**APOLLO 17 LANDING SITE: EVALUATING A JOINT UVVIS-NIR FEO ALGORITHM THAT NULLIFIES TOPOGRAPHIC SHADING EFFECTS ON LUNAR REFLECTANCE SPECTRA.** J.T. Cahill[1], P.G. Lucey[1], and S. Le Mouelic[2], [1]Hawaii Institute of Geophysics and Planetology, University of Hawaii at Manoa, and the [2]CNRS/Université de Nantes, (jcahill@higp.hawaii.edu).

**Introduction:** Iron concentration strongly influences the ultraviolet (UV), visible (VIS), and near-infrared (NIR) reflectance spectra of lunar surface minerals. Because of this, quantifying FeO content accurately from lunar spectra has been pursued with much interest. Several methods of estimating FeO content have been formulated and improved over the last decade [1-6]. A recent study by *Lucey* [7] evaluated a majority of these algorithms with a radiative transfer model to measure the ability of each method to estimate FeO accurately from spectra created from varying mineral mixtures. Although all algorithms show difficulties accurately estimating FeO from combinations of minerals containing significant olivine and ferroan orthopyroxene content, the method of *Le Mouelic et al.* [5, 8] tested the most favorably.

An added benefit of the *Le Mouelic et al.* [5, 8] method is the negligible effect of topography on its estimate of FeO. *Jolliff* [9] demonstrated that topography creates shading effects that translate to a noticeable difference in FeO estimates. This is because algorithms (such as Lucey's) that use only the UVVIS, rely on the 0.75 µm reflectance band. This introduces systematic artifacts due to topographic shading at high phase angles (i.e., Sun-facing slopes appear brighter than flat surfaces leading to an overestimation of FeO content), which is particularly important at high latitudes in Clementine data where high phase angles are the norm. However, even at relatively low latitudes *Robinson and Jolliff* [10] have demonstrated, using the algorithm of Lucey, that slopes approaching 30° can result in errors of ~5 wt% estimated FeO. Le Mouelic's algorithm overcomes this challenge by integrating information from the NIR. These Clementine data are used little due to calibration problems [11], however this difficulty has been solved for localized areas for which ground-based spectra are available for calibration with the methods of *Le Mouelic et al.* [12] and *Daydou et al.* [13]. The addition of the NIR allows use of the 1.5 µm filter, which in conjunction with the 0.75 µm filter allows a reliable estimate of the continuum slope of a spectrum [14] and subsequently a better evaluation of the Fe induced 1 µm absorption feature band depth.

Here we perform a study of the Apollo 17 landing site in order to evaluate the work of *Le Mouelic et al.'s* [5, 8]. The Apollo 17 study area is unique since it provides an area of high topographic and spectral diversity and for which lunar soil samples and elevation data are also available. Using a high resolution digital elevation model, *Robinson and Jolliff* [10] corrected the photometry of Clementine UVVIS imaging of the Apollo 17 landing site to standard viewing and illumination geometry. This allowed them to calculate an estimate FeO data product free of topographic uncertainty (via *Lucey et al.* [2]). Here we will use their FeO product to test the algorithm of *Le Mouelic et al.* [5, 8].

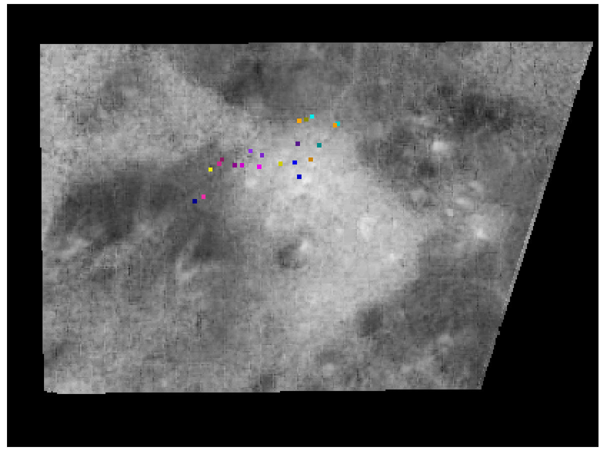

**Fig. 1:** Estimated FeO data product computed by *Robinson and Jolliff* [10] of the Apollo 17 (20°N, 31°E) landing site via the algorithm of *Lucey et al.* [2] (100 m/pixel spatial sampling).

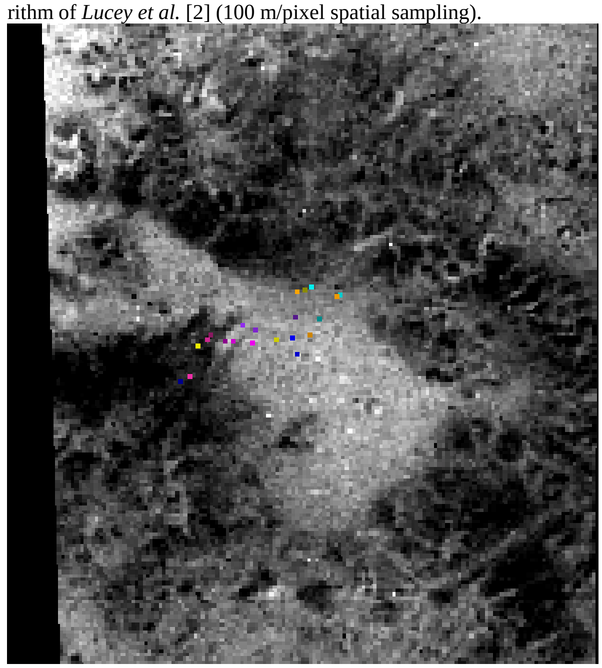

**Fig. 2:** Estimated FeO data product of the Apollo 17 (20°N, 31°E) landing site produced using the algorithm of *Le Mouelic et al.* [5, 8] (250 m/pixel spatial sampling).

**Data & Method:** In 1994, Clementine collected 11-band multispectral data of most of the lunar surface in the UV, VIS, and NIR portions of the spectrum [15]. From this data, *Robinson and Jolliff* [10] produced an image cube of the Apollo 17 landing site sampled at 100 m/pixel for the five bands between 0.415 to 1.0 µm. They also created a second image cube with similar characteristics, but photometrically corrected the UVVIS bands to standard viewing and illumination geometry on a pixel by pixel basis using a high resolution digital elevation model of the area. For each of these image cubes estimated FeO data products were computed using the algorithm of *Lucey et al.* [2] (Fig. 1).

Here we have constructed a third image cube of the Apollo 17 landing site integrating the UVVIS and NIR filters. This cube is calibrated using Earth-based telescopic spectra of dark and bright localities in this restricted area via the method of *Le Mouelic et al.* [12] and *Daydou et al.* [16]. It has a spatial resolution of ~250 m/pixel for the nine bands between 0.415 to 2.0 µm. The calibration details of this image cube is previously documented in the dissertation of *Le Mouelic* [17]. Recently, *Eliason et al.* [18] and the USGS completed a global calibration of the Clementine NIR for the lunar surface implementing a variation of this method.

We use eight control points to coregister these three image cubes using the registration tool of ENVI. The mean RMS error of this coregistration is 0.11. We use the algorithm of *Le Mouelic et al.* [5, 8] to compute an estimated FeO data product from the UVVIS-NIR image cube created here (Fig. 2).

**Results & Discussion:** Three by three pixel regions of interest are selected around the sample collection sites of Apollo 17 for analysis. These analysis points are shown overlaying the FeO data products in Figures 1 and 2. To the first order, *Le Mouelic et al.'s* [5, 8] algorithm is in agreement with both data products of *Robinson and Jolliff* [10] (Fig. 3 & 4). Equally important, *Le Mouelic et al.'s* [5, 8] algorithm gives results that are consistent with lunar soil samples collected during the Apollo 17 mission *Jolliff* [9]. Although the correlation coefficients of the topographically corrected product and our product are not in complete agreement, these results show the algorithm provides a robust estimate of FeO content at relatively mild slopes. At more extreme slopes, in the higher lunar latitudes, this algorithm should consistently produce results of this quality.

**Summary:** A preliminary study of the *Le Mouelic* [5, 8] joint UVVIS-NIR FeO estimation algorithm shows good agreement with Apollo 17 soil samples detailed by *Jolliff* [9]. Favorable results are also found with *Robinson and Jolliff* [10] estimated FeO data products calculated from photometrically corrected imagery data. Although, topographic data should be returned in the future for proper calibration of reflectance imagery, the algorithm of *Le Mouelic et al.* [5, 8] is proving to be a sufficient alternative until that data arrives.

**References:**

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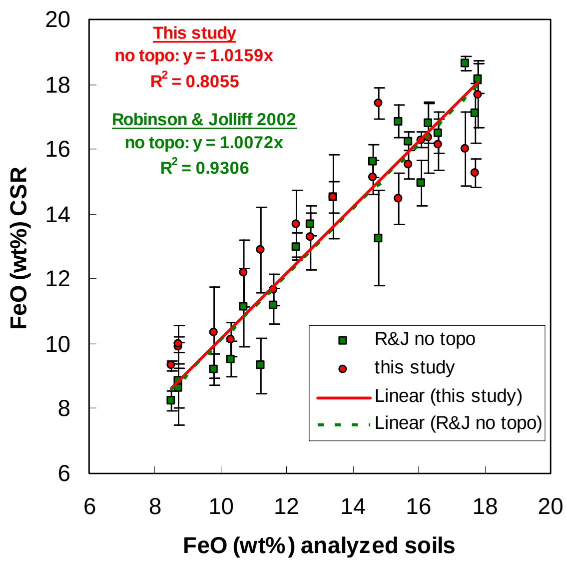


**Fig. 3:** Iron of Apollo 17 landing site sampling stations [9] correlated against iron computed from non-topographically corrected Clementine data products of [10] and this study.

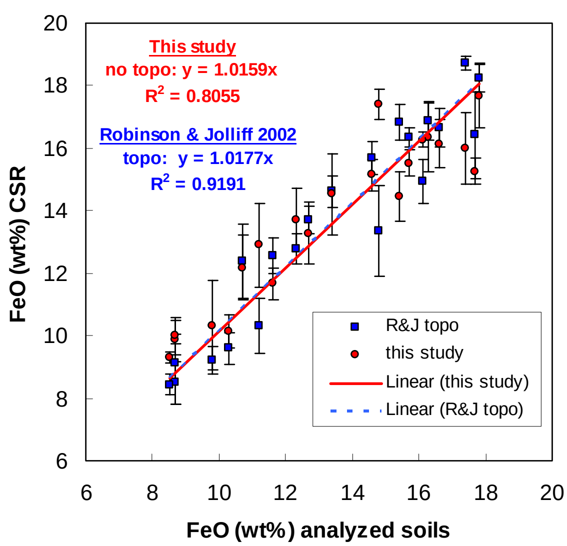


**Fig. 4:** Iron of Apollo 17 landing site sampling stations [9] correlated against iron computed from topographically corrected Clementine data products of [10] and non-topographically corrected data products of this study.