

Minerals Mapping of the Lunar Surface With Clementine UV-VIS-NIR Data Based on Spectra Unmixing Method and Hapke Model. Yan B. K.¹ Wang R. S.¹, Gan F. P.¹, Gan F. P.¹, and Wang Z. C.² 1. The Earth Observation Technology Center, China Aero Geophysical Survey and Remote Sensing Center for Land and Resources. 2. China University of Geosciences(Beijing)

Introduction: Reflectance spectra of near-infrared has been proved to be a useful method of studying compositions of the Earth and other planets surface. Rocks on the lunar surface are mainly composed of plagioclase, ilmenite, clinopyroxene, orthopyroxene, and agglutinitic glass^[1], and its distribution could be mapped with UV/VIS/NIR reflectance spectra. Lucey^[2] mapped the distribution of clinopyroxene, orthopyroxene, olivine, and plagioclase with Clementine UV/VIS data based on the Hapke radiative transfer model^[3]. If the data could be used to map minerals distribution of the lunar surface, it would be helpful for improving minerals mapping results. In this paper, the distribution of clinopyroxene, orthopyroxene, olivine, ilmenite, and plagioclase on the lunar surface has been mapped based on Hapke radiative transfer model and linear unmixing of spectra with Clementine UV/VIS/NIR data. The results were discussed on the basis of previous work^[3] and mineral composition of Apollo samples^[1].

Method: The method is mainly composed of two steps. The first is establishing statistic relationship between true abundance and spectral unmixing abundance of endmember minerals, and the second is minerals abundance mapping of lunar surface. The first step is divided into four steps: (1) random mixing of endmember minerals spectra, (2) continuum removal of mixed spectra, (3) linear unmixing of mixed spectral, and (4) establish statistic relationship between true abundance and spectral unmixing abundance of endmember minerals.

Results: The distribution of mineral abundance was mapped by using the above method(Fig.1). From the distribution map, we find that, the lunar mare is mainly composed of clinopyroxene and ilmenite, and the lunar highland is mainly composed by plagioclase and orthopyroxene. South Pole-Aitken basin also shows high clinopyroxene abundance reflecting a significant component of mare basalt throughout the basin^[4]. The results show that there is not large amount of olivine on lunar surface(olivine distribution is not showed in Fig.1, and this is different from Lucey's result which showed there existed olivine of large area and of high abundance(approach to 50Vol%) at western regional mare basalts. The result indicate that there is not olivine of large scale(10 Km scale) on lunar surface although there exists olivine at center peak of some craters such as Copernicus^[5].

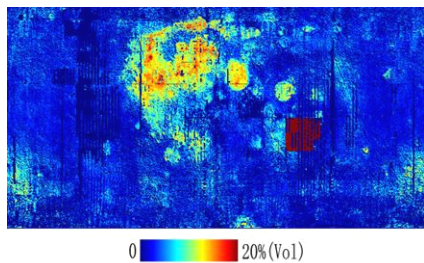
Validation: In order to validate our results further, we compared the abundance of minerals on lunar surface with the composition of the Apollo samples(Fig.2). The Apollo 12 data was not used because the Clementine data at site of the Apollo 12 is bad and no any mineral was retrieved. The composition of the Apollo samples also show that the abundance of olivine in lunar soils is very low(Fig.3)^[1].

Although all the abundance data of plagioclase of our result are greatly larger than plagioclase abundance of Apollo samples, the abundance of plagioclase of our result is approximately identical with the total abundance of plagioclase and agglutinitic glass of Apollo samples(Fig.2a). This phenomenon is due to that agglutinitic glass spectra is approximately identical with shocked plagioclase and the spectra of which is not show obvious spectra absorption features although its has pyroxene composition^[6], therefore plagioclase distribution of our results should represent the total abundance distribution of plagioclase and agglutinitic glass. The plagioclase abundance is slightly lower than the abundance of Apollo samples, which is due to the nonlinear mixing characteristic of mineral spectra. The retrieved ilmenite abundance is greatly larger than the abundance of Apollo samples, which is due to the nonlinear mixing characteristic of mineral spectra. The experimental study on minerals abundance retrieval indicated that minerals of higher reflectance will be underestimated and minerals of lower reflectance will be overestimated in the minerals mixed system. Although our method has the ability to correct the nonlinear mixing characteristic, the correction will not thoroughly because Clementine data is a multispectra data and the band is not enough. From Fig.2b, we can conclude that, although the absolute abundance of ilmenite is larger than its true abundance, the relative abundance is reliable.

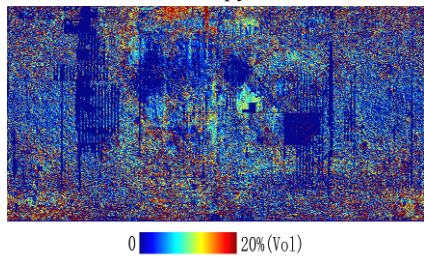
Discussion and conclusion: In this study, although the band number of the Clementine data is larger than the number of endmembers which allows to retrieve minerals abundance in terms of mathematical principle, the so few band must affect the reliability of results. If we have got hyperspectra data in the near future from other lunar satellite such as SMART-1 and Chandrayaan-1, the result based on the method of this study could be improved greatly, and the overestimation of ilmenite would be eliminated probably..

References:

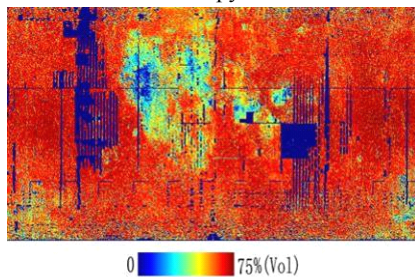
- [1] Taylor L. A., Pieters C. M. and Keller L. P. et al. (2001) *JGR*, 106(E10), 27985-27999. [2] Lucey P. G. (2004) *GRL*, 31, 1-4. [3] Hapke B. (2001) *JGR*, 106(E5), 10039-10073. [4] Pieters C. M., Head J. W., and Duke M. (2001) *JGR*, 106(E11), 28001-28022. [5] Mouélic S. L., Langevin Y. (2001) *Planetary and Space Science*, 49, 65-70. [6] Adams J., McCord T. (1971) *Proceedings of the Lunar Science Conference*, 2, 2183-2195.



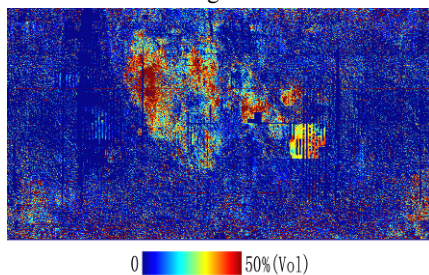
a. Clinopyroxene



b. Orthopyroxene

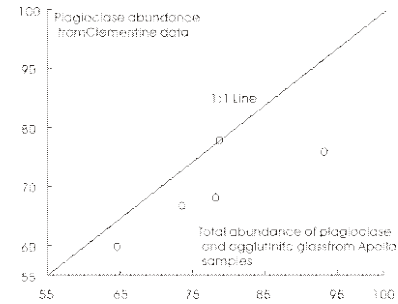


c. Plagioclase

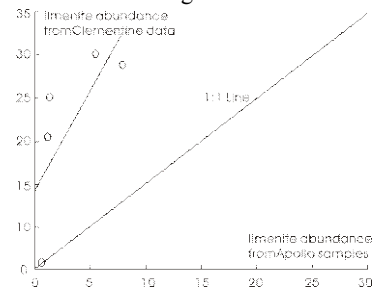


d. Ilmenite

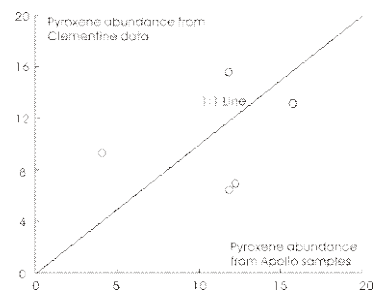
Fig.1 Minerals abundance distribution of lunar surface
(Longitude is 0 to 360°, latitude is 70°S to 70°N)



a. Plagioclase



b. Ilmenite



c. Pyroxene

Fig.2 Correlation of minerals abundance between Clementine data and Apollo samples

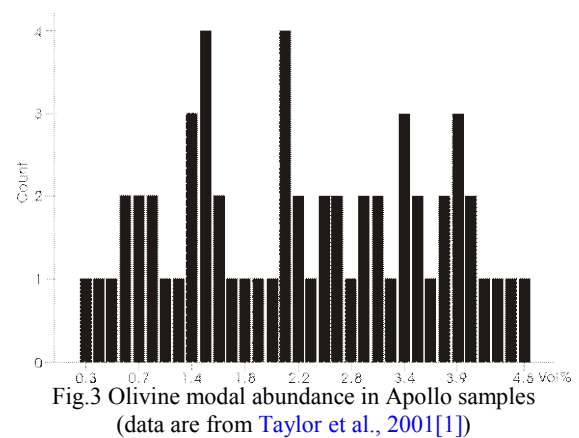


Fig.3 Olivine modal abundance in Apollo samples
(data are from Taylor et al., 2001[1])