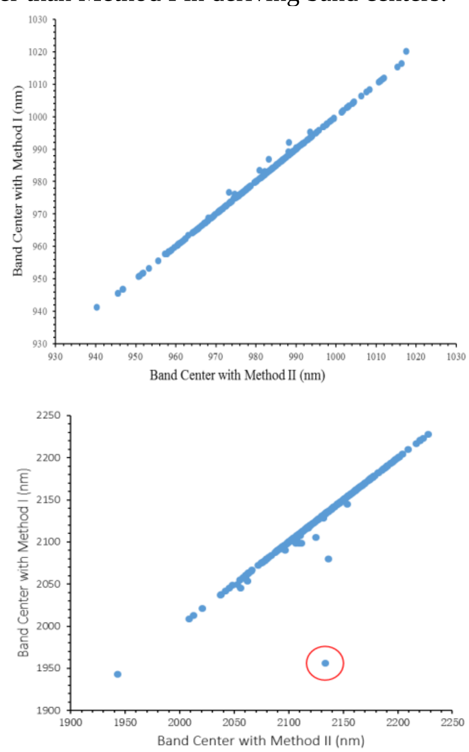
RESEARCH OF THE CONTINUUM REMOVAL METHOD FOR MOON MINERALOGY MAPPER (M^3) AND APPLICATION. X. Y. Zhang[1], Z. Y. Ouyang[2], X. M. Zhang[3], Y. Chen[3], A. A. Xu[1], Z. S. Tang[1], Y. Z. Wu[3], [1]Space Science Institute, Macau University of Science and Technology (zhangxunyugeology@gmail.com), [2]National Astronomical Observatories, CAS, Beijing 10012, China, [3]School of Geographic and Oceanographic Sciences, Nanjing University, Nanjing, 210023,China.

Introduction: The Moon Mineralogy Mapper (M^3) was a hyperspectral imaging spectrometer on board Chandrayaan-1 spacecraft which launched on October 22nd, 2008. This research mainly studied the continuum removal methods for M^3 data and applied to Mare Humorum and Mare Nubium for mineral identification. Space weathering changes the spectra of the Moon by reducing albedo and absorption strength but increasing red slope, which makes it difficult to identify minerals [1]. To reduce these effects and derive the accuracy absorption centers of lunar minerals, it is necessary to remove the continuum of spectra. As for M^3 data, the method of fixing the right endpoint at 2500 nm and deriving the tangent to the left shoulder has been commonly adopted by previous researches to avoid the thermal emission [2, 3]. In the band center plot of Band II (2000 nm) versus Band I (1000 nm), which is often used for assessing compositional variability of pyroxenes [4,5], data points derived from the above continuum removal method obviously deviate from trends of natural and synthetic pyroxenes [6]. Furthermore, the plot of Band Area Ratio (BAR) versus Band I center [7], is also presented to analysis the mineral compositions.

Data and Methods: M^3 images the Moon in two modes: global mode and target mode [8], and operates in the spectral channels from 0.43 to 3.0 μm. For target mode, M^3 acquires images with a spatial resolution of 70 m/pix in 260 channels. In global mode, it acquires images with 140 × 140 m or 140 × 280 m per pixel in 85 channels. There are five different sets of sub-Optical Periods (Ops) [9]. OP2A data were used in this study, the resolution of which is 140 m/pix and phase angle is 40°-90°. To reduce the space weathering effects, small fresh craters, usually with diameters smaller than 500 m, were used for extracting spectra. Totally, 260 fresh craters were selected from Mare Humorum and Mare Nubium.

The spectra were firstly smoothed to reduce noise. Two methods were then used to remove the continuum. One is the convex hull method (Method I) [10], which uses a convex hull to fit over the top of a spectrum with straight-line segments that connect local spectrum maxima. The second method (Method II) is constructing two straight line across the 1000 nm (Band I) and 2000 nm band region (Band II) by an automatic algorithm as a tangent line to the target spectrum. To analysis the influence of different endpoints on band center position, we set the right endpoint at three different positions. One is maintaining the spectrum before 2537 nm (Point I), others are 2616 nm (Point II) and 2776 nm (Point III).

Results: The continuum removal methods of Methods I and II have a good correlation in Band I and Band II, when they have the same endpoint (e.g. Point I) (Fig. 1). Some outliers deviating from the trend in Fig. 1 may be related to the weak absorption features of Band II (Fig. 2). In this case, Method I tends to acquire a bigger Band I center and a smaller Band II center than Method II, such as the outliers shown in Fig. 1. Considering that Method II is stable (could gain the same Band I center even using different endpoints) and convenient for calculating the band area, Method II is better than Method I in deriving band centers.



(a)

(b)

Fig. 1. The relationship between band centers derived from Method I and Method II (the endpoints are set at Point I). (a) Band I centers. (b) Band II centers. The red circle represents the outlier and its spectrum is shown in Fig. 2.

The variations of the Band II center between different endpoints would affect the samples' location in the plot of Band I centers versus Band II centers. For Method II, the farther right endpoint was set, the bigger Band II center would get. The samples of Point II are more match trends of natural and synthetic minerals than that of Point I and Point III (Fig. 3), which means that the Band II centers of Point I are too short and that of Point III are too long. So it is seem that making the endpoint around 2616 nm would be more reasonable. More detail about the influence of different endpoints on band centers would be discussed in other paper.

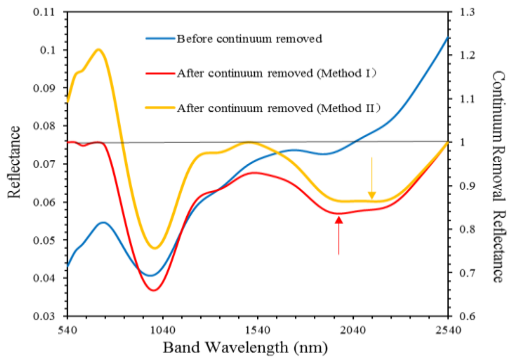


Fig. 2. Different band center positions derived from Method I and Method II. Blue line represents the original spectra. Red line stands for the result of Method I. Yellow line is the result of Method II in Band II. The arrows point out the approximate location of the band centers.

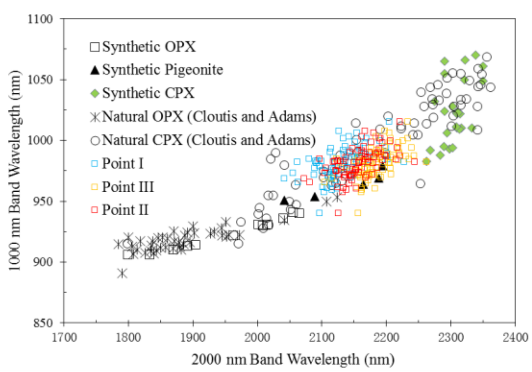


Fig. 3. Plot of Band II centers versus Band I centers for 78 samples (Method II) in Mare Humorum. Blue, red and yellow boxes present the data of Point I, II and III, respectively.

According to above discussion, Method II and Point II seems the best method for deriving the absorption centers of lunar minerals among all the methods (Fig. 3). The minerals of Mare Humorum and Mare Nubium were identified using the method suggested above. The Band I centers are between 940 to 1015 nm and the Band II centers are mainly between 2072 to 2243 nm, suggesting low- to moderate-Ca pyroxenes features. Fig. 4 shows the plot of BARs versus Band I centers. The data points are mostly located on the upper side of OC region (represents the mafic silicate components) [7]. These data points can be also divided into three types, which are cataloged as S(III) type, S(IV) type and S(V) type. Few spots fall into the BA region, which have the same component as the pyroxene-dominated basaltic achodrite. The reasons for this situation are multiple, including caused by different methods.

Conclusions: According to the former discussion, constructing two line across two band region straightly (Method II) has an advantage over the convex hull method (Method I), because it is stable and convenient. Comparing with the results of Point I (2537 nm) and Point III (2776 nm), the method setting up the endpoint around 2616 nm (Point II) fit the trends of natural and syn-thetic minerals better in the plot of Band I centers versus Band II centers. The samples of Mare Humorum appear low- to moderate-Ca pyroxenes features. The plot of BARs versus Band I centers presents that the most samples of Mare Humorum and Mare Nubium are located on the upper side of OC region.

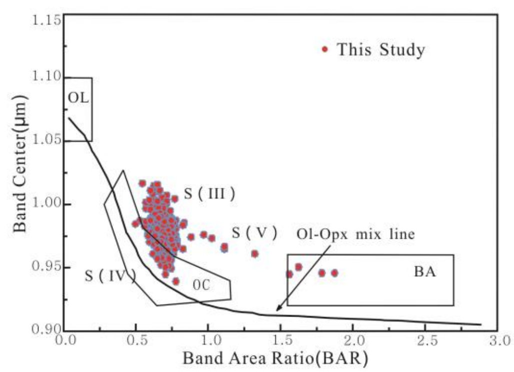


Fig. 4. Plot of BARs versus Band I centers with Method II (Point II). Three polygons (OL, OC and BA), representing monomineralic olivine assemblages, mafic silicate components of ordinary chondrites and pyroxene-dominated basaltic achodrite respectively [7], are also shown.

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