MAUNDER AND KOPFF CRATERS: WINDOWS INTO THE UPPER LUNAR CRUST. J. L. Whitten[1] and J. W. Head[1], C.M. Pieters[1], J.F. Mustard[1] and the M[3] Team, [1]Brown Univ., Providence RI 02912; (jennifer_whitten@brown.edu).

Introduction: The compositional stratigraphy of the lunar crust is one of the most important clues to the history of the thermal and chemical evolution of the Moon. Craters and basins can be used as "windows" into the crust. These morphologic features expose material from depths related to their diameters and expose it on the surface [1,2]. There are several craters that have impacted into partially filled basins, allowing them to excavate further into the crust than the basins themselves. A comprehensive study and comparison of the craters Kopff and Maunder can have significant implications for the basin forming and volcanic processes that occurred within Orientale basin.

Maunder and Kopff are located in the central region of Orientale basin on the border between the Maunder Formation and Mare Orientale [3,4]. These two craters are similar in size (55 km and 42 km respectively) but they have very different morphologies. Maunder is a classic example of an impact crater, having a central peak, a flat floor, terraced walls, a raised rim and continuous ejecta deposit, and a system of radial rays [5, 6]. In contrast, Kopff crater has no central peak, no wall terraces, an unusual rim shape, unusual smooth crater ejecta deposits and no apparent secondaries. Kopff was thought to form from an impact into partially molten material that was later volcanically modified [e.g. 7,8]. The compositions of Maunder and Kopff craters were analyzed for evidence about the composition and stratifgraphy of the lunar crust, following the initial analysis of M^3 data of Orientale that showed penetration predominantly into the upper crust and sampling of the lower crust, but no evidence of mantle material [9,10].

Data: This analysis is being conducted with Moon Mineralogy Mapper (M^3) data [e.g., 9]. Mosaics of M^3 data were made for both Maunder and Kopff craters. Data included in these mosaics are in the "K" calibration of M^3 radiance data from optical period 1B [11,12]. In order to collect spectra (3x3 pixel avg.), the radiance data were converted to apparent reflectance and spectral parameters that characterize key spectral features were calculated, including 1 µm integrated band depth (IBD; sum of band depths between 0.79 and 1.3 µm) and 2 µm IBD (sum of band depths between 1.66 and 2.5 µm).

Maunder: Based on depth/diameter relationships [1,2] Maunder crater should have sampled another ~4-5 km into the lunar crust [10]. Several spectra were collected from various locations within the crater (Fig. 1). Crystalline anorthosite [9] was found at the top of the northern crater wall (MC1). Pending final calibration of M^3 data, the lack of pyroxene absorptions near 1 and 2

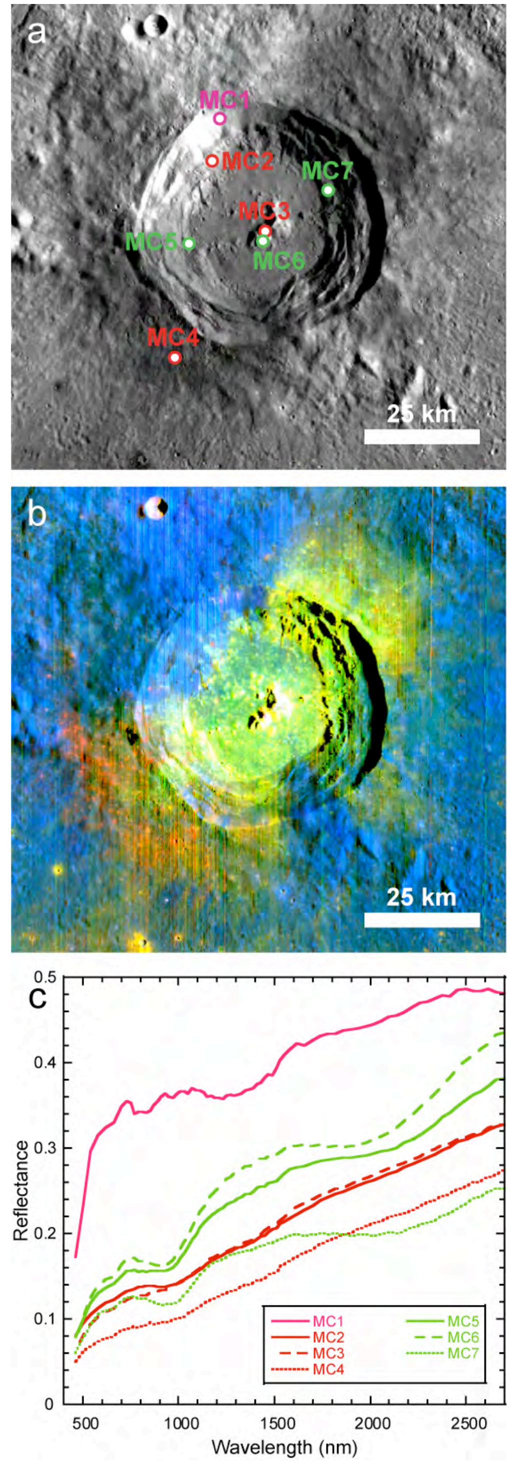

Figure 1. Maunder crater: a) M^3 thermal band (2936 nm) image with spectra locations labeled. b) M^3 mafic parameter map of the Maunder crater region (R: 1 µm IBD G: 2 µm IBD B: 1489 µm). c) Maunder crater spectra.

μm indicates the sample appears to be pure anorthosite. Samples MC5, MC6 and MC7 are from the walls and central peak of Maunder. These spectra are clearly noritic in composition based on low-Ca pyroxene absorptions near 0.95 and 2.1 μm. Lastly, spectra MC2, MC3 and MC4 correspond to regions inside and outside the crater, including the central peak and crater walls. Candidate compositions include excavated mare material, olivine-containing lithologies and some type of glass (impact melt on the rim?).

Kopff: The unusual morphology of Kopff makes it difficult to constrain the exact depth of excavation. Nonetheless, Kopff can be used to compare the basalt deposit with the composition of Mare Orientale to determine if the source regions are the same and also to investigate the composition of the melt sheet (Maunder Formation; Fig. 2). The rim of Kopff has a distinctly feldspathic signature similar to soil spectra from the Maunder Formation, suggesting that the rim is comprised largely of pre-mare basin material (KC1).

The smooth region of the crater floor is basaltic (KC2). Slumped material around the base of the crater walls is slightly more noritic in composition (KC3 and KC4). Most of the slumped material appears neither purely noritic, nor purely basaltic. Many of the 1 μm absorptions fall between ~930 and 970 nm, sugggesting that they could be mixtures of basaltic floor and noritic wall material. This is supported by the unconsolidated nature of the material. In addition, a small impact crater ~3 km in diameter on the eastern edge of the mare-covered floor has excavated anorthositic material. KC5 shows a pure weakly crystalline anorthosite spectra, with no indication of a noritic component.

Conclusions: Maunder penetrated down through anorthosite layers [9] into lower-crustal noritic materials, suggesting that the boundary between the lower part of the upper crust (more pure anorthosites) and the lower crust (norites) must be near this depth [10]. Kopff could be a candidate for penetration down into a partially differentiated melt sheet. Further work is being conducted to understand the implications of the compositions of Maunder and Kopff craters for lunar crustal stratigraphy.

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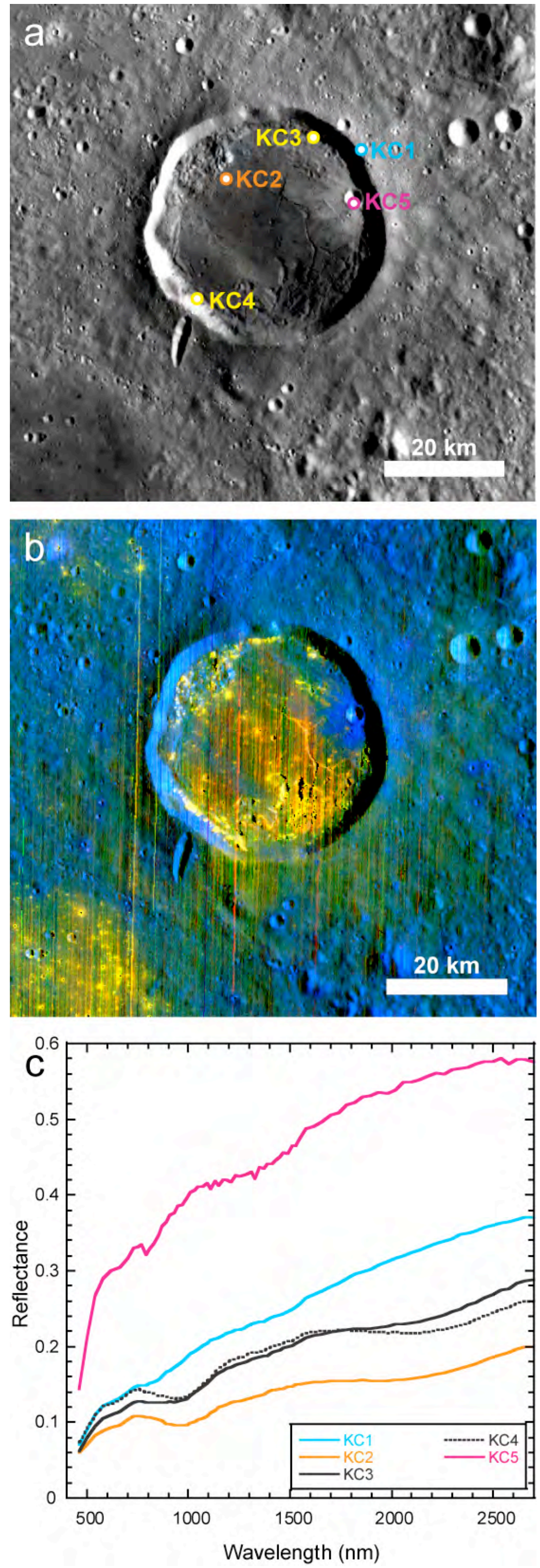

Figure 2. Kopff crater. a) M^3 thermal band (2936 nm) image with spectra locations labeled. b) M^3 mafic parameter map of the Kopff crater region. c) Kopff crater spectra.