SPECTRAL STUDIES OF LUNAR DARK-HALO CRATERS: PRELIMINARY RESULTS.

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Introduction: The existence of lunar craters surrounded by deposits of low-albedo material has long been noted. However, the origin of these features has been the source of considerable controversy. Some dark-halo craters, such as those in Alphonsus, have been established to be of endogenic origin (e.g., Head and Wilson[1]). These dark-halo craters of volcanic origin are often non-circular, commonly aligned along structural features such as linear rilles and lineaments, and exhibit exterior deposits which are smooth and untextured[1]. These craters are thought to be the source vents for the pyroclastic material which now forms the dark halo.

Dark haloes have also been identified around craters with characteristics indicative of an impact origin[2]. In some instances, the dark material is clearly related to deposits of impact melt[3,4,5]. These occurrences are characterized by the limited extent of the dark material, which is usually concentrated in a narrow zone adjacent to the rim crest, and by the albedo of the dark material, which is never lower than that of mature highland surfaces. In other cases, impact craters appear to have excavated and ejected dark material from beneath a lighter surface unit. Schultz and Spudis[2] have recently presented the results of a major study concerning the identification, origin, and distribution of this type of dark-haloed impact craters. They suggested that basaltic volcanism may have pre-dated the impacts responsible for the last major basins, that early farside volcanism may have been widespread, and that at least some lunar light plains may be early volcanic deposits which were subsequently buried by varying thickness of impact ejecta. In addition, Hawke and Spudis[6] have recently demonstrated that lunar geochemical anomalies are commonly associated with light plains units which exhibit dark-halo craters.

Because of the key role dark-halo craters may play in the solution of several major lunar problems, we have undertaken a program to study these features using a variety of spectral reflectance techniques. The purpose of this investigation includes the following: (1) to confirm the existence of the postulated mare basalt component in the ejecta of dark-haloed impact craters, (2) to determine the compositions of these buried basaltic units, (3) to establish spectral criteria to distinguish dark-halo craters of impact origin from those formed by volcanic or other processes, and (4) to conduct regional studies to determine the extent of early volcanic activity on the lunar nearside. The preliminary results of this effort are presented here.

Copernicus H: This 4.5 km crater on the ejecta blanket of Copernicus appears in orbital photographs as a typical very fresh impact crater; however in low-phase telescopic photos it is surrounded by a dark ring extending over 2 crater diameters from the rim. It has been considered to be a prime example of a dark-halo crater produced by an impact excavating a dark layer buried beneath brighter surface material[1,2]. In this case mare basalts are excavated from beneath a blanket of highland materials. The near-IR reflection spectrum of Copernicus H as measured with the Mauna Kea 88-inch telescope (Fig. 1) fully confirms this interpretation as it is essentially identical to spectra of numerous recent small mare craters. Essentially no weathering effects are present. Either the entire ejecta blanket of Copernicus H is immature, or the spectrum is dominated by the brighter crater interior which might be expected to be kept fresh by mass wasting on the steep inner slopes. The .95/.56 micron color ratio images of the area show a deep IR absorption band over the whole dark halo, which supports the first alternative.

Schickard R: The Schickard area contains many dark-halo craters of probable impact origin[2]. They have been interpreted as excavations of ancient

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mare surfaces now buried by Orientale basin ejecta, and revealed only by the dark-halo craters. Isolated mare patches exist where eruptive activity continued after the Orientale event. The large highland crater Schickard exhibits a floor partly covered by terrain with grooves radial to Orientale (SW portion), light plains deposits, and patches of mare basalt (NW and SE portions). The small dark-halo crater Schickard R lies between the mare patches on a smooth high-albedo area of the crater floor. It is smaller and less prominent than Copernicus H and the spectrometer entrance aperture included some of the surrounding light plain. Nevertheless the spectrum (Fig. 2) is distinct from that of mature highlands regions. Subtraction of various fractions of an Apollo 16 site telescopic spectrum produced residual spectra characteristic of fresh mare basalts. A model constructed by linear mixing of Apollo 16 and fresh mare crater (Reiner K) spectra is shown as a solid line on Fig. 2. The absence of additional spectra in the immediate area makes interpretation more difficult . Either 1) the Schickard R dark halo is at least partly composed of fresh basalt, 2) the inner walls dominate the spectrum and expose fresh mare material (as discussed above as a possibility for Copernicus H), or 3) local highland rocks have more pyroxene than at previously observed lunar sites. We consider (1) to be the most likely. If either (1) or (2) are correct, this would provide strong support to the contention that Schickard crater was flooded with mare basalt prior to the Orientale event and that a deposit related to the formation of Orientale subsequently covered the area forming light plains.

Crater North of Inghirami (67°W, 44 30'S): An infra-red spectrum was also obtained for a well developed dark-haloed impact crater located west of Schickard and north of Inghirami. The spectrum is similar to that of Schickard R but exhibits even stronger pyroxene absorption bands. It appears that this crater has also excavated mare material.

Conclusions and Implications: The spectral data presented here conclusively demonstrate that Copernicus H excavated mare material from beneath a lighter surface layer. Evidence was also presented that two of the numerous dark-halo craters in the Schickard-Schiller region exposed mare basalt. Although we intend to obtain spectra for other dark-halo craters in this region, it seems likely that they will also contain a mare component. The existence of these dark-halo craters plus other factors, such as the unusual interior morphology of Wargentin crater, lend support to the hypothesis that this region experienced an episode of volcanic activity prior to the Orientale event.

In addition, post-Orientale volcanic activity may have been more prevalent in this region than has been commonly recognized. In particular, there is strong evidence that much of the Schiller plains, which occupy large areas of the interior of the Schiller-Zucchius basin, are of volcanic origin. These plains display a lower albedo and crater density than nearby highlands plains units[7] and are distinct on Whitaker's color-difference photograph. They also exhibit mare-type ridges and well-defined enbayment relationships with adjacent terrain.

We wish to offer the tentative conclusion that mare volcanism in the Schickard-Schiller region was more important in both space and time than is currently recognized.

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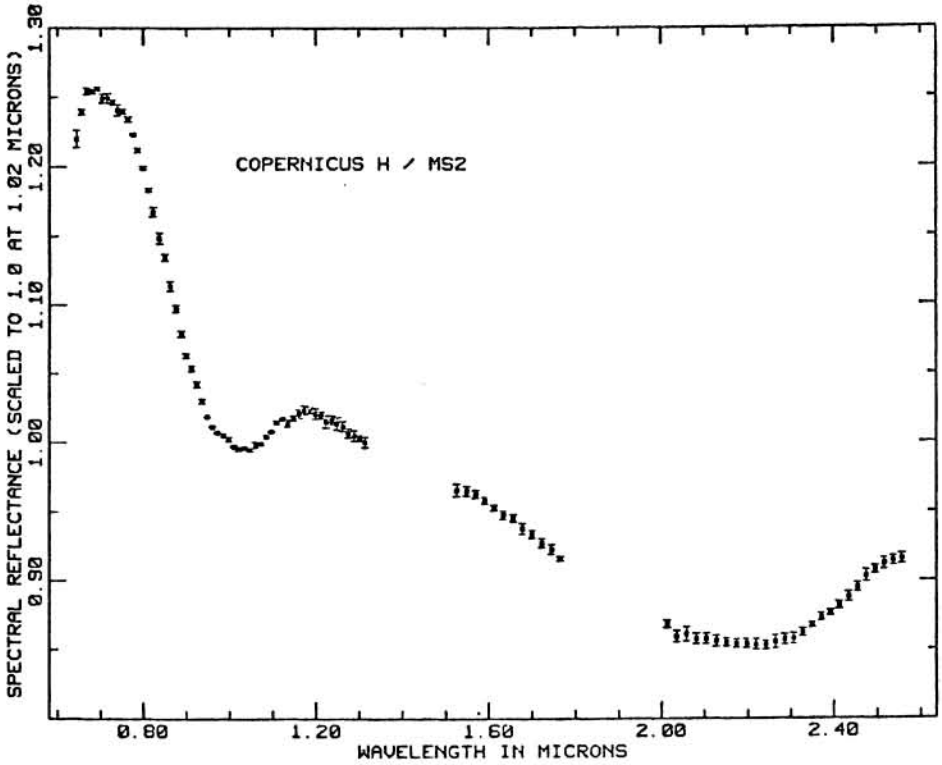

Fig. 1: Telescopic spectrum of Copernicus H divided by MS2.

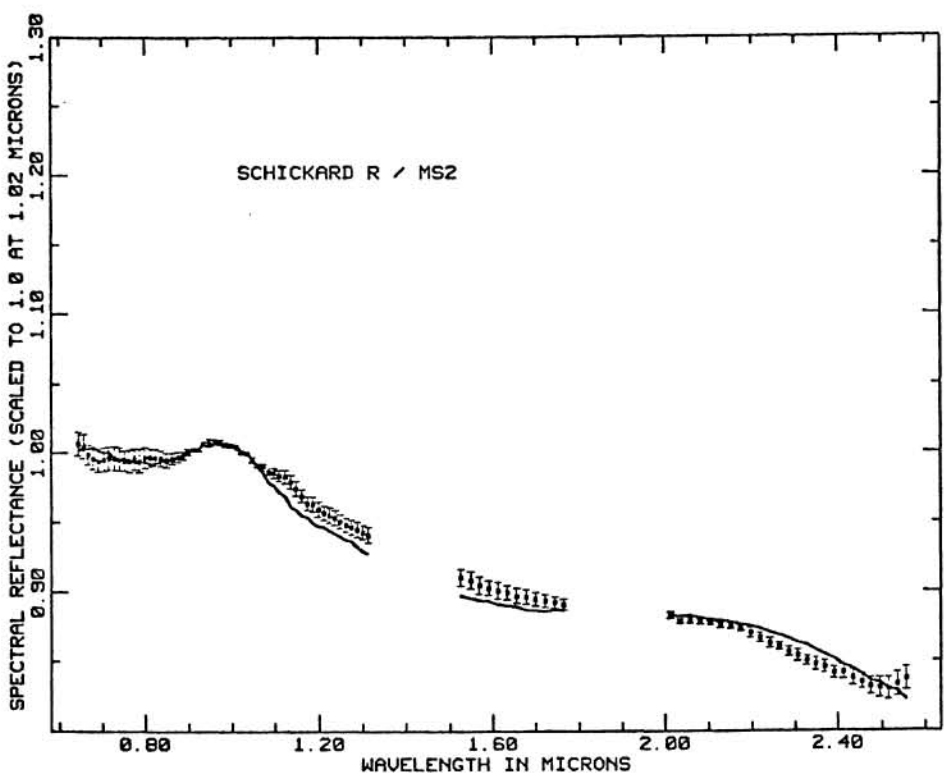

Fig. 2: Spectrum of Schickard R divided by MS (points) compared to a model spectrum (solid line) made by mixing spectra for the Apollo 16 site (80%) and a fresh mare crater (Reiner K, 20%).

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