IDENTIFYING AND CHARACTERIZING IMPACT MELT OUTCROPS IN THE NECTARIS BASIN.

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Introduction: The Nectaris Basin is an 820-km-diameter, multi-ring impact basin located on the near side of the Moon. Nectaris is a defining stratigraphic horizon based on relationships between ejecta units, giving its name to the Nectarian epoch of lunar history [1, 2]. Lunar basin chronology based on higher-resolution LRO imagery and topography [3, 4], while assigning some important basins like Serenitatis to pre-Nectarian time, were generally consistent with those previously derived. Based on this stratigraphy, at least 11 large basins formed in the time between Nectaris and Imbrium. The absolute age of Nectaris, therefore, is a crucial marker in the lunar time-stratigraphic sequence for understanding the impact flux on the Moon, and by extension, the entire inner solar system.

For several decades, workers have attempted to constrain the age of the Nectaris basin through radiometric dating of lunar samples [5-9]. However, there is little agreement on which samples in our collection represent Nectaris, if any, and what the correct radiometric age of such samples is. The importance of the age of Nectaris goes far beyond assigning a stratigraphic marker to lunar chronology. Several dynamical models use Nectaris as their pin date [10, 11], so that this date becomes crucial in understanding the time-correlated effects in the rest of the solar system.

The importance of the Nectaris basin age, coupled with its nearside, mid-latitude location, make remnants of the impact-melt sheet an attractive target for a future mission, either for in-situ dating or for sample return. We have started exploring this possibility [12-14]. We have begun a consortium data-analysis effort bringing multiple datasets and analysis methods to bear on these putative impact-melt deposits to characterize their extent, elemental composition and mineralogy, maturity and geologic setting, and to identify potential landing sites that meet both operational safety and science requirements.

Methods: We began with the updated geologic map of the Nectaris basin and its surrounding terrain made from the LRO Wide-Angle Camera (WAC) global basemap, the GTM 100 global topographic map, and Lunar Orbiter photographs [13, 14]. Relatively smooth plains units, along with moderate to heavily cratered, higher albedo plains materials, lie between Nectaris basin rings, sometimes perched on uplifted basin rock and filling topographic lows. These units are similar in location and appearance to the Maunder Fm in Orientale and may be remnants of the Nectaris Basin impact-melt sheet (outlined in black in Figs. 1 and 2), though typical surface textures of a melt-sheet, such as the folding, flow features, and cooling fractures seen in the Orientale basin impact melt sheet are not readily apparent at Nectaris, due to its older age and advanced degradational state.

We are currently examining legacy datasets from Clementine, Lunar Prospector, Chandrayaan-1, and recently-collected Lunar Reconnaissance Orbiter (LRO) data, including NAC and WAC albedo differences and color ratios, elemental abundances, derived mineral maps, Clementine UV identification of shocked and glassy materials, radar-based surface and subsurface unit mapping, rock abundance, and thermal inertia to understand the origin and characteristics of these Nectaris impact-melt units.

Preliminary Results: FeO and TiO_2 abundances (Fig. 1b,c) show that the mean iron content of the Nectaris basin outcrops (5.6 wt.%) is higher and more variable than for the Orientale melt sheet (4.6 wt.%), suggesting a slightly more mafic target for the Nectaris basin along with extended regolith formation [13]. Th variability is apparent across the basin (Fig. 1c) and likely to be correlated with Imbrium ejecta, an

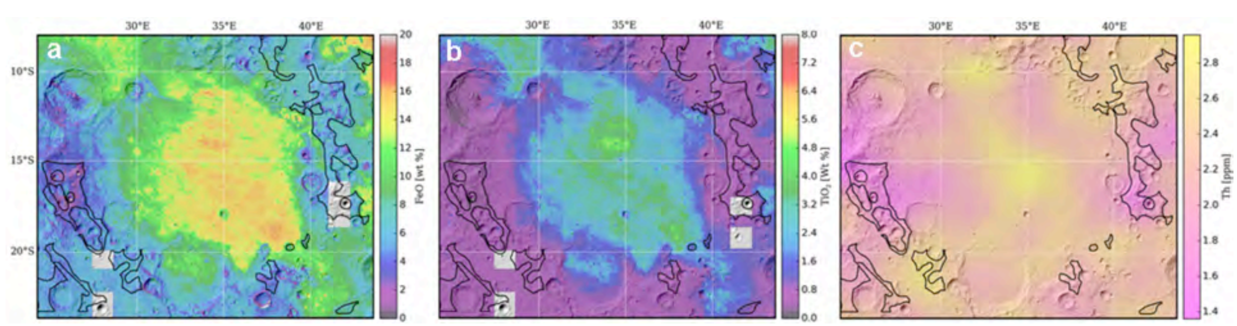

Figure 1: a) FeO, b) TiO_2, and c) Th maps of the Nectaris basin with outlines of possible impact-melt outcrops from [13].

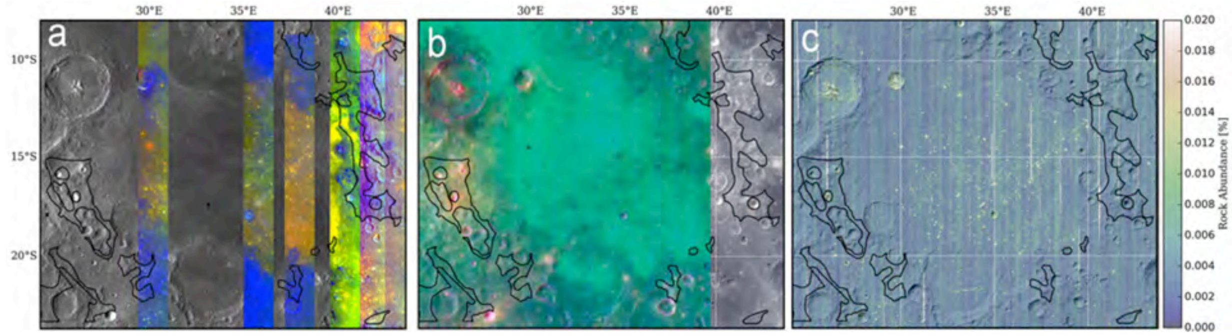

Figure 2: a) M3, b) Clementine UV color composite, and c) Diviner rock abundance maps across Nectaris basin with outlines of possible impact-melt outcrops from [13].

important constraint for understanding the origin of the materials at the surface and their history of mixing.

Approximately 90% of the Nectaris basin was imaged by M^3, from both the 100 and 200 km orbits, and many of the targets have been imaged multiple times at different viewing geometries, showing a rich dataset of spectral (and therefore mineralogic) information (Fig. 2a). An LRO WAC color composite in the ultraviolet (415 nm, 321/415 nm, and 321/360 nm in RGB; Fig. 2b) reveals craters that expose both crystalline (yellow) and glassy materials (red) in the Nectaris impact-melt units [15]. Impact-melt units can produce distinctive signatures in radar images and in rock abundance maps derived from the LRO Diviner instrument, representing a source of fresh rocks where primary ejecta blocks have long since been broken down by micrometeorite impacts and other phenomena [16, 17]; Fig 2c shows that such blocky deposits may be exposed in the impact-melt units, possibly correlated with glassy exposures in the UV map.

Summary: Having failed to definitively identify Nectaris impact-melt materials in our current returned sample collection, Nectaris is a prime candidate for a sample-return or in situ dating mission to acquire this crucial absolute age. Our team is using multiple data sets to better characterize the geologic characteristics of putative Nectaris impact melt exposures to better understand their origin, evolution, and current state. Our rich set of remote sensing data will be examined and correlated with geologic units; slopes, boulder abundances, and young fresh craters will be quantified to understand whether safe landing sites exist, and we will use modeling techniques to estimate the abundance of different potential components at the sites [18, 19]. This work will bring important new scientific insight into the formation of the Nectaris basin as well as lay groundwork for future mission planning for either sample-return mission or in situ dating missions [20].

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