from 0.7-2.2

weight percent. In general, the highest values of FeO are correlated with the highest values of TiO<sub>2</sub>, as well as the darkest portions of the low-albedo area.

Five-point Clementine spectra were extracted from the darkest portions of the low albedo region and interpreted. These spectra all have absorptions centered on the 950 nm band, indicating that the low-albedo material has a mafic assemblage dominated by high-calcium clinopyroxene. These spectra generally resemble spectra extracted from dark haloed impact craters on the lunar nearside [e.g., 12]. In summary, the FeO and TiO<sub>2</sub> abundances, as well as a mafic assemblage dominated by clinopyroxene, suggest the presence of mare basalt-like material.

**Discussion:** There are several mechanisms that could plausibly account for the emplacement of mare basalt-like materials in the lunar highlands adjacent to Dewar crater.

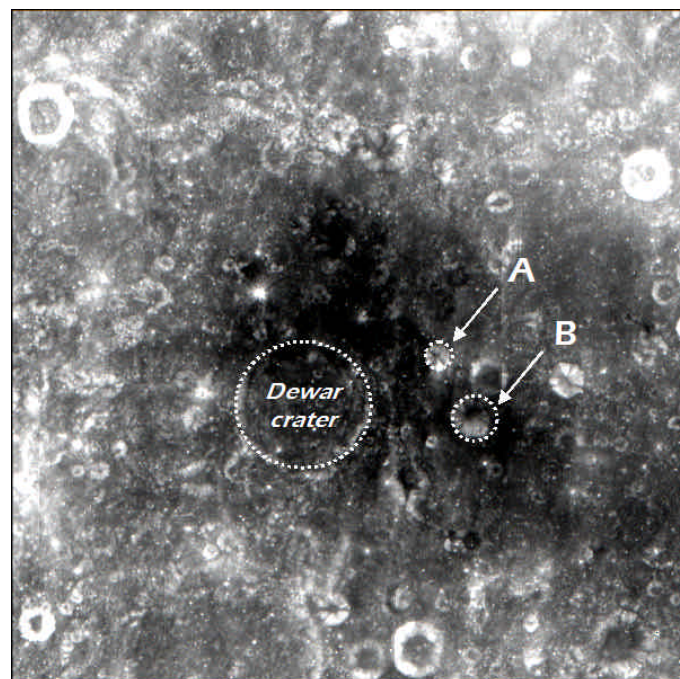
*Mare basalt ponds:* Since there are no level surfaces in the study area that resemble mare basalt ponds, it is unlikely that the anomaly is simply a ponded mare basalt. In addition, no lava flows were distinguishable in Clementine imagery.

*Mafic Impact-melt Breccia:* In [1], it was proposed that the thorium enhancement in the Dewar region could be produced by the presence of mafic impact-melt breccias (MIBs). However, the dark material in the Dewar region has a mafic assemblage dominated by high-Ca clinopyroxene. In contrast, the MIBs generally have low abundances of high-Ca clinopyroxenes [13].

*Regional Pyroclastic Deposit:* Because the low-albedo material appears in some areas to be draped over the surrounding terrain, the anomaly in the Dewar region could be a regional pyroclastic deposit. The spectra extracted from the dark material in the Dewar area do not resemble spectra collected from comparable regional pyroclastic deposits on the lunar nearside, such as Taurus-Littrow or the Aristarchus Plateau [14,15]. In addition, the albedo of the Dewar anomaly is higher than regional pyroclastic deposits on the lunar nearside [14]. Finally, no clearly defined pyroclastic vents can be distinguished using the available orbital imagery. However, because there are localized pyroclastic deposits that are spectrally similar to mature, low-Ti mare basalts, the possibility that the Dewar anomaly is a result of pyroclastic activity cannot be dismissed [14].

*Ancient Mare Deposit:* Finally, it is possible that an early Imbrian or Nectarian age mare basalt deposit was present in at least a portion of the Dewar pre-impact target site. The Dewar impact event would have excavated this pre-existing basalt and redistributed it throughout the study area. Other ancient mare basalt units in the region may have been buried or obscured by the ejecta of Dewar and other impact craters. Such buried mare deposits are defined as cryptomare. Cryptomare deposits are commonly identified based on the presence of dark-haloed impact craters and are often associated with mafic geochemical anomalies [e.g., 16]. Several impact craters with either partial or complete dark haloes were identified in the Dewar region, and examples are highlighted in Figure 1 (craters A and B). The haloes of these craters exhibit enhanced FeO and TiO<sub>2</sub> abundances and have spectra that indicate the presence of basaltic debris. These craters appear to have excavated material from a buried mafic layer.

**References:** [1] Lawrence D. J. et al. (2003) *JGR-Planets*, 109(E9), 6-1-6-25. [2] Lucey P. G. et al. (2000) *JGR-Planets*, 105(E8), pp. 20377-20386. [3] Eliason E. M. et al. (1999) *LPSC 30*, Abstract #1933. [4] Robinson M. S. et al. (1999) *LPSC 30*, Abstract #1931. [5] Isbell, C. E. et al. (1999) *LPSC 30*, Abstract #1812. [6] Tompkins S. and Pieters C. M. (1999) *MAPS 34*, pp-25-41. [7] Pieters C. M. et al. (2001) *JGR-Planets 106(E11)*, pp. 28001-28022. [8] Gillis J. J. et al. (2003) *JGR-Planets 108(E2)* [9] Gillis J. J. et al. (2004) *GCA 68(18)*, pp. 3791-3805 [10] Lucey P. G. et al. (2000) *JGR-Planets*, 105(E8), pp. 20377-20386. [11] Stuart-Alexander D. E. (1978) *USGS Miscellaneous Investigations Series Map I-1047*. [12] Giguere T. A. et al. (2003) *JGR-Planets 108(E11)*, pp. 4-1-4-14. [13] Taylor G. J. et al. (1991) in *Lunar Sourcebook*, Cambridge Univ. Press, New York, Ch. 6. [14] Gaddis L. R. et al. (2003) *Icarus 161* (2) pp. 262-280. [15] Gaddis L. R. et al. (1985) *Icarus 61* (3), pp. 461-489 [16] Hawke B. R. et al. (2004) *LPSC 35*, Abstract #1190.



**Figure 1.** 750 nm Clementine Spectral Reflectance image of the Dewar crater area. The positions of Dewar crater as well as two smaller craters with partial dark haloes (labeled A and B, respectively) have been highlighted. Diameter of Dewar crater is 50 km. Image extends from 2° N to 6° S and 162° E to 170° E. (S. Lawrence, HIGP)