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Deconvolution of Chang'e-4 Reflectance Spectra on Rocky Targets along the Yutu-2 Traverse across Von Karman crater. P. C. Pinet¹, Y.H. Daydou¹, C. Li², D. Liu², B. Liu², X. Ren², ¹Institut de Recherche en Astrophysique et Planétologie (IRAP), CNRS/CNES, Observatoire Midi-Pyrénées, Université de Toulouse, France; patrick.pinet@irap.omp.eu), ²Key Laboratory of Lunar and Deep Space Exploration, NAOC, CAS, Beijing, China; licl@nao.cas.cn).

Introduction: Chang'E-4 spacecraft touched down in the 186-km-diameter Von Kármán crater on the floor of the South Pole-Aitken basin on January 3rd, 2019. The results presented here are based on spectra of reflected light acquired on rock surfaces, that were recorded by the Yutu-2 rover as it traversed successfully across the Von Kármán crater covering as of today more than 1500m.

Observations: In situ reflectance observations of local targets have been made by the VNIS/SWIR spectrometer onboard the rover [e.g.,1]. Among the targets which have been surveyed along the traverse and which include soils and rocks, the focus is put here on the rocky surfaces. We analysed about 20 spectra but highlight in this presentation only three of them (see fig. 1), acquired on the lunar days 26 (18/01/2021) and 41 (05/04/22) of the traverse. The location, geomorphological and geologic context of these measurements are indicated here below (see figs. 2 and 3).

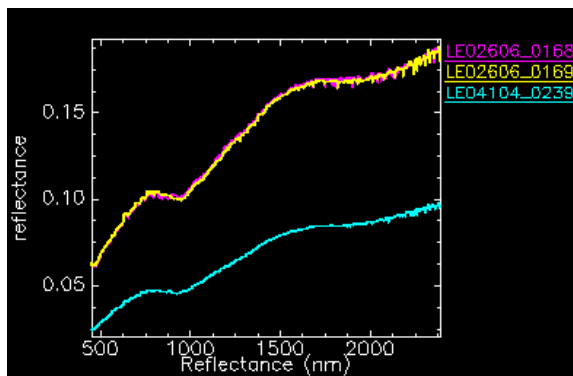


Figure 1. VNIS/SWIR spectra acquired along the Yutu-2 traverse

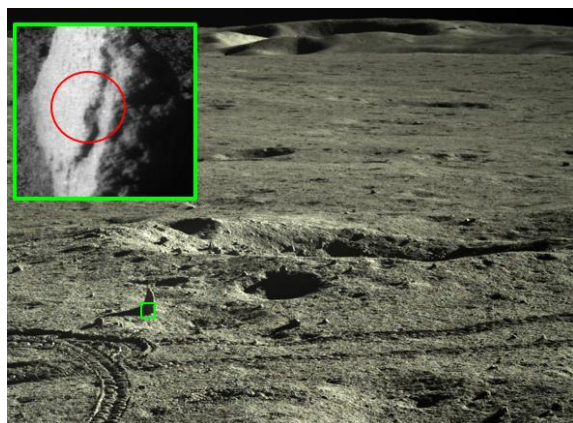


Figure 2. Location of spectrum LE02606_0169

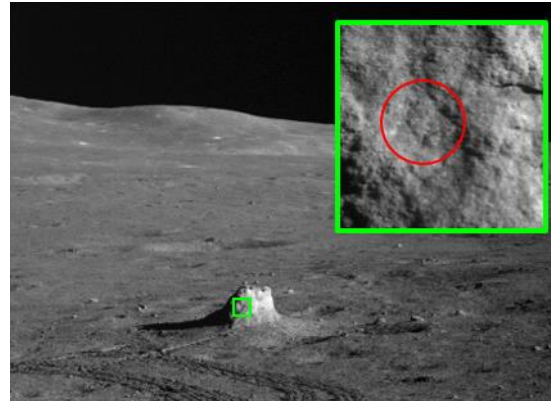


Figure 3. Location of spectrum LE04104_0169

Methodology: Advanced spectral deconvolution by means of MGM implementation:

The principle of the Modified Gaussian Model is to deconvolve overlapping absorptions of mafic mineral spectra into their fundamental absorption components. Spectra are modeled in the logarithm of reflectance space as a sum of modified Gaussian distributions superimposed on a baseline continuum [e.g., 2, 3]. The current procedure is described in [4].

MGM inverse modeling provides with band center, band width and band depth estimates. Band centers are used to determine trend line equations for each individual absorption band, with an assessment on the regression performance (rms spectral distance between bandcenter estimate from MGM and the one from the trend line) [5].

The olivine composition (Molar Forsterite Fo#) is then predicted based on minimizing the deviations in band centers from the established trends for the three absorptions simultaneously, using the integrated rms spectral distance to trend quantity (**sdt**).

Analyses and Results : A systematic search has been implemented with different mineralogic configurations (OL, OL-OPX, OL-OPX-CPX) [3, 5, 6]. The best modeling outputs are produced with the OL-OPX-CPX case and two examples are shown hereafter (figs. 4 and 5). As displayed on the figures, the modeling appears well behaved (with quite low residuals), both in terms of continuum (second-order polynomial adjusted on the main maxima) and band centers, band widths and depths, which meet a number of spectroscopic constraints associated with pyroxenes and olivine.

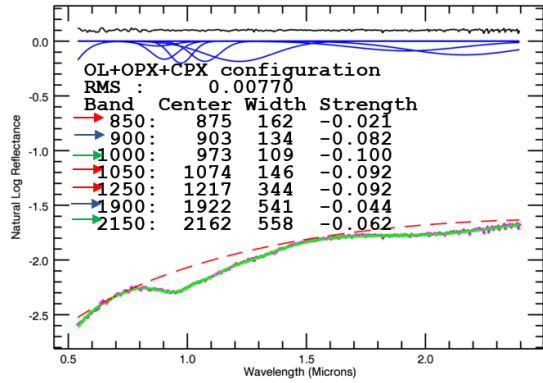


Figure 4. MGM deconvolution of spectrum LE02606_0169. Measured spectrum (light pink dotted line) and MGM modeled one (thick green solid line) with the Gaussians (solid blue lines, vertically stretched x 3) and polynomial (hatched red line); residuals displayed by the black line along the spectral domain. For clarity, the residuals (observed - modeled quantity) are shifted by +0.1 which means that a perfect fit would be displayed with a 0.1 flat line (here rms : 0.0077).

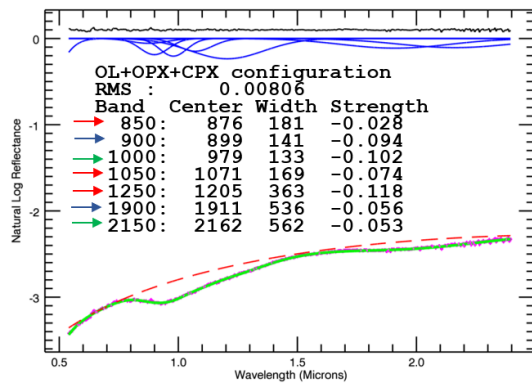


Figure 5. MGM deconvolution of spectrum LE04104_0169 (rms : 0.008) (see legend Fig.4)

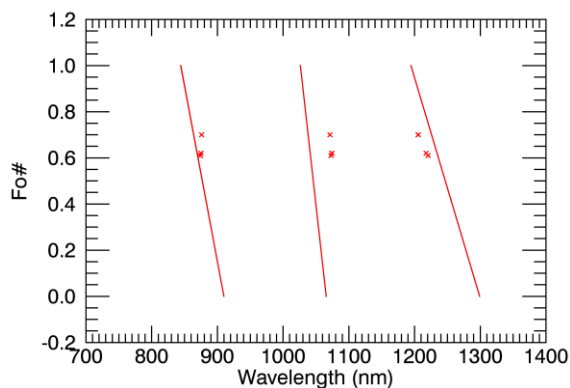


Figure 6. Fo# determination. Red crosses (x) plot the M1-1, M2, M1-2 band centers for each spectrum determined by MGM deconvolution (Gaussians '850', '1050', '1250'). Composition trend lines from [4].

The continuum slopes are well known to be highly variable, being affected by a number of parameters, which include surface texture, grain size, viewing geometry, and alteration due to space weathering [5]; the polynomial description here is quite useful.

We note that the band center associated with M2 site (Gaussian '1050') is shifted longward by about 30nm (already noted in [7]), resulting in a sdt estimate of 20-22nm, which calls for the presence of either additional mineral phases or minor amounts of non-stoichiometric cations in the crystal structure.

Inferences and Prospects: Overall these results obtained on rocks with coarse textures disseminated along the Yutu-2 traverse agree with conclusions drawn from previous studies [7, 8, 9, 10] mainly conducted on regolith spectra.

The present results support the view that the rock mineralogy is driven by assemblages of enstatite, augite and olivine (Fo# 60-70, consistent with hyaloserite composition). It is of note that the relative proportion of olivine appears to be higher in rocks than in regolithic soils.

It remains to determine the precise origin of these rocks found along the traverse across Von Karman crater. In this respect, it is of high value to acquire as many rocky targets as possible in the future navigation of the rover, to test various geological hypotheses involving impact melt differentiation, volcanic resurfacing events and/or distant impact ejecta [e.g., 1, 11].

References:

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