MOON MINERALOGY MAPPER INVESTIGATION OF THE INA IRREGULAR MARE PATCH. K. A. Bennett[1], B. H. N. Horgan[2], J. F. Bell III[1], H. M. Meyer[1], and M. S. Robinson[1]. [1]School of Earth and Space Exploration, Arizona State University (Kristen.A.Bennett@asu.edu), [2]Earth Atmospheric and Planetary Sciences, Purdue University.

Introduction: Ina is an irregular mare patch located in the mare unit Lacus Felicitatis near 18° N and 5° E. Irregular mare patches (IMPs) are small (< 5 km across) unusual lunar features that are chacterized by topographically high, smooth deposits (or mounds) that occur with topographically low, blocky or uneven surfaces [1]. Ina (Figure 1) was first identified in Apollo images [2], and has since been hypothesized to be either a volcanic construct [1,2] or a result of sudden degassing [3].

The uneven surface appears to be immature relative to the surrounding area [3-5], and crater counts on the smooth deposits yield model ages <100 Ma [1,3]. The primary hypothesis for a heat source that could generate this late stage volcanism is an enrichment of heat producing elements in a 'urKREEP' mantle layer.

In this study we use Moon Mineralogy Mapper (M^3) data to investigate the maturity and mineralogy of Ina and therefore place constraints on its origin.

Background: Previous work investigating the maturity of these features used Clementine, Kaguya, and M^3 data [3-5]. These studies proposed that the uneven surface is immature relative to the smooth deposits and the surrounding mare. However, greater maturity does not necessarily imply longer surface exposure [6]. In the case of Ina, the uneven surface may remain immature longer (until the blocks have been broken down) than the smoother mounds and the surrounding mare.

Previous Clementine UVVIS multispectral (5 bands) observation based compositional studies suggested that the uneven surface in Ina is primarily composed of freshly exposed high titantium basalt [3, 4]. M^3 spectra have 83 bands and can therefore yield more detailed analyses of the lunar surface [7]. Previous work at Ina with M^3 data was performed with preliminary calibration and the work presented here uses the most recent Level 2 and 3 calibrations available on the Planetary Data System [4].

The goal of this study is to investigate the relationship between the smooth deposits and the uneven surface. If the smooth deposits and the uneven surface have the same composition and maturity levels, they were likely emplaced at the same time.

Methods: We used the methods described in Horgan *et al.* (2014) [8] to remove the continuum from a calibrated M^3 spectral observation using an interactive linear fit with two segments and tie points near 0.7, 1.5, and 2.6 μm. We also computed the optical maturity parameter (OMAT) using methods described in [6]. To verify that we can use the Clementine derived equation and constants with M^3 data, we compared OMAT values from the two datasets at the Aristarchus plateau. The fresh ejecta has Clementine and M^3 OMAT values, respectively, of .306 and .238, while the more mature pyroclastic deposit has Clementine and M^3 OMAT values of .198 and .096. This shows that while the absolute OMAT values of these two datasets are not the same, the relative maturity of two units remains the same. Therefore we can use M^3 derived OMAT values to compare the relative maturity of different units in our study region.

Results:

Maturity: Our results (Table 1) agree with previous studies in that the uneven surface is less mature than the smooth deposits and the surrounding area. However, our results also show that the smooth deposits are less mature than the surrounding area. A small (< 50 m diameter) fresh crater NW of Ina has a maturity that is between the uneven surface and smooth deposits.

Table 1: M^3 OMAT values for Ina

ROI	OMAT
Uneven Surface	.17 ± .05
Smooth Deposits	.07 ± .01
Surrounding Mare	.05 ± .01
Fresh Crater	.11 ± .03
Highlands	.04 ±.01

Mineralogy: The M^3 spectra (Figure 2) show that the uneven surface, the smooth deposits, and the surrounding mare all exhibit a high calcium pyroxene signature consistent with the basaltic composition found in previous results. Figure 2 also shows that the uneven surface has the deepest absorption bands.

Discussion: The M^3 observations show that the uneven surface is less mature than the smooth deposits, and the smooth deposits are less mature than the surrounding area. In addition, the uneven surface, the smooth deposits, and the surrounding mare have similar mineralogies; the main difference between the spectra amongst the three units is the variation in band depth. These observations can be explained by the blockiness of the uneven surface. The uneven surface will remain immature until the blocks are broken down, and the fresh surfaces of the blocks cause the observed strong band depths. Since the smooth deposits will mature more rapidly than the blocky uneven surface, it is possible that the floor and the mare patches are the same age. In summary, Ina (smooth and uneven deposits) has a younger surface exposure age than the surrounding mare, but they both have similar mineralogy to the mare.

There are several implications we can draw from these observations. First, since the surrounding mare and Ina are the same composition, it is not likely that the magma that sourced Ina was a long lived chamber that also sourced the surrounding mare. A long lived magma chamber that is not being recharged with fresh magma would experience fractional crytallization and any late stage volcanic activity likely would have had a different composition than the original source. A possible solution is that both the mare and Ina were sourced from the deep mantle, which likely would not change its composition greatly, even over such a long period of time.

Second, since the uneven surface and the smooth deposits are both immature relative to the surrounding mare and are also the same composition, they could have been emplaced contemperaneously consistent with the origin proposed in Garry et al. (2012) [9], in which the smooth deposits are inflated lava flows and the uneven surface forms as blocky lava breakouts. The breakouts did not inflate, resulting in the elevation difference between the uneven surface and the smooth deposits [9]. This could also be consistent with a caldera collapse (which would create the uneven surface) followed by lava inflation (the smooth deposits) [i.e. 1,2], provided the lava was emplaced shortly after the caldera collapse.

Finally, the differences between the spectra of the uneven surface, the smooth deposits and the surrounding mare can be explained by varying levels of maturity. Specifically, the "blue" spectra of the uneven surface is caused by its blockiness. The results from this study do not require outgassing or the presence of volatiles to explain the spectral signatures at Ina.

References:

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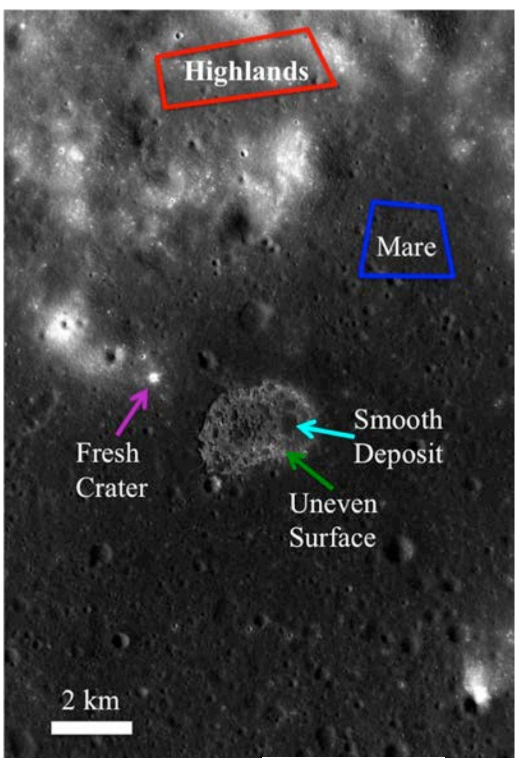

Figure 1: LROC NAC (M104483493LE, M104483493RE) of Ina and the surrounding area. Locations of M^3 spectra (Figure 2) are shown. Arrows were used for regions of interest only a few pixels across.

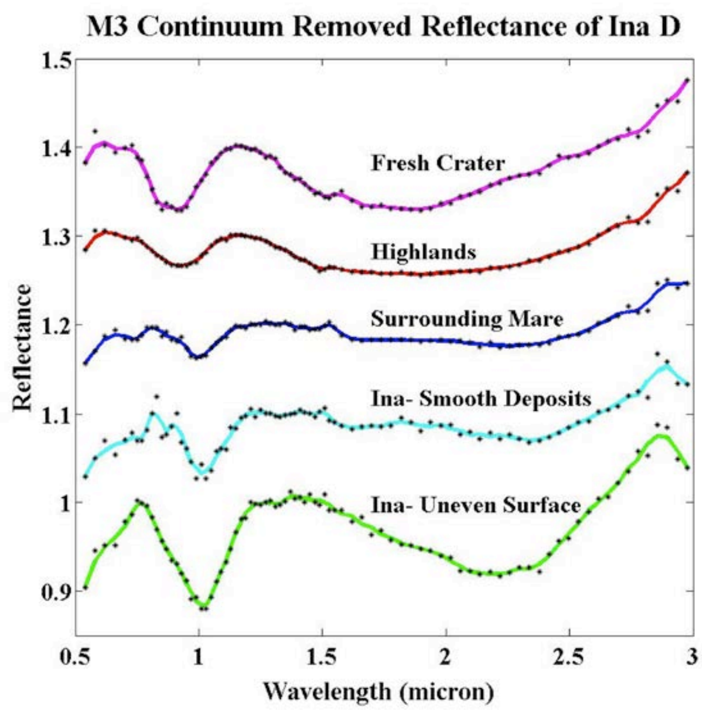

Figure 2: M^3 reflectance spectra (from M3G20090205t071411) of several units in and around Ina (shown in Figure 1) with the continuum removed. Each spectrum is offset vertically. The black points are individual data points, while the solid colored lines are the data smoothed by averaging each point with its two neighboring points.