COPERNICUS : COMPARISON AND COMPLEMENTARITY BETWEEN TELESCOPIC MULTISPECTRAL SOLID STATE IMAGING AND REFLECTANCE SPECTRA.

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Near-infrared reflectance spectra have been used to obtain global information about the composition of the lunar near-side crust . Spectra of immature surface material from small fresh craters, mountains and massifs, and large craters with central peaks allow to recognize rock types which are described in terms of anorthositic, noritic, gabbroic, and troctolitic mineral assemblages (1). As large impact craters excavate materials from different depths, they give information on pre-impact stratigraphy of various target sites and mineralogical heterogeneities in the upper lunar crust, both laterally and vertically (1,2).

While spectra provide detailed mineralogical information for the sampled area (10x10 Km^2), multispectral ratio images are necessary to map in detail the areal extent of crater-associated spectral units. Multispectral narrow-band imaging in the near-infrared domain, where significant absorption features are known to occur, has proven to be a powerful technique to investigate upper crustal stratigraphy and impact cratering processes through the detailed compositional mapping of complex morphological units (3,4). This approach, which couples high spatial (0.5 Km/pixel) and spectral (r=100) resolution, is indeed perfectly suited for the identification of spatially heterogeneous areas.

High spatial resolution CCD images (0.5 to 1 Km/pixel) have been obtained for several lunar craters at the 2-meter aperture telescope (F/D=50) of the Pic du Midi Observatory in France. Technical information about instrumentation, and procedures for data acquisition and processing are given in a previous paper (5). The results presented here are for the crater Copernicus which is one of the largest fresh lunar crater. It is located in an area where the crust was affected by repeated early and large impacts in the lunar history, suggesting that the lower crust and the mantle itself are uniquely more accessible in this region of the Moon. Several reflectance spectra have been obtained across the crater in specific spots located on the central peaks, the floor, and the walls (6,7), and have detected the unambiguous presence of olivine within the central peak complex (7,8). This provides with a unique opportunity : (i) to carry a critical assessment of the narrow-band near-infrared solid-state images (SSI), obtained by telescopic means, in preparation to the analysis of the Galileo SSI data ; (ii) to use the locations where spectra have been obtained within the crater as standards for the making of a detailed spectro-mineralogical mapping within the crater. Multispectral imaging of this crater may supply with constraints to the stratigraphy of the preimpact target site and the crater formation.

As a critical test, images taken in four close near-infrared narrow bands have been selected and the following 0.91 , 0.97 , 0.98 , and 1.02/0.56 μm ratio images have been performed. These ratios are normalized to an area about 12x12 Km located on the floor of the crater, corresponding to a relatively homogeneous area referenced as F2 in previous work (7). Each ratio image exibits variations in a + 10% range relatively to the standard F2, calling for significant mineralogical variations. The comparison of the spectral ratio values for particular spots within the images, where spectra are available (peaks P1 and P3, wall W1 (7)), proves to be fully consistent with the earlier spectroscopic spot-to-spot ratios normalized to the chosen standard area F2, within a 1-2% mean deviation.

In addition to the usual IR/VIS images, a powerful analysis tool has been developed which consists in ratio image composite maps exhibiting the spectral distribution of the most depleted 0.91, 0.97, 0.98 and 1.02/0.56 µm spectral ratio (9). The composite map shows conspicuously that the lowest spectral ratio values for the three separate peaks of Copernicus are obtained with the 1.02/0.56 µm ratio. This spectral information fits perfectly with the spatial extent of the three central peaks, and agrees with the olivine composition of the two westernmost peaks studied by (6,7). In addition to the caracterization of the central peaks, several major spectral units are identified within Copernicus. For these units, the presence of orthopyroxene, clinopyroxene, and olivine dominant mineral assemblages is proposed in relation with a maximum of absorption towards 0.91, 0.98 and 1.02 µm respectively.

Excluding the central peaks spectral features, these units consist in : (i) Two regions, comprising the northwestern portion of the crater wall and a portion of the northern rim of Copernicus, which also exhibits olivine as major mineralogic component. For these regions, values of the 1.02/0.56 µm ratio are respectively depleted by about 5% and 8% relatively to the standard F2; (ii) A relative morphologically homogeneous low albedo region, located north of central peak complex presents an orthopyroxene composition. This material generally interpreted (e.g.,(6)) as an homogeneous part of impact melt material flooding the crater floor,is believed to originate near the point of impact, at a shallower depth than the peak material; (iii) The rest of the crater interior, including the floor and the wall displays an heterogeneous composition (ortho-clinopyroxene). The part of the floor included in this unit consists in hummocky terrains having a higher albedo than the unit described in (ii).Other subtle spectral variations detected within Copernicus are under study.

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