RECENT LUNAR ACTIVITY: EVIDENCE AND IMPLICATIONS. P. H. Schultz, M. Staid and C. M. Pieters, Brown University, Geological Sciences, Providence, RI 02912-1846 (Peter_Schultz@Brown.edu)

Introduction: Returned lunar samples established that widespread lunar volcanism ceased about 3.2 AE. Even though degradation models and crater statistics indicate that last-gasp effusions of thin basalt sequences may have extended to 1.0 AE, the Dead Moon Paradigm is widely accepted. Here we present morphologic and spectral evidence for recent endogenic activity (perhaps 1 Ma). Although lunar volcanism ceased long ago, degassing events from deep within the Moon continue and may provide a new challenge for future lunar exploration.

Strategy: Four morphologic criteria have been used to constrain the relative age of lunar features and surfaces: retention of photometric properties [1, 2]; preservation of relief and surface texture [3, 4]; and relief and surface texture [3, 4]; and degradation of slopes [5, 6]. Such criteria have been used to argue that small, distinctive depressions in four lunar locations must be exceedingly young since all exhibit fresh scarps only 3-6 m high bounding flat rubbly interiors [1, 7]. One of these depressions is the Ina depression. This D-shaped, shallow depression was previously studied in detail and argued to be a lunar caldera [8], the significance of its fresh appearance was not recognized until later [7]. Although 2.9 km in diameter, (maximum depth of 30m), Ina contains numerous smooth mounds and plateaus less than 10m high, each surrounded by reflective, low-lying, rubbly plains. More critical, however, is both the absence of small craters and the preservation scarps at meter scales. For comparison, studies of crater slope evolution [5, 6] predict that 100 m diameter craters on the ejecta of Copernicus (about 1 AE), would have been degraded by subsequent impacts to a slope less than 1^o. Surface textures on the scale of 5m associated with North Ray Crater ejecta (50 Ma) at Apollo 16 have been destroyed yet remain preserved at South Ray Crater (2 Ma). Consequently, based on preservation of textures and topography alone, meter-scale features associated with Ina could not date back to the time of mare emplacement. Rather, they are consistent with an age measured in millions, not billions of years.

Recent advances in lunar spectroscopy enabled by the Clementine missions now provide an additional approach using the combination of spectral band strength and albedo.

Spectral Properties: The reflectance properties of the Ina depression and surrounding deposits have been examined using a USGS 100m/pixel Clementine mosaic [9]. Figure 1 provides an overlay of the Clementine 415/750 and 750/950 nm ratio images on an Apollo 15 pan photograph. Materials within the Ina depression have distinctly blue UV/Visible ratio values (high 415/750 ratio, displayed in blue) that are comparable to high-titanium basalts within Mare Tranquillitatis. Ina also exhibits a very strong 750/950 mafic ratio (displayed in green) relative to surrounding materials. The strongest mafic ratios within Ina are directly associated with the interior bright materials. The band strength and overall spectral properties of the brightest materials within Ina are most similar to very fresh mare craters in Tranquillitatis, implying exposure of high titanium basalts.

Plots of spectral ratios against albedo are a useful means of examining the optical maturity and composition of a wide range of lunar materials [e.g. 10-14]. An approach developed by Staid and Pieters [14] is used here to compare the reflectance properties of Ina materials with surrounding deposits. In Figure 2, mafic band strength and albedo are plotted for Ina, the surrounding Felicitatis region, and a separate region of mare deposits in western Felicitatis. Materials within Ina (shown in blue) and the surrounding deposits (purple and green) form a curved low albedo group, which are distinct from mare deposits to the west (orange and red). Though the majority of the soils surrounding Ina have a weak mafic band (shown in purple in Figure 2), the 0.8 km diameter "western" crater (displayed in green) exhibits a stronger band with no change in albedo, indicating the presence of more mafic and/or less weathered materials. High-resolution Apollo Pan photography reveals a strewn field of ejecta blocks contributing to this fresh spectral signature. The Ina trend (shown in blue in Figure 2) parallels the Felicitatis fresh mare crater trend (shown in red). Since the UV/Visible spectral properties of Ina and the western crater are also much bluer (higher 415/750 nm ratio) than surrounding deposits, the difference suggests the exposure of an underlying high-titanium mare basalt unit both at Ina and the western crater. Bright materials within the Ina depression exhibit the strongest mafic band ratio in central Felicitatis and are interpreted as the least weathered exposures of the underlying high-titanium mare unit indicating a very young exposure age for these materials. For reference, the band strength for materials within Ina approach high-Ti basalts freshly exposed on the wall of Dawes crater [15].

Discussion and Conclusions: Both morphologic and spectral criteria indicate that Ina is exceedingly young. In fact, our observations do not preclude the possibility that it is still in the process of formation.

We interpret the low-lying, fresh exposures within Ina as a high-Ti basalt surface exposed by the removal of a pyroclastic surface layer or very thick regolith (>12m). The original basaltic surface dates back to 3.5 AE. Sudden degassing removed this layer to expose a long-buried basalt surface and to develop a faint halo and raised rim of ejected regolith encircling the D-shaped structure.

Ina is just one of at least four similar endogenic features, all located around the Imbrium basin. Their locations suggest that volatiles were trapped near the surface and only recently escaped or that these sites, typically near dark-mantle deposits, represent conduits for gases escaping from the deep interior. In either case, they may provide a unique resource for future lunar exploration.

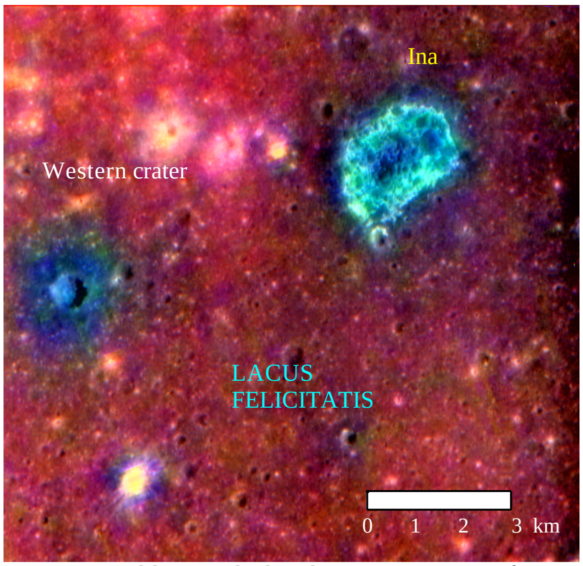

Figure 1: "Galileo Standard" color ratio composite of Ina and surrounding region on Apollo 15 pan #176.

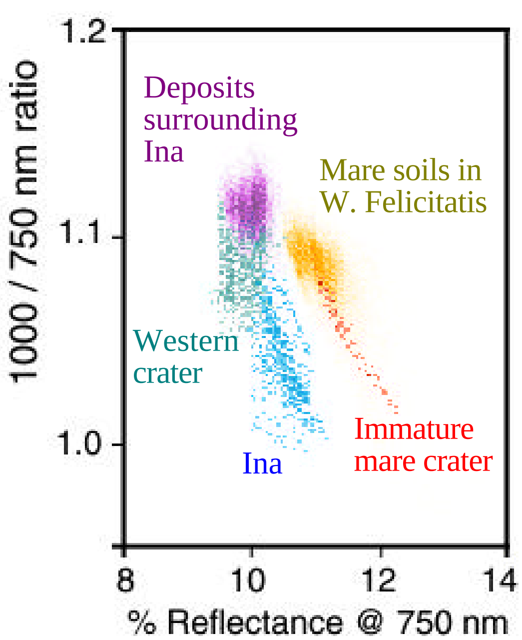

Figure 2: Mafic band strength (1000/750 nm ratio) vs. albedo (750 nm) comparison of Ina to other regional deposits.

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