RESEARCH ON INVERSION OF MINERAL CONTENT INFORMATION BASED ON HYPERSPECTRAL REMOTE SENSING

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ABSTRACT

Due to its ultra-high spectral resolution, hyperspectral remote sensing has the advantages of identifying and quantitatively detecting ground features.In this paper, three methods, including multiple linear regression, partial least square regression and random forest regression, are used to invert the content of chlorite minerals in Liuyuan, Gansu, China.The results show that the R^2 of the multiple linear regression model is 0.73 and the RMSE is 0.0565; the R^2 of the partial least squares regression model is 0.75 and the RMSE is 0.0535; the R^2 of the random forest regression model is 0.80 and the RMSE is 0.0309. Comparative analysis found that the optimal prediction model for chlorite mineral content inversion was random forest regression, and the optimal prediction model was applied to the hyperspectral data of the GF-5 satellite to show the distribution characteristics of chlorite mineral concentration.

Index Terms— hyperspectral remote sensing, quantitative inversion, GF-5 satellite

1. INTRODUCTION

Mineral identification is one of the advantages of hyperspectral remote sensing technology. This is because the spectral absorption characteristics and mechanisms of minerals are clear and definite, and different minerals have corresponding characteristic absorption spectrum shapes [1]. With the continuous deepening of application practice, the demand for surface mineral content information is also increasing [2], such as rapid indicator screening of abnormal information, mineral dynamic change detection, and so on.At present, the mineral content inversion of hyperspectral remote sensing data mainly uses spectral unmixing [3,4], but this method requires the number of mineral endmembers to be known, and due to the different characteristic absorption spectrum shapes and positions of different minerals, this will cause a large error in the weight of each mineral, so related practical applications are rarely reported.

The depth of the mineral diagnostic absorption band has a certain indication of the mineral content, and it is often used to approximate the relative content of minerals, which provides mechanism support for the quantitative inversion of minerals [5], but the previous remote sensing data is limited by the spectral resolution, and the absorption position of different mineral characteristics is confused and difficult to distinguish, so that it is impossible to carry out quantitative inversion.With the successful launch of GF-5 satellite, GF-5 hyperspectral data has become the current hyperspectral data source with the highest spectral resolution. Different mineral absorption characteristic positions are easy to be distinguished, and their width is large, which has a great prospect in the future hyperspectral application.In this paper, based on the depth parameters of mineral diagnostic absorption bands, three methods of multivariate linear regression, partial least squares regression and random forest regression were selected to carry out quantitative inversion of chlorite minerals using GF-5 data.

2. STUDY AREA AND DATA SOURCE

2.1. Study Area

The study area is located in Liuyuan, Gansu Province, China. It belongs to the Beishan mountain system, with

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Table.1: Basic parameters of GF-5 hyperspectral load

Wavelength range	0.4-2.5μm
Spectral resolution	VNIR：5nm SWIR：10nm
Spatial resolution	30m
Number of bands	330
Width	60km
Average orbit height	705km

an average elevation of about 2000 meters.The bedrock in the study area is well exposed, and the stratum is mainly Sinian and Paleozoic. The Jurassic is only scattered in this area.The magmatic hydrothermal activity in the area is strong and intrusive rocks are well developed, especially in the Variscan period. The main types are granite, potassic granite, quartz diorite, diorite and basic ultrabasic rock, which are produced in the form of batholith, stock and vein.The mineralization in the area is developed, with Au, Cu, Fe, Ni, Pb, Zn, W and other mineralization as the main mineralization. The alteration minerals closely related to mineralization are mainly limonite, sericite, tremolite, and calcite /dolomite, chlorite, epidote, etc.

2.2. Data

2.2.1. GF-5 Hyperspectral Data

The visible shortwave infrared hyperspectral camera carried by the GF-5 satellite is the first hyperspectral camera in the world that takes into account both wide coverage and wide spectrum. The basic parameters of its payload are shown in Table 1.

The data preprocessing first performs radiometric calibration to convert the DN value of the image into a radiance value,then use the modtran model to perform atmospheric correction to obtain the ground reflectivity value,finally,perform radiation uniformization correction to eliminate inconsistencies between different modules.

2.2.2. Sample Collection and Measured Spectrum Data Acquisition

According to the existing geological data in the experimental area, in order to reflect the overall change of chlorite as much as possible, the samples were collected in areas with concentrated and uniform chlorite distribution in different areas, and the samples were representative of the features in the area.

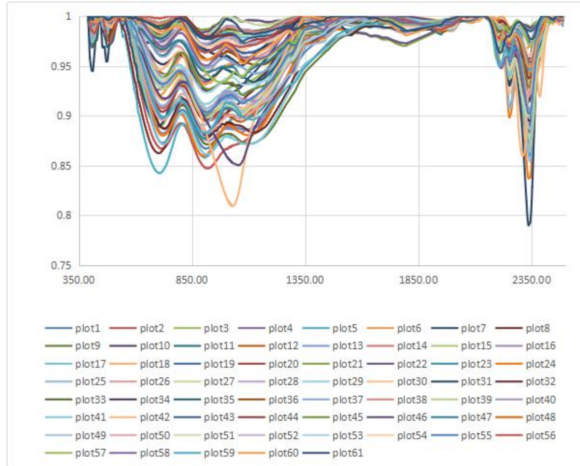


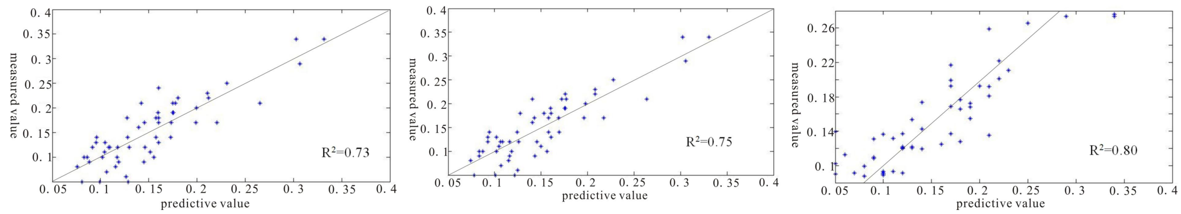
Fig.1: Measured spectral curves after continuum removal of chlorite samples

A total of 61 samples were collected in the field, and a ASD spectrometer was used to measure the spectrum of the sample.When measuring, select the weathered surface and fresh surface of mineral rock to measure separately, keep a vertical distance of 10cm from the probe of the spectrometer, and the spectral reflectance data is the average of 5 measurements. After the continuum of the measured ASD spectrum was removed, it was shown in Fig.1.

3. MODELING AND APPLICATION

3.1. Establishment of Inversion Model for Chlorite Mineral Content

Resample the measured spectral curve to the spectral resolution of GF-5 hyperspectral data, and compared and analyzed the chlorite spectrum in the USGS, combined with the electronic process and vibration process mechanism generated by the absorption spectrum, it is concluded that the chlorite spectrum has obvious absorption characteristics at 2252.01nm and 2336.28nm. Therefore, calculate the absorption depth of each sample curve at 2252.01nm and 2336.28nm, establish the correlation model between it and the real measured value, analyze the accuracy of the three models, the accuracy of the multiple linear regression model is: R^2=0.73, RMSE=0.0344; the accuracy of the partial least squares



(a)multiple linear regression (b)Partial least squares regression (c)random forest regression

Fig.2: Scatter plots of measured and predicted values of chlorite

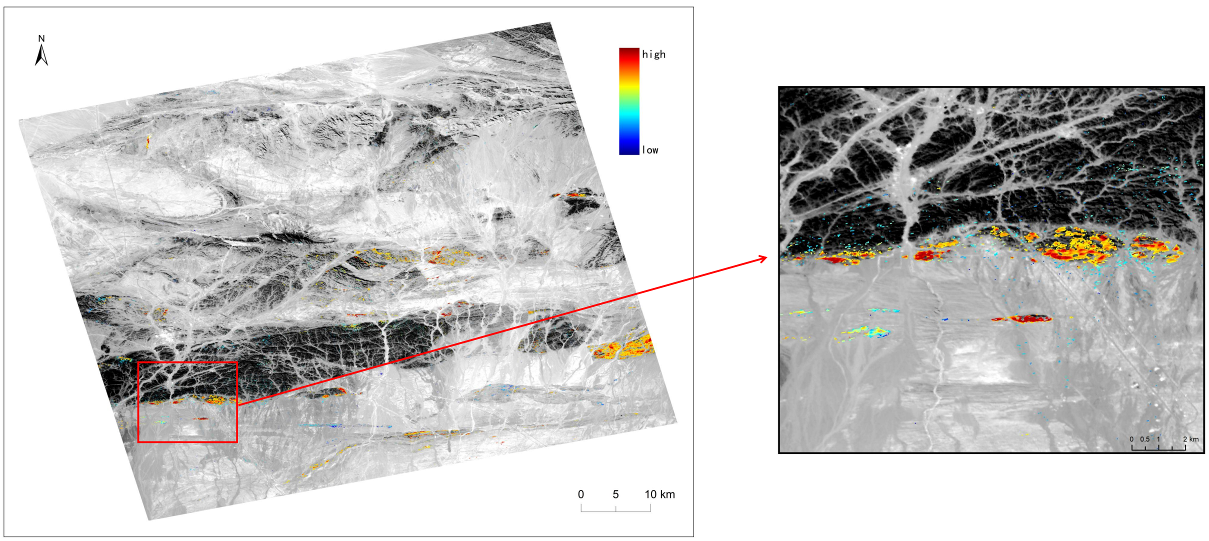


Fig.3: Random forest method chlorite content inversion result diagram

regression model is: R^2=0.75, RMSE=0.0325; the accuracy of the random forest regression model is: R^2=0.80, RMSE=0.0309.The scatter plot of the measured and predicted values of the model is shown in Fig. 2.

3.2. Application of Optimal Forecasting Model in The Study Area

It can be seen from the above that the optimal prediction model for the inversion of chlorite mineral content is the random forest regression method. Therefore, the random forest regression model is applied to the GF-5 data, and the inversion result is shown in Fig. 3.

4. CONCLUSIONS

This article is the first attempt to use GF-5 hyperspectral data to study the content of chlorite minerals based on three models of multiple linear regression, partial least square regression, and random forest regression.The results show that random forest regression has higher accuracy than multiple linear regression and partial least square regression, and can better reflect the distribution of chlorite content in the study area, indicating that hyperspectral remote sensing has certain application value in mineral quantitative inversion.The next step will be to collect samples with gradients, large areas, and multiple regions according to the level of mineral inversion content while verifying information.On the one hand, it improves the accuracy of the model and enhances the universality.On the other hand, it provides effective data support for the application evaluation of the model, and realizes the complete chain of data modeling-modeling application-application evaluation for mineral quantitative inversion,so as to play the greatest advantage of hyperspectral data mineral content inversion in engineering and business applications.

5. ACKNOWLEDGEMENTS

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6. REFERENCES

[1] Yan Shouxun, Zhang Bin, Zhao Yongchao et al., "Summarizing the VIS-NIR Spectra of Minerals and Rocks", *REMOTE SENSING TECHNOLOGY AND APPLICATION*, vol. 4, pp.191-201, 2003.

[2] Li Qianqian, Chen Xiaomei, Liu Xing et al., "Quantitative Analysis of Content and Spectrum of Altered Mineral in the Oil and Gas Microseepage Area", *Spectroscopy and Spectral Analysis*, vol. 12, 2013.

[3] Yan Bokun, Li Jianzhong, Gan Fuping et al., "A Spectral Unmixing Method of Estimating Main Minerals Abundance of Lunar Soils", *Spectroscopy and Spectral Analysis*, vol. 32, no. 12, pp. 3335-3340, 2012.

[4] Tian Feng, "Identification and Quantitative Retrival of Minerals Information Integrating VIS-NIR-MIR-TIR (0.35~25μm) Hyspectral Data", *China University Of Geosciences(Beijing)*, 2010.

[5] Gan Fuping, Dong Xinfeng, Yan Baikun et al., "Research progress of spectrometry geological remote sensing". *Journal of Nanjing University of Information Science & Technology*, vol.10, no. 1, pp. 44-62, 2018.