PRELIMINARY RESULTS OF HIGH RESOLUTION UV-VISIBLE SPECTROSCOPY OF LUNAR RED SPOTS; Barbara C. Bruno, Paul G. Lucey, and B. Ray Hawke, Planetary Geosciences Division, Hawaii Institute of Geophysics, University of Hawaii at Manoa, Honolulu HI 96822.

Introduction. Telescopic color difference photography enabled the identification of many small lunar red spots almost two decades ago, yet their nature and origin still remain poorly understood and highly speculative today. Red/near-IR minus near-UV color difference photographs reveal anomalously light ("red") highland areas (1). These light areas represent red spots, characterized by a strong absorption in the UV relative to red/near-IR. Red spots exhibit a wide range of morphologies and are located in a variety of geologic settings. They commonly appear as domes, smooth plains units and rugged highland patches (2). Many red spots are associated with Imbrium basin. Some of these red spots are domes and mountains in the vicinity of Imbrium basin rings. Others are associated with post-Imbrian impact craters both within and exterior to Imbrium basin. Largely based on limited Apollo 15 x-ray fluorescence and gamma ray spectrometry data, it has been proposed that red spots may represent the surface signature of highland material enriched in radioactive elements (Apollo 14/KREEP/norite), emplaced before the period of mare volcanism (3). Citing geologic and spectral reflectance evidence, Head and McCord (4) similarly proposed that certain domical red spots may have been produced by Imbrian-age highland volcanism, predating and possibly extending into the period of mare volcanism. The existence of highland volcanism has major implications for lunar thermal history and crustal evolution. Thus the study of red spots can provide crucial information in understanding the early Moon.

We are conducting a spectral reflectance study of selected lunar red spots. The goals of this study include (1) obtaining spectra of various red spots, (2) comparing these red spot spectra to previously obtained red spot spectra, (3) determining the mineralogical composition of red spots, (4) exploring the relationship between red spots and KREEP and (5) interpreting the significance of red spots in terms of lunar geologic evolution. The purpose of this paper is to present the preliminary results of this effort.

Method. We obtained imaging spectroscopic data over the wavelength region 0.38 to 0.8 μm for several red spots on the western portion of the Moon. Data were taken with a CCD spectrograph at the University of Hawaii 2.24-m telescope of Mauna Kea Observatory in October, 1989. We removed the extinction effects of the Earth's atmosphere by dividing the red spot spectra by the spectrum of the solar analog star KCET.

Results. Spectra obtained for 5 lunar red spots are presented here: Helmet East, Helmet West, Lower Gruithuisen, Riphaeus Mountains and Lassel West. These 5 spot/star spectra each display a concave-downward red slope. These spectra are quite similar to one another, to spectra of lunar soils (5) and to red spot/MS2 data previously obtained with a lower resolution spectrophotometer (4). To enhance differences among these spectra, we calculated relative reflectance by dividing each spectra by a standard site in Mare Serenitatis, referred to as MS2. These spot/MS2 spectra (Figure 1) are all characterized by a sharp absorption in the UV, but the strength of the drop-off varies. Lassel West exhibits the steepest violet/UV absorption, with relative flux dropping 20% over the wavelength region 0.42 to 0.38 μm. Helmet East and West have intermediate absorptions of approximately 15%. Lower Gruithuisen and Riphaeus have only minor absorptions of approximately 5% and less than 5% respectively. Note that the spectrum for Riphaeus shown in Figure 1 corresponds to a moderately red area slightly to the north and barely intersecting the Riphaeus red spot. The wavelength position of the drop-off also differs among the red spots. Spectra of the two Helmet
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regions and Lower Gruithuisen begin to downturn toward the UV at 0.46 μm. Lassell West and Rhiphaeus, however, remain relatively constant from 0.46 until 0.42 μm, where they begin to drop-off. This is consistent with previously published low-resolution red spot/MS2 spectra (4), however the much higher resolution and sampling of the data presented here allow much better characterization of the UV absorption.

The high sampling density of our spectra also enables us to detect subtle residual structure. All of our spectra display a broad, w-shaped residual structure in the visible, especially apparent for Helmet East and West. This structure was only detectable in some of the previously published spectra in the same wavelength region (4). This spectral feature is not found in ratios of lunar mare spectra to MS2 (6,7). Whether this feature is unique to red spot spectra or shared by all highland spectra has yet to be determined.

The dissimilarities among the spectra presented here in both the UV absorption and the broad w-shaped structure in the visible suggest that red spots may not share a single mineralogical composition. We shall investigate this possibility and its implication that red spots may not share a single origin.


Figure 1:
Spectra of five lunar red spots, relative to MS2.