PRIMARY EJECTA IN CRATER RAYS: THE COPERNICUS EXAMPLE
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Introduction and Background. For fresh large impact craters a discontinuous field of secondary craters and bright rays usually surround the crater, often extending hundreds of kilometers. Two different popular points of view that concern the nature of extensive rays from large craters can be summarized as follows: 1) The ray material is a depositional unit of foreign material excavated by the crater. The ray is brighter than the substrate because it is of a different composition and/or is fresher (less altered by soil maturation). 2) The ray material is fresh local material that has been brought to the surface by a relatively small amount of high velocity foreign material ejected by the primary crater. Presented here is evidence from the lunar crater Copernicus that surface deposition of foreign material to form a ray is a dominant process in creating such an observed crater ray.

Copernicus is a fresh, bright rayed impact crater 95 km in diameter on the lunar nearside (9.5°N, 20°W). The stratigraphy of the target region is thin mare overlying Imbrium basin deposits and lunar highlands crust. Material excavated by the cratering event which comprise the crater wall and rim deposits exhibit mineral assemblages similar to highlands crust (feldspar, + opx, + cpx) (1, 2). The rays to the north are observed on a variety of Imbrium mare material, both low titanium intermediate age basalts and younger high titanium basalts (3, 4).

The Data. A variety of available remote sensing data (5) for one of the extensive Copernicus rays were examined in order to better understand the nature of crater rays. Recent near-infrared spectra of selected small regions are discussed below. Earthbased 3.8 cm radar backscatter data, sensitive to block population and surface texture, show much (but not all) of the ray to be somewhat diffusely (with non-discrete centers) brighter than the mare. These data and orbital images and multispectral images will be discussed in more detail elsewhere.

The location of 5 small areas for which spectra were obtained on 7/5/81 are shown in Figure 1. Good repeat spectra for a few of these areas were also obtained on three other nights. The spectra are shown in Figure 2. For each spectrum a straight line continuum is estimated (usually tangent at .73 and 1.60 μm) in order to examine the nature of the weak absorption features near 1 μm. Note that for the 4 ray spectra a different continuum should be estimated for the feature near 2 μm. The residual absorption (spectrum/continuum) around the 1 μm feature is shown in Figure 3.

It has been well documented since the earliest studies of returned lunar samples and remote measurements of the lunar surface (6, 7) that fresh lunar surfaces have strong absorption features and mature soils have much weaker features. As a fresh soil matures it becomes darker and its absorption features become weaker. For a crater ray to be fresh or disturbed local material, it must not only be brighter, but it must exhibit stronger absorption features than the local soil. Experience has also demonstrated that the spectrally dominant mafic mineral for most lunar material is pyroxene. Highland materials exhibit orthopyroxene absorption features (absorption centered near .93 μm) and the basaltic mare exhibit more calcium-rich clinopyroxene features (centered beyond .95 μm) (8, 9).
All the spectra for Copernicus ray not only exhibit absorption features weaker than the local mature mare, but the band centers are also at shorter wavelengths than that for the mare.

Interpretation. These data suggest that the surface materials of the observed crater ray are dominated by materials of crustal composition rather than either mature or immature soils derived from subjacent mare deposits. We interpret these data as evidence that the high albedo surface material of this Copernicus ray (the upper few millimeters which interact with solar radiation) may be largely a depositional unit rather than immature local mare excavated by secondary craters. Mixing models are being investigated to estimate the possible amount of local material that could be present.

References