REMOTE ANALYSIS OF REGIONAL LUNAR PYROCLASTIC DEPOSITS – CONSISTENCY AND PRECISION OF LRO DIVINER ESTIMATES

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Lunar pyroclastic deposits, the products of explosive volcanic eruptions [1], are composed of sub-millimeter beads of basaltic composition [2], ranging from glassy to partially-crystallized (Fig. 1).

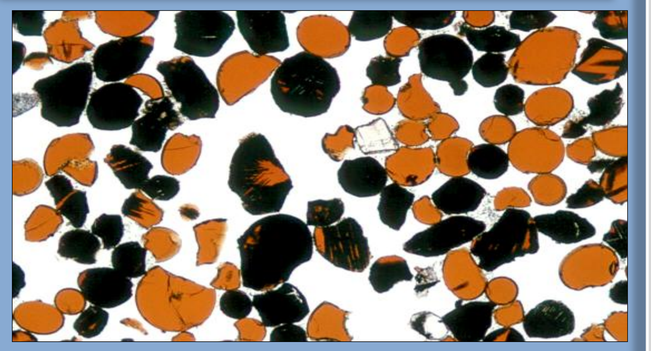

Figure 1. Apollo 17 sub-millimeter orange and black glass beads – samples of the Taurus Littrow deposit

The Taurus Littrow regional pyroclastic deposit, located in eastern Mare Serenitatis, extends across the Apollo 17 landing site (Figure 2). The Shorty crater orange and black glass beads, with an average diameter of 44 µm, are understood to be samples of this deposit [3].

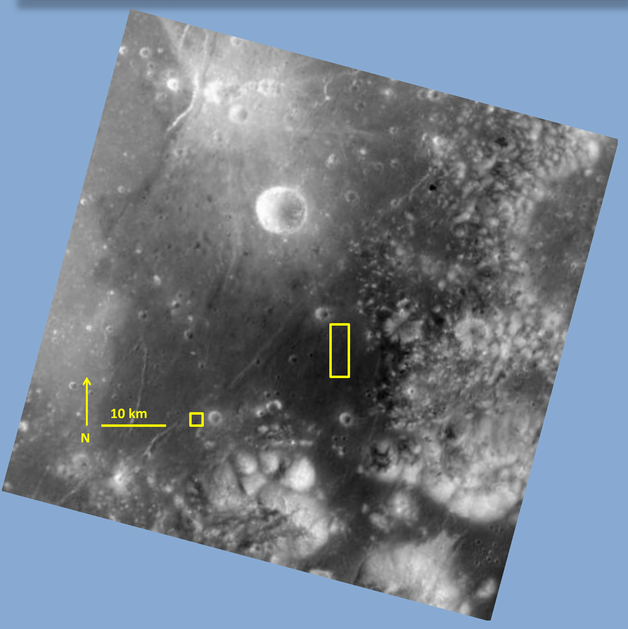

Figure 2. Taurus Littrow regional pyroclastic deposit, with analyzed areas outlined (Apollo metric mapping camera image AS15-M-0972)

Diviner Lunar Radiometer Experiment: Diviner is a near- and thermal-IR mapping radiometer on LRO, with a 320 m (in track) by 160 m (cross track) detector field of view and a 3.4 km swath width at an altitude of 50 km [4]. Three channels centered near 8 µm are used to measure the emissivity maximum known as the Christiansen feature (CF) [5]. Diviner CF wavelength values, taken from data obtained near local noon, were reduced using the most recent corrections of *Greenhagen et al.* [6]. These corrected CF values are particularly sensitive to silica polymerization in minerals including plagioclase, pyroxene and olivine. Given the restricted mineralogy of most lunar samples, CF values are closely correlated to major element abundances, particularly FeO.

Corrected CF values were determined for 2 x 2 km areas near five Apollo landing sites (excluding Apollo 14) as well as a dark area on the Taurus Littrow deposit. These averaged values were plotted against published FeO abundances for Apollo soil samples, along with Apollo 17 pyroclastic glass. The CF and FeO values closely correlate across the full range of Apollo soil and glass compositions. The published correlation [7] between FeO (wt. %) and CF (µm) is:

$$FeO = 74.24 \times CF - 599.9 \qquad r^2 = 0.90$$

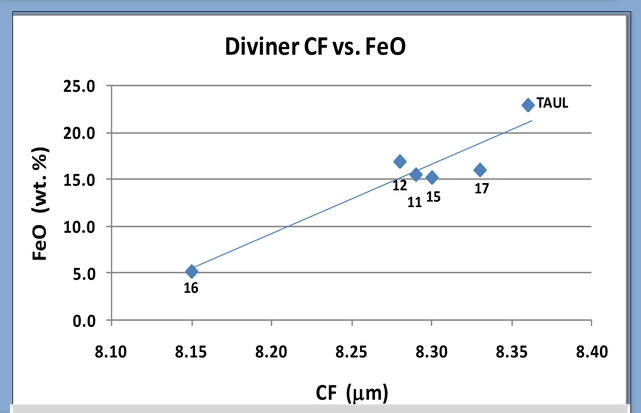

Figure 3. Correlation of Diviner CF to FeO for lunar soils from five Apollo sites and Taurus Littrow pyroclastic glass samples

Consistency: The initial study [7] included corrected CF data averaged over a 4 km² area centered at 20° 45' N, 29° 21' E (Fig. 2). This area, in the SW portion of the Taurus Littrow deposit, was chosen for its low albedo. The average CF value was determined to be 8.36 µm, with a standard deviation of 0.03 µm.

In the present study, average CF values and standard deviations were determined for a series of ~ 20 km² areas along a single orbit track in the eastern portion of Taurus Littrow, within the darkest area of the deposit (Fig. 2). The area bounded by 20.93 to 21.15° N and 30.02 to 30.10° E had the smallest standard deviation, 0.03 µm, and the highest average CF value, 8.37 µm.

Regional pyroclastic deposits are large and generally smooth at the scale of Diviner "pixels" (Figs. 4,5). Corrected CF values, averaged over areas of 4 and 20 km², on two of the darkest parts of the Taurus Littrow deposit, are indistinguishable within one standard deviation. This consistency suggests that the deposit is generally homogeneous over large areas. Therefore, it can provide a well-constrained "test case" for determining the precision of Diviner CF measurements.

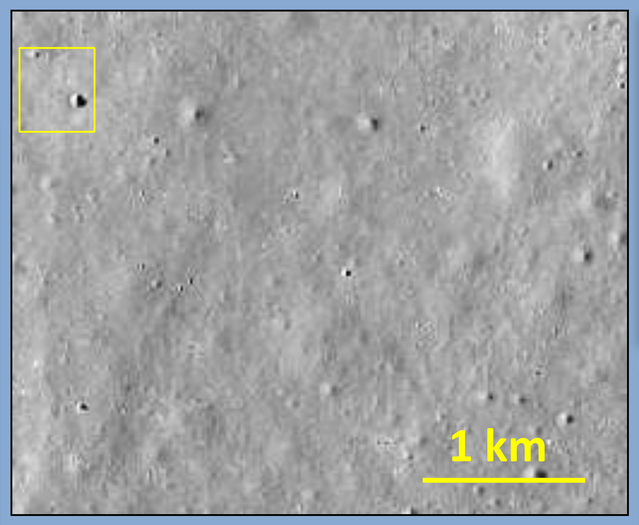

Figure 4. 15 km² area of eastern Taurus Littrow pyroclastic deposit showing location of Figure 5 (LROC NAC image)

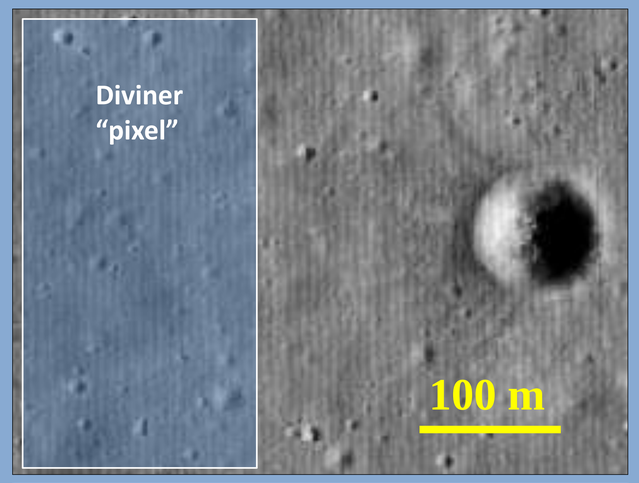

Figure 5. Area of Taurus Littrow pyroclastic deposit, showing dimensions of a Diviner "pixel" (LROC NAC image)

Precision: The smallest standard deviation determined for any 20 km² area in the darkest portion of the deposit is 0.03 µm. This value reflects both the absolute precision of the Diviner CF derivations (<0.02 µm), and the physical and mineralogical variability of the pyroclastic deposit [7]. As shown in Figs. 4 and 5, the Taurus Littrow deposit is strikingly smooth and uniform when averaged over tens of km², with a low areal density of craters at the 100 m scale of individual Diviner "pixels".

Conclusions: The Taurus Littrow regional pyroclastic deposit maintains a consistent maximum CF value, implying a consistent composition, over large areas. A standard deviation of 0.03 µm represents the inherent precision of averaged Diviner CF values for the deposit. This value corresponds to a precision of ~ 2.2 wt. % FeO.

References: [1] Gaddis, L.R. *et al.* (2003) *Icarus, 161,* 262. [2] Pieters, C.M. *et al.* (1974) *Science, 183,* 1191. [3] Heiken, G. *et al.* (1974) *GCA, 38,* 1703. [4] Paige, D.A. *et al.* (2009) *Space Sci. Revs*, DOI 10.1007/s11214-009-9529-2. [5] Greenhagen, B.T. *et al.* (2010) *Science, 329*, 1507-1509. [6] Greenhagen, B.T. *et al.* (2011) *42nd LPSC, Abs. #2679.* [7] Allen C.C. et al. (2012) *JGR, 117,* E00H28, doi:10.1029/2011JE003982.