THE LOW-TI BASALTS OF TSIOLKOVSKY AS SEEN BY CLEMENTINE;

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Tsiolkovsky is a prominent 180 km Late Imbrian crater on the lunar farside (20°S, 129°E) filled with dark mare deposits (**1**). Because maria are not extensive on this side of the Moon, the mare-filled Tsiolkovsky was a notable feature in the earliest Zond images of the farside. The crater was later imaged at higher resolution by Lunar Orbiter 3 as well as by Apollo 15. Tsiolkovsky is located in a 700 km pre-Nectarian basin, Tsiolkovsky-Stark. Although the crust generally is thicker on the farside and is believed to restrict basalt emplacement, the size of the crater and the basin environment may help account for the occurrence of this rare farside mare fill. Crater counts of the mare have indicated that these farside mare deposits are of an age comparable to those of the eastern nearside maria (**1,2**), but until recently little was known of their composition. The darkness of the mare deposits suggested to some that they might be Ti-rich basalts comparable to those of Apollo 11 and 17 of similar age (**1,2**). The multi-spectral images from Clementine (**3**) provide the first color data for the Tsiolkovsky region. These data indicate that the Tsiolkovsky mare is a low-titanium basalt filling a crater which excavated feldspathic highland materials.

Data Calibration and Processing. The global 5-color data from the Clementine Ultraviolet-Visible (UVVIS) camera requires extensive processing after decompression to produce multispectral image mosaics for lithologic mapping and analysis (**3,4**). Current *image calibrations* for each frame include: 1) additive corrections (dark subtraction) based on preflight calibration factors which are dependent on gain, offset, exposure time, and temperature; 2) additive readout corrections which are scene dependent and vary with exposure time; 3) multiplicative sensitivity corrections (flat field) based on preflight calibrations scaled to unity and modified slightly by in-flight experience. *Image processing* then includes a) registering to <0.2 pixels of the five images in a frame set (5-color) to a reference image (usually the 750 nm image); b) adjusting for exposure variations; c) registering and merging long and short exposures; d) mosaicking frame sets along an orbit (S-N); e) mosaicking contiguous orbits (E-W). Steps d and e should also include photometric corrections to account for variations in viewing geometry. To compare the spectral properties of one area to another requires additional radiometric or spectral calibrations. We have chosen to use the Apollo 16 site as a calibration standard, which allows derivation of 5-color spectra through laboratory measurements of lunar sample spectra (Apollo 16 mature soils) (see **4**). Current *spectral calibrations* include the following steps: i) DN values for Apollo 16 Cayley Plains are extracted from an Apollo 16 frame set (orbit 295); ii) each spectral image is adjusted for the exposure time of the Apollo 16 frame set and divided by the Apollo 16 DN values; iii) spectral images are multiplied by values for laboratory Apollo 16 spectra (convolved with Clementine filters). Inevitable residual errors result primarily from inaccurate calibration factors as well as from uncorrected scattered light. Cumulative filter to filter (spectroscopic) errors are currently estimated to be approximately 4%.

Tsiolkovsky Results. Thirty-nine frame sets from orbits 120, 121, 252, 253 and 254 were processed to produce the 750 nm mosaic centered on the crater Tsiolkovsky shown in Figure 1. All data except for a few frame sets in orbits 252 - 254 were obtained in compressed form. A compressed frame set including the central peaks, surrounding maria, and northern wall was selected from orbit 253 for initial spectral analysis. All image data were processed through steps 1, 2, 3, and b. Production of the mosaic of Figure 1 included steps c, d, and e with additional empirically derived gain and offset factors to create a well matched mosaic. The central peak frame set was processed through steps a, i, and ii. Resulting 5-color relative reflectance spectra for selected regions are shown in Figure 2. Representative error bars indicate the statistical variation within a 4x4 pixel area and do not represent calibration errors. Spectral repeatability errors between the long (A) and short (B) exposure frame sets were up to 5%.

Discussion. The highland soils at Tsiolkovsky are, to a first order, comparable to those at Apollo 16, deviating only about 2% from Apollo 16 in spectral properties (Fig. 2b). The central peaks, while brighter and bluer with minor but distinct peak-to-peak variations, do not exhibit significant mafic mineral absorptions near 1 μm. These combined data indicate the highland material at Tsiolkovsky is quite feldspathic (some peaks may be anorthositic), and that soils in flat areas have reached optical maturity (**5**). Albedo gradients across mare-highland boundaries indicate lateral mixing has occurred to some extent over tens of km. The mare exhibits classic spectral features of basaltic soils and craters. Mare craters exhibit a prominent absorption near 1 μm indicative of the presence of abundant clinopyroxene. Compared to highland soils, these mare soils have a stronger mafic mineral absorption near 1 μm but are similar to Apollo 16 in the visible, indicating a medium to low-Ti basaltic composition (e.g., **6**). Although medium-high titanium basalts have been recognized in Mare Orientale (**7**), no high-Ti basalts have been detected on the lunar farside. If the Tsiolkovsky basalts are indeed of comparable age to those at Apollo 11 and 17, then the difference in composition and volume is probably linked to the difference in crustal structure. Characterization of these basalts thus provides constraints for basalt petrogenesis on the lunar farside.

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References: **1**. Wilhelms (1987) USGS Prof. Paper 1348; **2**. Wilbur (1978) *LPS IX*, 1253-1255; **3**. Nozette et al. (1994) *Science 266*, 1835-1838; **4**. Pieters et al. (1994) *Science 266*, 1844-1848; **5**. Fischer and Pieters (1994) *Icarus 111*, 475-488; **6**. Pieters et al. (1993) *JGR 98*, 17127-17148; **7**. Greeley et al. (1993) *JGR 98*, 17183-17205

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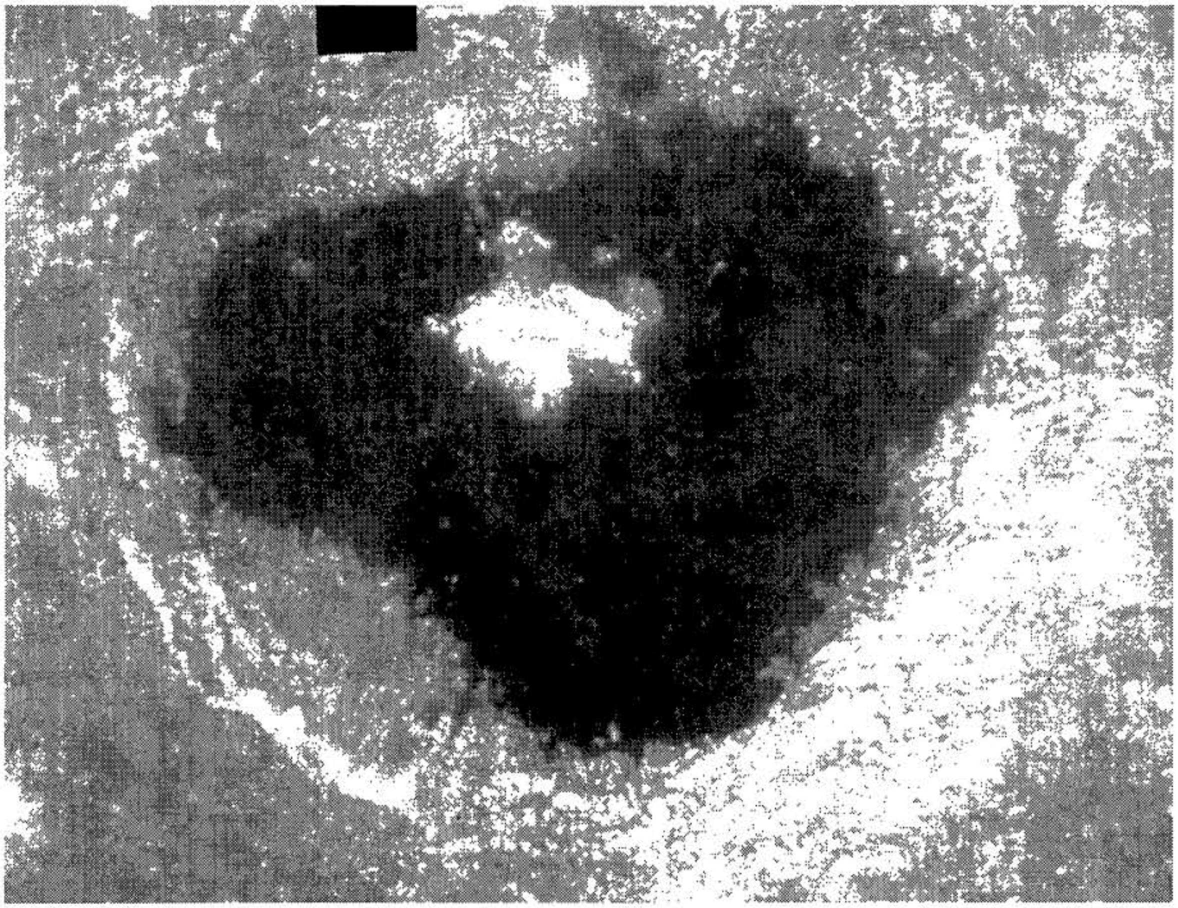

Figure 1: Mosaic of Clementine 750 nm images for the farside crater Tsiolkovsky

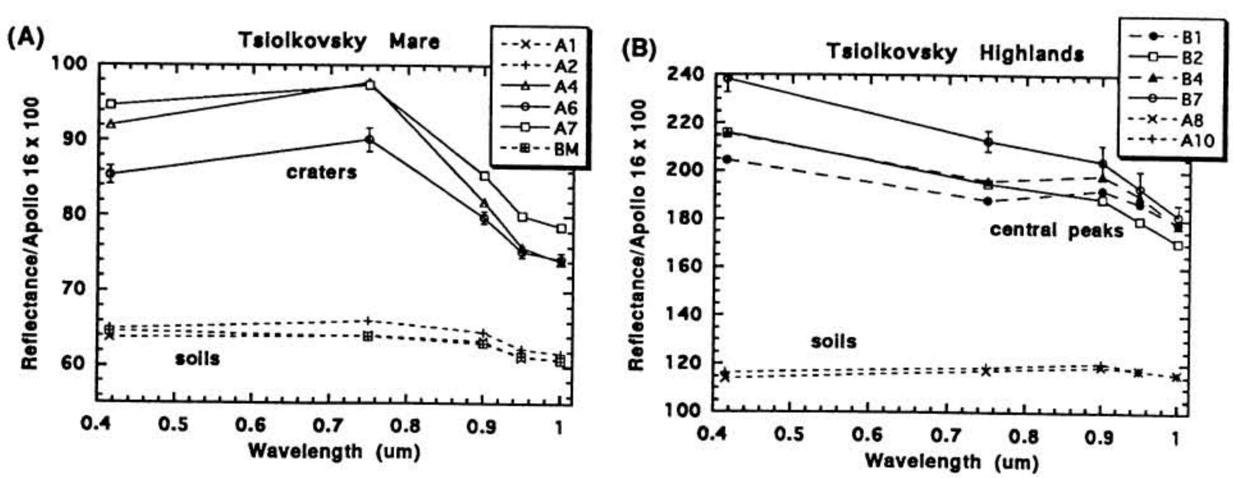

Figure 2: Reflectance spectra of representative Tsiolkovsky regions relative to Apollo 16. Each spectrum is an average of 4x4 pixels.

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