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Mapping MgO and Mg-number with Chang'E-1 IIM data

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Abstract

Based on the LSCC data, we got the algorithm to map MgO by using Chang'E-1 Imaging Interferometer (IIM) data. In combination with our previous FeO model, we further obtained the method for Mg# mapping.

1. Introduction

China's first lunar probe Chang'E-1 has returned about four Terabytes science data from eight payloads as well as various science returns, e.g., lunar global CCD image, first microwave image of the complete Moon, etc[1,2]. As one of eight scientific payloads on Chang'E-1, Imaging Interferometer (IIM) is selected to detect the distribution of lunar chemical compositions and minerals on Moon surface [3,4]. Vis-NIR Reflectance properties of Moon are sensitive to the mineralogy, mineral chemistry and physical states of lunar regolith [5]. The distribution of chemical elements such as (FeO, TiO_2, MgO, etc) is important for understanding the petrogenesis of lunar rocks and therefore the thermal and physical history of the Moon [6]. We have produced the FeO and TiO_2 distribution mapping based on the link between remote and chemical data from lunar Apollo and Luna landing sites [3,4].

Similar to Fe and Ti, Mg is also a very important element to determine the lunar rock types and the evolution of lunar magma ocean. Early formed mafic mineral (Mg- and Fe-bearing) mineral for usually have a greater Mg/Fe ratio than last-formed crysatls.rock[7]. The Mg number (Mg#), the ratio of Mg to the sum of Mg and Fe on an atomic basis, is a useful quantity in defining and understanding lunar rocks. Here we will present our MgO and Mg# mapping by using Chang'E-1 IIM images based on the spectral and chemical data acquired by Lunar Soil Characterization Consortium (LSCC).

2. IIM data description

Imaging Interferometer (IIM) aboard Chang'E-1 lunar orbiter is a Sagnac-based pushbroom Fourier transform imaging spectrometer, which operates from visible to near infrared (0.48-0.96 μm) with 32 spectral channels. When on a ploar orbit of 200 km above the Moon, Chang'E-1 IIM yields a ground resolution of 200m/pixel and 25.6 km swath width. The IIM data processing pipeline include dark current subtraction, relative calibration, spectrum reconstruction，radiometric calibration, photometric normalization and reflectance conversion, etc. IIM data used in this paper is level 2C based on the above calibrations.

3. Algorithm

Apollo and Luna missions have returned a large amount of valuable lunar soils and rocks as 'ground truth' for following lunar explorations. LSCC measured bidirectional reflectance spectra for all 76 samples using the RELAB spectrometer with the spectral range 0.3–2.6 μm [8]. The spectra were converted to the effective absorbance spectra by applying a natural logarithmic function to each reflectance spectrum. Multiple linear regression (MLR) was applied for the prediction of MgO abundance in lunar soils. We got the formula for modeling MgO as follows,

$$\log(MgO) = -3.16\times R_{891} + 3.234\times R_{757} - 1.295\times R_{618} + 1.0969 \quad (1)$$

The correlation conefficent is as high as 0.89 based on our calculation. Based on this model and our algorithm for FeO mapping[3], we can produce the Mg# map using the following formula,

Mg#= atomatic Mg /(Mg+Fe)

= atomatic MgO/(FeO+MgO)   (2)

4. Regional case study

Based the above models, we produced the MgO and Mg# map for Bullialdus crater (20.7ºS, 22.2ºW), as shown in Figure 1. The central peak of Bullialdus crater is known as noritic rock[9]. As can be seen in the MgO map (Figure 1), the MgO content for this region is intermidiate (8 wt.%). However, the Mg# map show that it's a region with very high Mg# value(60~80), which agree well with the previous studies that the central peak is comprised of noritic rock. Except for the central peak and some other greater Mg# regions, most other regions nearby are very low of Mg#(<50). To the first order, our Mg# map could be used to discriminate the Mg-suite rock. However, we should take care when using these models for local geology interpretions, keeping in mind of the statistics nature of MgO model, limitation of spectral quality of IIM data as well as topographic shading effect, etc.

5. Summary and Conclusions

We presented the preliminary algorithm of model MgO using Chang'E-1 IIM data. Mg# map was also produced in combination with our previous FeO model. As suggested by our MgO and Mg# map, the central peak of Bullialdus crater is comprised of noritic rock. We will continue to focus on the analysis of uncertainties of our models for a purpose of refining them in future.

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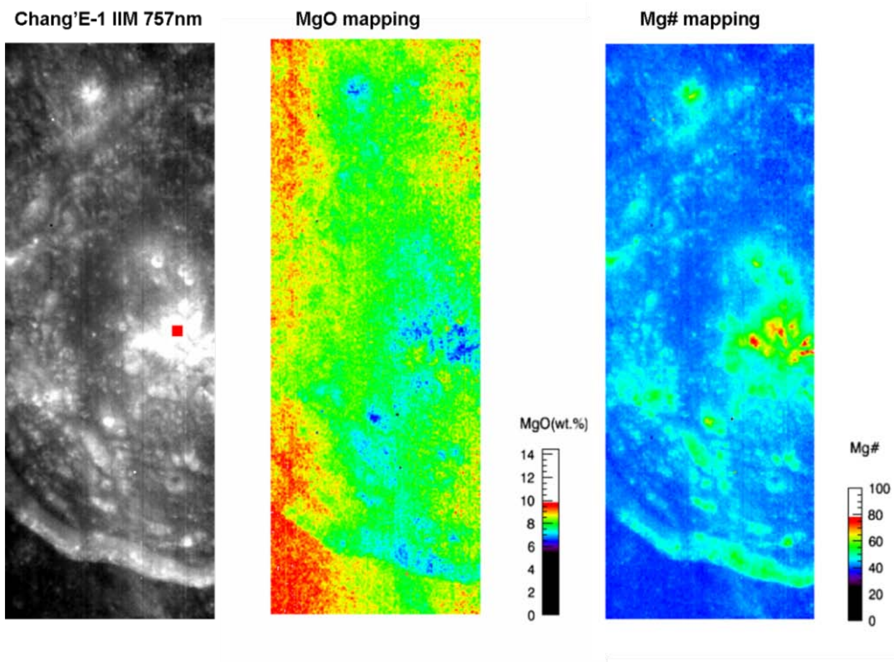

Figure 1. MgO and Mg# mapping near Bullialdus crater using Chang'E-1 IIM data