THE COMPOSITION AND ORIGIN OF THE DEWAR GEOCHEMICAL ANOMALY: FINAL RESULTS. S. J. Lawrence[1], B. R. Hawke[1], D. J. Lawrence[2], J. J. Gillis-Davis[1], P. G. Lucey[1], G. J. Taylor[1], J. Cahill[1], G. A. Smith[1], J. Hagerty[2], and K. Keil[1], [1]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), [2]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). 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. In [3], we presented the preliminary results of our remote sensing investigation into the composition and origin of the Dewar geochemical anomaly. Since that point, we have also conducted UVVIS mineral modeling and examined Clementine NIR spectra from the Dewar region. Here, we present the final results of this investigation.

Methods: Elements of the calibrated Clementine five-channel ultraviolet/visible digital image model for the Moon were used to create three image cubes centered on Dewar crater and two nearside pyroclastic deposits identified in [4] in simple cylindrical projection at a resolution of 100 m/pixel [e.g., 5-7]. These five-channel image cubes were 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 [8] and [9]. The calibrated image cube was used to generate FeO and TiO_2 abundance maps using the techniques recently presented by [10] and [11], which evolve the technique of [2] by including empirical calibrations to Apollo landing sites. Optical maturity images (OMAT) were created using the method of [12].

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.

A version of the spectral mineralogical extraction method first described in [13] and discussed further in [14] was used to determine model mineralogies for several of the 5-point spectra extracted from the Dewar region. This method involves the inversion of an intimate mixture radiative transfer model for airless bodies based on the theories of Hapke [15,16] and the work of Lucey [17]. This algorithm computes synthetic spectra of arbitrary mixtures of olivine, ortho- and clino- pyroxene, ilmenite, anorthite, and glass of varying compositions, mineral chemistries and particle sizes while accounting for the spectral effects of submicroscopic iron (SMFe). Synthetic spectra are iteratively fit by the operator using a gradient descent algorithm to the extracted spectra of interest to produce estimates of the modal mineralogy.

Elements of the calibrated Clementine nine-channel UVVIS/NIR digital image model for the Moon were used to create an image cube of the Dewar region in simple cylindrical projection at a resolution of 100 m/pixel [e.g., 18-20]. Nine-channel spectra were extracted from both the Dewar anomaly and the surrounding highlands and interpreted.

Results: Dewar crater is an Imbrian-age crater with a diameter of approximately 50 km located north of South Pole-Aitken (SPA) basin [21]. 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 this investigation showed that the location of the enhanced thorium area correlates with the low-albedo area visible in the Clementine imagery.

FeO and TiO_2 mapping showed that both FeO and TiO_2 enhancements correlate with the low-albedo area, as well. FeO values within the anomaly range from 9-16.6 weight percent. TiO_2 values range from 0.7-2.2 weight percent. In general, the highest values of FeO are correlated with the highest values of TiO_2, 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 .95 μm band, indicating that the low-albedo material has a mafic assemblage dominated by high-Ca clinopyroxene. These spectra generally resemble spectra extracted from dark haloed impact craters on the lunar nearside [e.g., 22] and spectra extracted from small, localized pyroclastic deposits on the lunar nearside, including comparable albedoes and similar mafic absorptions centered on the .95 μm band.

Using the spectral mineralogical extraction method described above, model mineralogies were extracted from locations within the Dewar anomaly. Without exception, the extracted mineralogies were mafic assemblages dominated by high-Ca pyroxenes.

A preliminary examination of nine-color UVVIS/NIR Clementine spectra extracted from the Dewar anomaly showed that the 1 μm band is consistently centered at or beyond .95 μm, which is consistent with the UVVIS results.

In summary, the FeO and TiO_2 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 either Clementine visible or Lunar Orbiter 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 [23].

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 pyroclastic deposit. Although the albedo of the Dewar anomaly is higher than large, regional pyroclastic deposits on the lunar nearside, the Dewar low-albedo area shown in Figure 1 is morphologically similar to nearside pyroclastic deposits[e.g., 4]. Additionally, as previously discussed, the spectra extracted from the dark material in the Dewar area resemble spectra collected from localized pyroclastic deposits on the lunar nearside, including similar albedoes and mafic absorptions. However, no clearly defined pyroclastic vents can be distinguished using the available orbital imagery. Nevertheless, there is a distinct possibility that the Dewar anomaly is a pyroclastic deposit.

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., 24]. 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 F). The haloes of these craters exhibit enhanced FeO and TiO_2 abundances and have spectra that indicate the presence of basaltic debris. These craters appear to have excavated material from a buried mafic layer.

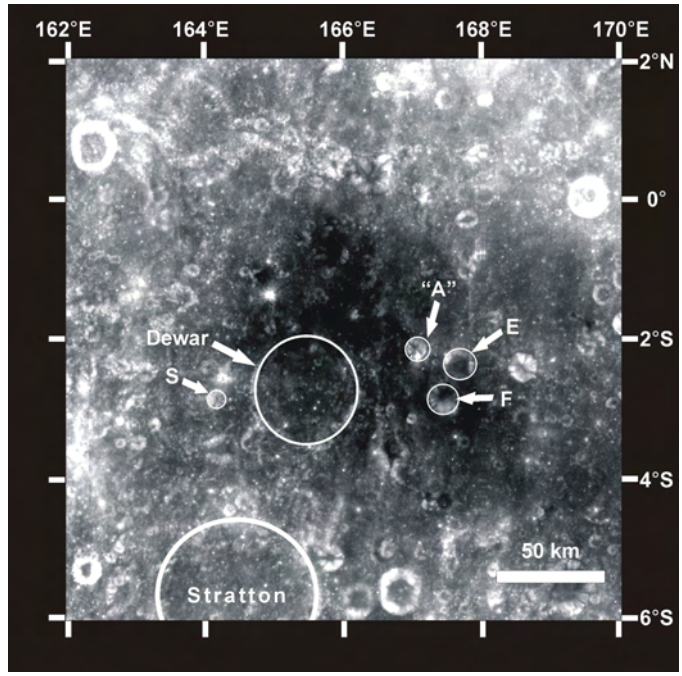

Figure 1: Clementine 750 nm image mosaic showing the Dewar region. Named lunar features, as well as a smaller crater with a possible partial dark halo (labeled "A"), are delineated with arrows and white lines. The image mosaic is shown in simple cylindrical projection and has a spatial resolution of 100 m/pixel.

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