VISIBLE AND INFRARED IMAGING OF COPERNICUS CRATER AND SURROUNDINGS; Paul G. Lucey, B. Ray Hawke, and Keith Horton; Planetary Geosciences Division, Department of Geology and Geophysics, School of Ocean and Earth Sciences and Technology, University of Hawaii at Manoa, 2525 Correa Road, Honolulu, Hawaii, 96822.

Recent major advances in IR detector technology has made relatively large IR image arrays available to astronomers at major observatories. To begin to utilize this new capability we obtained IR imaging of about 60% of the angular extent of the Moon as viewed from the Earth using one such array in operation at the University of Hawaii 2.24-m Telescope at Mauna Kea Observatory. The array is 256x256 pixels, with a wavelength sensitivity range of 1 - 2.5 μm. Our data covers the mid-latitudes in four wavelengths: 1.28μm, 1.45μm, 1.55μm, and 1.99μm. In addition, we targeted the craters Aristarchus, Copernicus, and Tycho for individual observations. The entire data set includes over 2000 images of which only a tiny fraction have been reduced. We present here a small example of the what can be accomplished using the IR images in conjuction with visible imaging.

It is well known that the central peaks of the crater Copernicus are rich in the mineral olivine and poor in pyroxene(1,2). In contrast, areas on the floor and portions of the walls have been shown to have relatively low olivine contents. Using wavelengths available to visible imagers (CCD's and vidicons) it is not possible to distinguish olivine and pyroxene so that previous imaging experiments have been unable to map the distribution of olivine or identify locations similar in composition to the central peaks. However, we can exploit the spectral characteristics of olivine in the near-IR to remotrly distinguish olivine from pyroxene. While pyroxene shows two absorption features in the near-IR, one near 1 μm and a second near 2 μm, olivine has a single composite feature centered near 1 μm and has a high reflectance in the 2 μm region. This spectral difference allowed the identification of olivine-rich asteroids based on broad band near-IR photometry(3) as suggested by (4). Using both visible and near-IR images it should be possible to use an analogous technique to identify olivine rich areas on the Moon.

We test this idea using data presented in the accompanying figures. Figure 1 is a ratio of 0.73 μm to 0.96 μm of the Copernicus region. This ratio is sensitive to two spectral parameters which are in term functions of at least two compositional parameters. First, the ratio is affected by the depth of an absorption feature near 1 μm. Thus areas which possess deep absorptions, due to either pyroxene or olivine, will tend to have high values in this ratio. A deep absorption feature relative to surroundings can be due to either an intrinsic high abundance of the mafic minerals, or because the surface is very immature and lacks a significant amount of agglutinate glass which tends to suppress the absorption feature. So the absorption band depth is affected both by mineralogy of the nonagglutinate component in a soil and by the relative abundance of agglutinates. The 0.73/0.96 μm ratio is also affected by the IR continuum slope. The spectra of all locations observed telescopically and most lunar soils measured in the laboratory are superimposed on a "red" slope, one that increases in reflectance toward the infrared. This slope is a function of maturity, as agglutinates are spectrally "red". The IR continuum slope is also influenced by compositional parameters which are not well understood but probably include the effects of agglutinate composition, impact melt glass, the abundance of ilmenite among others. Thus the 0.73/0.96 μm ratio for highland areas is a function of abundance of mafic minerals (but not a strong function of their identity), the maturity of the surface, and compositional parameters which can influence the continuum slope but are not well quantified at this time. Figure 1 demonstrates some of these effects. The rim, walls and central peaks of Copernicus, as well as fresh craters surrounding the crater can be seen to have high values, consistent with low abundance of agglutinates due to intrinsically young ages, or freshening of the surfaces by downslope movement of debris. However, both within and without Copernicus there is wide, subtler variation in the ratio values which are likely due to compositional effects, but not necessarily mafic mineral abundance. It is clearly not possible to distinguish the central peaks as unusual in this image.

We should observe similar effects of composition and and maturity on an infrared ratio utilizing the second rather than the first pyroxene band. Figure 2 is a ratio of 1.45 to 1.99 µm. In general the two images show similar relationships. Small craters and the walls and rim of Copernicus have generally high values consistent with deep pyroxene absorption features. And again we observe a many weaker variations around and within Copernicus. However, note that the central peaks appear dark in this image, showing the opposite spectral behavior to that exhibited in Figure 1. This low value either shows that the central peaks have very weak 2 µm absorption bands consistent with the olivine known to be present.

References: 1. Pieters, C.M. (1982) Science, 215, 59-61. 2. Pieters, C.M., et al., LPSC XXI, 962-963. 3. Veeder, G.J., et al.(1983), Icarus 55, 177-180. 4. Clark, R.N. (1982) Icarus 49, 244-257.

Figure 1. Ratio of 0.73µm to 0.96 µm for Copernicus and surroundings. Image is mirror reversed left to right. Note that the central peak complex appears bright.

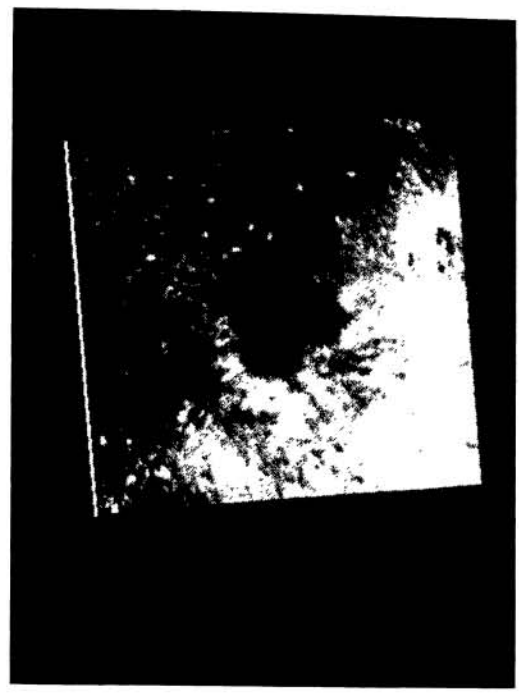

Figure 2. Ratio of 1.45 µm to 1.99 µm of Copernicus crater and surroundings. Image is mirror reversed left to right. Note that the central peak complex appears dark.