HIGH-RESOLUTION REMOTE-SENSING STUDIES OF CRATER RAY MATERIALS IN MARE SERENITATIS: B.A. Campbell, S.H. Zisk, J.F. Bell III, B.R. Hawke: Planetary Geosciences Div., Hawaii Inst. of Geophysics, Honolulu, HI.

Introduction: Preliminary studies indicated that the bright ray which crosses Mare Serenitatis along a SW-NE trend presented the opportunity for both a general high-resolution radar study of crater ray morphology, and a spectral remote-sensing study which addressed the question of the parent crater and current state of maturity of this deposit [1]. Such a ray study is important to the understanding of impact ejecta distribution with distance from the parent crater, and the manner in which inhomogeneities in the ejecta curtain lead to clumping of the secondary-crater-forming and fine-grained ray materials [2]. This abstract describes the results of new 3.0-cm wavelength radar mapping of portions of this region, and comparison with several other mapped ray deposits attributed to Tycho and Copernicus craters. In addition, we have collected a group of near-IR reflectance spectra for Menelaus crater, Bessel crater, their immediate ejecta deposits, and several small regions of the ray itself.

Radar Data: Recent improvements in data collection and reduction at Haystack Observatory have made it possible to obtain radar images of the lunar surface with a spatial resolution of 30 m or better. These images are collected at a radar wavelength of 3.0 cm, and both senses of circular polarization are recorded [3]. For this study, the raw data were averaged (in 4x4 pixel groups) to form 16-look images with a spatial resolution of 120 m. The resulting polarized (handedness orthogonal to the transmitted wave) and depolarized (handedness identical to the transmitted wave) images were analyzed, as was the ratio of the depolarized to polarized echo strengths. At 3.0 cm wavelength, scattering is expected to come largely from surface roughness or buried scatterers on the scale of a few cm. Five images were processed for this study: a region immediately southeast of Bessel, a swath across Menelaus crater, the crossing of Copernicus and Tycho rays in Mare Vaporum, a Tycho ray near Rosse crater, and an area north of Copernicus crater. The image swaths cover about 30 km in the range direction, and 120 km in azimuth. Their orientation is dependent upon the location of the target area relative to the lunar doppler axis at the time of observation.

Spectral Observations: The question of the origin and emplacement history of crater rays is better understood if compositional information on the source crater (if known), surrounding substrate, and ray materials themselves is available. To date, only one major study of this kind [4] has been carried out, concentrating on Copernicus and its ray system. In an effort to expand on this work as well as to supplement our own new radar data, we have obtained a number of near-IR reflectance spectra of regions in Mare Serenitatis. Data were obtained using a 0.7-2.0 μm CVF at Mauna Kea Observatory during the summer and fall of 1989. Spectra of some 20 regions, each about 25 km in diameter, were measured of the craters Bessel and Menelaus, their ejecta blankets, and numerous surrounding mare and ray regions. These spectra were ratioed to a mature mare region (near MS2) for interpretation; eventual final calibration of the data will be through Apollo 16 and returned sample spectra [5].

Radar Interpretation: The area in Mare Serenitatis southeast of Bessel shows a strong depolarized radar enhancement associated with the continuous ejecta of the crater itself, as well as a bright trace of the ray which passes to the west of the crater. The rays have high polarization ratios (.75-1.0), indicating a large degree of cm-scale surface roughness. This was also evident in the strongly enhanced depolarized echo along the ray seen in previous 3.8-cm radar maps [1]. A number of secondary crater clusters are evident, but there appears to be a largely continuous deposit of fine material or small-scale roughness. The Menelaus image covers primarily the immediate area of the crater rim, but lower-resolution imagery includes portions of the Sulpicius Gallus pyroclastic deposit. Future work will study the effect of the pyroclastic substrate on the radar backscatter properties of the Menelaus ray.

For comparison purposes and as part of a wider study of lunar crater ray micro-topography, we collected radar images of Copernicus and Tycho rays at varying distances from their sources. The Copernicus image (centered on 20.0 N, 18.8 W) reveals a number of continuous radar-bright linear

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rays. These rays have significantly higher polarization ratios than the surrounding mare, indicating a large degree of cm-scale roughness. There are numerous small secondary craters, often with narrow deposits of very rough secondary ejecta aligned along the direction of the ray. The radar brightness of these rays varies, but is generally higher in the vicinity of the secondary crater clusters.

The Vaporum region (centered on 13.5 N, 1.3 E) was chosen because it contains both a Copernicus ray and a Tycho ray. The Copernicus ray is immediately evident, trending E-W in a broad bright region. The Tycho ray is considerably less bright, and appears to be expressed as two diffuse patches to the south of the Copernicus ray. The crossing region itself appears to be dominated by materials associated with the Copernicus ray. The Copernicus ray is discontinuous at this range, and the bright regions are most distinct around isolated clusters of secondary craters.

The Rosse region (centered on 16.5 S, 36.0 E) represents a Tycho ray at a considerable distance from its source. Only a small portion of this ray was imaged due to the orientation of the swath, but a distinct bright region can be seen associated with a group of Tycho secondary craters. Interestingly, the high polarization ratio region continues away from this group of craters, and the depolarized radar brightness remains quite high.

Spectral Interpretation: Spectral data of regions within Mare Serenitatis ratioed to a mature mare region reveal some interesting information. Spectra of Menelaus and its nearby ejecta indicate that the Haemus mountains deposits excavated and exposed by the crater have a much lower pyroxene content (as evidenced by the 0.9-1.0 μm band) than mature mare within Serenitatis. Pyroxene content is very low at the crater proper, and grades into higher abundances at distances of 15-25 km from the crater rim. The crater Bessel, on the other hand, appears to have a higher pyroxene content than the surrounding mare, suggesting that the 16-km Eratosthenian crater [6] did not excavate below the thick mare fill, and that a discernable pyroxene band arises due to the exposure of "fresh," immature mare materials on the crater walls. There is a decrease in the pyroxene band depth with distance from the crater rim. Spectra of two regions on the ray ~50 km SW of Bessel and ~50 km NE of Menelaus both show little variation relative to the mature mare region. This is most likely an effect of our aperture size being too large to detect the faint ray signature (necessary at the time for S/N requirements). The observed pyroxene excess in the Bessel ejecta may be due either to immature mare material excavated by the cratering event (unlikely given the age of Bessel) or to reworking of the Bessel deposits by ejecta from Menelaus. Upcoming telescopic observations of this region at higher spatial resolution and higher sampling along the ray will provide key new data with which to address this problem.

References: [1] Campbell, B.A., et al. (1989) LPSC XX 139-140; [2] Oberbeck, V.R., (1975) Rev. Geophys. 13, 337-362; [3] Campbell, B.A., et al., (1988) LPSC XIX, 160-161; [4] Pieters, C.M., et al., (1985) JGR 90, 12393-12413; [5] McCord et al., (1981) JGR 86, 10883-10892; [6] Carr, M.H., (1966), USGS Map I-489 (LAC-42)