SPECTRAL AND MULTISPECTRAL IMAGING STUDIES OF LUNAR MANTLED MARE DEPOSITS; D.T. Blewett, B.R. Hawke, P.G. Lucey, Planetary Geosciences/SOEST, Univ. of Hawaii, 2525 Correa Rd., Honolulu, HI 96822; J.F. Bell III, NASA-ARC, Moffet Field, CA 94035; R. Jaumann, H. Hiesinger, G. Neukum, DLR, Oberpfaffenhofen, FRG; P.D. Spudis, Lunar & Planetary Inst., Houston, TX 77058

Near-IR reflectance spectra (0.6-2.5 μm) and CCD images in the extended visible range (0.4-1.0 μm) obtained with Earth-based telescopes have been used to investigate the composition and origin of formations in the Schiller-Schickard region of the Moon. Of particular interest are the Schickard light plains, which represent an area of mantled mare basalt, or cryptomare. Here local pre-existing mare basalts were eroded and incorporated into a highlands-rich deposit by ejecta from the Orientale Basin. Spectral observations of mature and immature highland and mare surfaces, as well as dark-halo crater materials provide information on the mafic mineralogy of features in the area. Analyses of the "1 μm" absorption band and spectral mixing models indicate that selected spots in the light plains contain on the order of 50% mare basalt. CCD image cubes can be used to map the amount of basalt in the light plains and evaluate changes with radial distance from Orientale.

INTRODUCTION: Lunar light plains deposits, which cover some 4-7% of the nearside [1], have been one of the most troubling features in the study of lunar geology. This flat, smooth landform often appears to have ponded in depressions and is characterized by albedo and crater densities intermediate between those of the highlands and the maria. The light plains were interpreted by early geologic mappers to be volcanic in origin, perhaps ash sheets or low viscosity silicic lavas [*e.g.*, 2]. The Apollo 16 mission sampled the Cayley Formation, an archetypal light plains unit, and discovered non-volcanic breccias - forcing a re-interpretation of the light plains. In the time since Apollo, three major types of light plains have been recognized. First, there may be examples of true volcanic light plains. A strong case has been made [3,4,5] for an extrusive KREEP volcanic origin of the Apennine Bench Formation [6], a classic occurrence of light plains in the Imbrium Basin and near the Apollo 15 site. Second, some light plains may represent assemblages containing much impact melt. For example, the light plains unit in the interior of Orientale Basin has be interpreted to contain a relatively large proportion of impact melt [7]. The third type of light plains is believed to have been emplaced in a fluidized state as the result of the debris surge produced by the impact of basin secondary-forming projectiles. This mode of formation was responsible for the Cayley Formation in the central highlands [8] as well as the light plains in the Schiller-Schickard (SS) region [9,10].

The SS light plains represent an important subtype of the debris surge-derived light plains. Near-IR reflectance spectroscopy has demonstrated [9,10] that the dark-haloed impact craters in the SS region excavated mare basalt from beneath the higher-albedo highlands-rich plains unit deposited by the Orientale debris surge. Such mantled mare (cryptomare) are found elsewhere on the Moon and have important implications for the extent and timing of lunar basaltic volcanism [*e.g.*, 11,12,13]. In addition, the presence of a spectrally distinct substrate (mare basalt) allows an evaluation of the local mixing process [14], *i.e.*, the degree to which the basin ejecta erodes local material and incorporates it into the resulting deposit. Recent analyses of Earth-based telescopic spectra [15] and Galileo imagery [16,17] have provided more information on the composition and distribution of surface units in the SS region. The purpose of this report is to describe the results of our ongoing analysis of spectral data for this interesting area.

DATA and ANALYSIS: We have been working with two data sets for the SS region: near-IR reflectance spectra and multispectral images. The spectra (0.6-2.5 μm) [18] have been analyzed [15] to extract information on the "1 μm" mafic absorption features as well as other spectral parameters. Of principal interest for determining mineralogy are the wavelength location of the reflectance minimum and the band depth. Also, mixing relationships were studied using a linear model [19]. Portions of the spectra longward of 2 μm (thermal contamination) and in the vicinity of water bands were not included in the analysis. Additional insight into mixing systematics and endmember identification can be had through the application of principal components analysis [20].

Multispectral images (12 colors between 0.4 and 1.0 µm) of the Moon were collected with a CCD camera using the 61 cm telescope on Mauna Kea. Information concerning data reduction and calibration can be found elsewhere [21]. The twelve images of a scene of the region surrounding Schiller and the eastern portion of Schickard crater were assembled into an image cube. The SIPS image processing software [22] was used for analysis. Potential endmembers within the image were evaluated using a spectral angle mapping technique, and least-squares linear unmixing analysis performed.

RESULTS and DISCUSSION: Schickard crater contains two major mare basalt patches and a light plains deposit. The composition of the local highlands material is revealed by a spectrum for a crater on the rim of Schickard. The band minimum (0.92 µm) and relatively shallow depth are characteristic of a noritic anorthosite. Spectra for the Schickard mare deposits as well as for dark-haloed impact craters in the region have deeper bands with minima longward of 0.97 µm, as expected for the high-Ca pyroxene in basalt. Spectra for the Schickard light plains exhibit intermediate band minima and depths, indicating the presence of a significant component of mare basalt. Two-endmember (mare and highlands) mixing calculations for a light plains spectrum show that the proportion of basalt included is approximately 50%.

The Schiller plains, immediately to the southwest of Schiller crater, have a generally mare-like appearance on Lunar Orbiter photos, but have been mapped as "dark plains" attributed to ash fall deposition [23]. Spectra for the Schiller plains show a strong mare basalt signature; therefore we interpret the Schiller plains to be a post-Orientale mare surface contaminated with highlands debris from nearby craters. Our mixing results indicate that ~70% mare basalt is required to model a spectrum of the Schiller plains. This finding is supported by analysis of the image cube. Four endmembers (fresh mare, mature mare, fresh highlands, mature highlands) within the scene were selected. Endmember abundance images produced by the mixing model give high mare contents for the Schiller plains, with only minor contribution from highlands spectral types. This small component of highlands material is probably derived mostly from the 64 km diam. Copernican crater Zucchius, located ~250 km to the SW. Zucchius rays and secondiaries are abundant on the Schiller plains.

Light plains are found on the floor of Schiller crater. A spectrum of the floor material has a band minimum of 0.93 µm, indicative of a highlands mineral assemblage. The abundance images confirm that the floor of Schiller has a greater highlands affinity than the basalt-dominated Schiller plains. Wargentin crater also has an occurrence of light plains on its floor A dark-halo impact crater has penetrated the plains unit and exposed mare basalt [15].

This research represents one phase of our study of lunar light plains, of which the cryptomaria are a special case. Investigation of cryptomaria can provide key information on the subject of ancient mare volcanism. Additionally, the cryptomaria hold clues to a greater understanding of ballistic erosion and sedimentation processes. We have investigated a variety of mantled basalt units in the SS region. In the floor of Schickard highlands-rich basin ejecta has covered and incorporated pre-existing mare basalt. The light plains in Wargentin have also mantled mare material. The Schiller plains however, are an expanse of post-Orientale mare that has undergone slight modification by impact debris from surrounding highlands craters. The light plains on the floor of Schiller crater appear to have only a minor component of mare basalt.

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