HIGH SPATIAL RESOLUTION MAPPING OF LUNAR TITANIUM ABUNDANCES USING GROUND-BASED MULTISPECTRAL CCD IMAGES;

D.E. Melendrez[1,2], S.M. Larson[1], J.R. Johnson[1,2], R.B. Singer[1,2], W.V. Schempp[3], and P. Doherty[3], [1]Lunar and Planetary Lab/Planetary Image Research Lab, [2]Dept. of Geosciences, University of Arizona, Tucson, AZ 85721, [3]Advanced Technology Division Photometrics Ltd., 3440 Brittania Dr., Tucson, AZ 85706.

Considerable interest has been shown towards the mapping and regional distribution of lunar ilmenite [1,2,3,4,5,6] and in the feasibility of *in situ* processing and oxygen production [7,8,9] in support of a lunar base. Some earlier lunar remote sensing efforts utilized silicon vidicon tubes as image detectors [e.g., 5,10,11,12,13] prior to the development of solid state charge coupled devices (CCDs). Because vidicons are inherently less photometrically accurate than CCDs, the errors in the spectral ratio values from vidicon data given by [5,10] were estimated to be as high as 5%. The current CCD system allows intraframe photometric precision of > 1%.

In addition to improving on the older vidicon data sets, this study is designed to build upon the notable lunar remote sensing work accomplished by [4] in which the TiO_2 content of the entire nearside of the Moon was mapped at a spatial resolution of about 5 km. The mineral ilmenite ($FeTiO_3$ - composed of about 50 wt. % TiO_2 and about 50 wt. % FeO) is the dominant lunar mineral phase containing titanium and as such is a prime candidate as a potentially useful ore and a source of oxygen. We are continuing the search for economically important concentrations of TiO_2 (and by inference, ilmenite) on the lunar surface.

Multispectral CCD imaging of the entire nearside of the Moon has indicated where the highest TiO_2 concentrations are located. Abundances of approximately 10 to 11 wt. % were found in western Mare Tranquillitatis [4]. The next highest abundances were located near Flamsteed P and in northern Oceanus Procellarum [4]. These regions are of primary interest in our ongoing study and new high resolution telescopic CCD images have been obtained of them. Maps of TiO_2 abundance in wt. % have been made from the new images which have spatial resolutions better than 1 km. Evident in the images are the morphology and areal extent of the high TiO_2 regions and the sharpness of the contacts between them and the surrounding maria.

The observations were made using the University of Arizona Catalina Observatory 1.5 m telescope near Mt. Bigelow on December 2 and 3, 1990 (UT). The high resolution 950, 730, 560, 400, and 320 nm images were recorded during full moon using a new 2048 x 2048 element, phosphor-coated, CCD developed by the Advanced Technology Division of Photometrics, Ltd. of Tucson. The scale was 240 m/pixel, while the atmospheric seeing limited the effective spatial resolution to about 0.5 km. In addition, images were obtained of all of the Apollo landing sites where the most detailed ground truth and mineralogical data are available. Ratioed 400/560 nm images were used by [4] to generate nearside maps of TiO_2 abundance based on an empirical calibration derived by [1] and refined by [14] which relates the wt. % of TiO_2 in a mature mare soil to the 400/560 nm spectral ratio value. A mature mare soil is one that has been reworked by micrometeorite impacts and contains glassy aggregates, or agglutinates. The proportion of crystalline pyroxene grains at the surface (which would create a strong spectral absorption near 950 nm) will decrease as agglutinate content increases. Larger numbers of agglutinates will subdue the characteristic "1 μm" pyroxene absorption band and allow for greater reflectance in the 950 nm region. Regolith maturity is therefore estimated through the use of a 950/560 nm ratio in which the more mature regions will appear brighter. It was noted by [4] that the 400/730 nm ratio appeared to be a more sensitive indicator of TiO_2 concentration than the aforementioned 400/560 nm ratio. We are investigating this possibility but are basing our initial wt. % TiO_2 calibrations on the 400/560 nm ratio.

REFERENCES CITED

[1] Charette, M.P., McCord, T.B., Pieters, C., and Adams, J. (1974), *J. Geophys. Res.* **79**, 1605-1613.
[2] Davis, P.A. (1980), *J. Geophys. Res.* **85**, 3209-3224.
[3] Hawke, B.R., Coombs, C.R., and Clark, B. (1990), *Proc. Lunar Planet. Sci. Conf., 20th*, 249-258.
[4] Johnson, J.R., Larson, S.M., and Singer, R.B. (1990), *J. Geophys. Res.*, in press.
[5] Johnson, T.V., Saunders, R.S., Matson, D.L., and Mosher, J.A. (1977), *Proc. Lunar Planet. Sci. Conf., 8th*, 1029-1036.
[6] Metzger, A.E. and Parker, R.E. (1979), *Earth Planet. Sci. Lett.* **45**, 155-171.
[7] Gibson, M.A. and Knudsen, C.W. (1985), *Lun. Bases Space Act. 21st Cent.*, 543-550.
[8] Williams, R.J. (1985), *Lun. Bases Space Act. 21st Cent.*, 551-558.
[9] Cutler, A.H. and Krag, P. (1985), *Lun. Bases Space Act. 21st Cent.*, 559-569.
[10] Johnson, T.V., Mosher, J.A., and Matson, D.L. (1977), *Proc.Lunar Planet. Sci. Conf., 8th*, 1013-1028.
[11] McCord, T.B., Pieters, C.M., and Feierberg, M.A. (1976), *Icarus* **29**, 1-34.
[12] McCord, T.B., Grabow, M.A., Feierberg, M.A., MacLaskey, D.,and Pieters, C.M. (1979), *Icarus* **37**, 1-28.
[13] Johnson, T.V., Matson, D.L., Phillips, R.J., and Saunders, R.S. (1975), *Proc. Lunar Sci. Conf., 6th*, 2677-2688.
[14] Pieters, C.M. (1978), *Proc. Lunar Planet. Sci. Conf., 9th*, 2825-2849.