Research on Hyper-Spectral Data Processing of Rock Minerals

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Abstract. The most successful areas of application of hyper-spectral technology are: mineral identification and mineral mapping. Spectral reflection information and radiation information of mineral species, abundance and composition can identify altered minerals and hydrothermal mineralized alteration zones closely related to mineralization, and quantitative or semi-quantitative estimation of eclipse by correlation analysis methods. Variable strength and altered mineral content. In this study, the field spectral acquisition experiments were carefully designed, the spectral data was collected strictly according to the experimental design, and the data processing was carried out. The field spectral characteristics of different types of rocks in the study area were tested, and the spectral data characteristics of the rocks were compared and analyzed.

Introduction

In the study of hyper-spectral data geological applications, Wang Run sheng et al. based on the different waveforms of minerals, based on the neural network to carry out automatic identification of minerals; Gan Yi ping used image spectroscopy remote sensing technology to identify and extract mineralization alteration information, they Firstly, the low-resolution remote sensing data is used to identify the distribution of geological anomaly areas, and the key sections are circled together with the geological basic data. Then, in the hyper-spectral MAIS data, the erosion information of the circled key sections is extracted. Based on this research, they designed and developed a rock-mineral identification technology based on complete spectral shape imaging, which has achieved very practical effects in geology. Wang Qing hua et al. also used the MAIS image data to test the spectral characteristics of different types of rocks in the study area and compare the spectral characteristics of the rocks. According to the spectral characteristics of different rocks in the study area, the spectral information of the rock is extracted by the image processing method, and the purpose of identifying the rock mineral category is more accurately achieved. The research results of these researchers and the successful application of research methods have also promoted the development of hyper-spectral remote sensing [1]. The application of hyper-spectral remote sensing data has great potential for the study of rock minerals.

Field Experiment Data Collection

Collect data on natural geography, transportation, geological environment, social economy, etc. of the study area; consult research reports, literature, maps, etc. related to hyper-spectral data processing and application of rock mineral alteration information; determine hyper-spectral remote sensing images of research areas that need to be downloaded data [2,3]. Then, after preprocessing the hyper-spectral remote sensing image data, the number of sampling points of ground
hyper-spectral measurement in the study area is initially determined, and the number of samples of
rock mineral alteration samples collected and collected is accurately determined; the GPS control
points are uniformly selected in the study area, and the accuracy is measured. Location information
to provide information for geometric correction of the study area [4].

Field Route Development

According to the three previous field survey routes combined with remote sensing image data and
geological data, the key sampling areas were determined. A 63-day field work was carried out in the
West Junggar area, and 313 rock mineral samples were collected. In November 2011, 313 samples
were sent to the Xinjiang Bureau of Geology and Minerals for sheet inspection. The collected field
data is analyzed with the spectral data extracted indoors.

Sample Collection

(1) Method of sampling

Because remote sensing involves a large space and complex types, how to design a sampling
method that has both a reliable statistical theory and a feasibility in practice is a key issue. First, the
sampling design should use probability sampling to ensure the representativeness and validity of the
sample, so that the use of the sample estimated total parameters is based on a reliable basis.

Commonly used probability sampling methods include simple random sampling, hierarchical
sampling, clustering cluster sampling, and system sampling. Combining geological data and remote
sensing image maps, we use cluster sampling, which saves a certain amount of human and material
resources compared to simple random or systematic sampling. The mountainous terrain in the study
area is complex and not suitable for stratified sampling [5]. By means of spot sampling, more
samples can be taken in a limited space to facilitate field surveys and sample data collection. For
each rock sample collection, the length and width are required to be 12 cm*6 cm or more, and two
weathered faces and two fresh faces are guaranteed to prepare for the later indoor data collection.

(2) Experimental content

The experimental content includes field spectral testing, indoor control spectroscopy testing,
mineral component testing of samples, and thin film identification of samples. The spectral
reflectance of the weathered surface measured by each sample was compared with the spectral
reflectance of the fresh surface. The measured components were statistically compared to find the
reflectance of the spectrum and the correlation coefficient between the components. The purpose is
to obtain the mineral type and content of the sample, the type and content of the metal element, and
provide the basis for the extraction and mineral alteration information [6].

313 rock samples were collected in the study area, and the spectral data of the field were
simultaneously measured during each sample collection. The indoor spectral analyzer was used to
perform indoor spectral control experiments on the weathered surface and fresh surface of 313
samples, and the spectral data measured in the field. Conduct a comparative analysis.

Experimental Instruments

The ASD Field spec Proffer field Spectroradiometer manufactured by American Analytical
Spectroscopy (ASD) was used in this study. The spectrum of the sample was collected from the
surface of the rock mass at the sampling point of 0-40 cm using an ASD spectrometer between 350
and 2500 nm, and the short-wave, near-infrared 2 nm short-wavelength, spectral and normalized
panel at a spacing of about 0.7 nm (Lanfei Optics, NH). Using a tungsten lamp and a direct light
source as a light source in the room, the sensor obtained a data connection without fore-optic, the
lowest point height is 30 cm, and the sample was placed on a 40 cm diameter plate. The bulb is
mounted at a zenith angle of 15° from the sample 1 m [7, 8], operating the spectrometer correctly.

Data Collection

Spectral Data Acquisition Design

Because the spectral measurement of ground objects is an important basis to prove the feasibility
of remote sensing detection, and also the basis of remote sensing image processing and analysis and
application, we try to ensure the reliability of measurement data in the spectrum measurement. In addition to ensuring the stability of the instrument and reference board performance and the standardization and completeness of data records, the following principles are mainly followed: try to ensure the representativeness of the test object, and the selected objects must have a certain breadth distribution. There should be uniformity under the measurement; multiple measurements of multiple points within a certain breadth range for each target are measured. The accuracy of the field spectral measurement data will affect the accuracy of the sample spectrum, and there are many factors affecting the field spectrum observation. Therefore, it is necessary to carry out field spectrum observation according to certain specifications and steps [9, 10]. Spectral testing must follow experimental specifications in order to obtain accurate and valid data.

Spectral measurements of the study area were selected in sunny and windless weather, and the time of each measurement was 12:00 h~16:00 h Beijing time. The spectral resolution is resampled to 1 nm intervals and the output band number is 2151. At each sampling point, the spectrum of the weathering surface is collected before the sample is collected. First, the average point of the measured spectrum is taken, and the average value is taken as the reflectance spectrum of the sampling point. During the measurement, the measurer holds the spectral probe in the direction of the sun, and uses a 25° field of view probe to measure perpendicular to the surface of the soil sample by 2 cm. The spectrometer has a scan time of 0.1 s and the output spectrum is automatically averaged from 10 original scan spectra. After the spectrometer is optimized, the whiteboard is tested to obtain absolute reflectance. In order to reduce the error, each sample was measured for 2 sets of reflectance, and finally averaged. Before and after the measurement of the sample, the reflection brightness value of the reference plate is measured twice, and the average value is taken as the reflection brightness value of the reference plate. The reflectance spectrum of the sample is obtained by the ratio method. The specific spectrum measurement workload is shown in Table 1.

**Indoor Spectral Control Experiment**

After the sample was recovered from the field, the indoor spectral control experiment must be carried out immediately. In order to avoid the inaccuracy of the spectral measurement caused by the oxidation of the fresh surface, the reflectance spectra were measured on 313 samples in a laboratory equivalent to the darkroom. In the test, a 1000 W tungsten lamp and a direct light from the instrument were used as the light source. The angle between the tungsten light source and the vertical direction was 15°, and the distance between the light source and the center of the sample was 30 cm. The effect of background scattered light; using a probe with a 5° field of view, the probe is perpendicular to the surface of the sample at a distance of 5 cm; the direct light is in direct contact with the sample for spectral measurements. The spectrometer has a scan time of 0.1 s and the output spectrum is automatically averaged over 3 original scan spectra. Absolute reflectance was obtained with a white reference plate. In order to reduce the error, a total of 11268 spectral curves were obtained. Each sample was measured for 3 times and the arithmetic mean value was calculated by the ratio to the reflectance spectrum data of the sample.

| condition                  | White board | 2 weathered surfaces | 2 fresh surfaces | 313 sample |
|----------------------------|-------------|----------------------|------------------|------------|
| field                      | 20          | 20                   | 20               | 18780      |
| Indoor direct spotlight    | 6           | 6                    | 6                | 5634       |
| Indoor tungsten lamp       | 6           | 6                    | 6                | 5634       |
| total                      |             |                      |                  | 30048      |

Table 1. Sample spectral collection worksheet.

Under natural conditions, there are many factors affecting the reflectance spectrum of rock samples, such as rock texture, rock color, rock organic matter and soil moisture. In the indoor control test, the samples have the same lithology except for the mineral composition [11]. Under
natural conditions, the influence of the water in the rock on the spectral curve is obvious. Therefore, it is necessary to consider the moisture in the indoor control test. A spectral influence factor.

**Spectral Data Processing**

**Measured Sample Data**

Spectral tests, indoor control spectral test data were measured from 313 rock samples, and the difference in reflectance spectra and the relationship between spectral differences and composition were compared. Since the measured amount of spectral data is large, the spectral data measured for each sample is described in detail in order to avoid data confusion. Among the 60 spectral files measured: 0-9 correction data; 10-19 whiteboard spectral data; 20-39 are two weathered surface spectral data, 40-59 are two fresh surface spectral data; 50 spectra measured in the file: 0-9 whiteboard spectral data; 10-29 are two weathered surface spectral data, 30-49 are two fresh surface spectral data.

**Spectral Data of Mineral Rocks**

1. Field and indoor spectral data

The spectral data obtained by measuring each sample with the spectral radiometer ASD under field and indoor control conditions is the most primitive data, and processing analysis is required to obtain the result. The measured band data is the radiation intensity. The accuracy of the data is affected by the illumination and the stability of the instrument itself. In order to obtain the spectral characteristics of the mineral rock sample in the measurement, the measured radiation value data must be converted into reflectance data. [12]. The measured raw data is imported into the software ASD ViewSpecPro, which is included in the spectrometer, and the software operation is performed: the DN value is converted into the radiance value: Process-radiometric calculation, at which time all the files are automatically converted to *.rad; the spectral curve Correction, here mainly solves the switching problem between different sensors, mainly to stretch the joint between the two bands to make the curve smooth: Process-parabolic correction, pop-up dialog box prompts, whether to perform the same for all files The operation, the key point is, otherwise each file should be ordered a few times, then just click ok ok; export the results of the spectral data: Process-ASCII export.

2. Smoothing

Commonly used smoothing methods are moving average method, static averaging method, Fourier series approximation, and so on. The purpose of spectral smoothing is to eliminate high-frequency random errors. The basic idea is to take “average” or “fit” before and after smooth spectral points to obtain the best estimate of the smoothed spectral points, eliminating the random noise. In this study, the 9-point weighted moving average method is used to smooth and DE noise the spectral curve. The principle is to take the average value of a certain range of values before and after a measurement point on the spectral curve as the value of the point. The spectral curve gives the sequence of N measurement points \{R_i, i = 1, 2, 3..., N \} (N = 2151 for spectral data measured by the ASD Field Spec Pro FR spectrometer). At this time, the value of the i point is taken to include the average of the K points before and after. That is, the new value Ri’ of the i point is replaced by the average value of 2K+1 points including this point, which is called a smoothing value.

\[
R_i' = \frac{1}{2K + 1} (R_{i-k} + R_{i-k+1} + \cdots + R_i + \cdots + R_{i+k})
\]

(1)

This formula uses the sign of and can be expressed as:

\[
R_i' = \frac{1}{2K + 1} \sum_{j=-K}^{K} R_{i+j}
\]

(2)

In formula (2), each point is assigned the same weight \(\frac{1}{2K + 1}\). In fact, according to the distance of each measured value from the point, different weights can be given. The closer to the center
point, the higher the weight. Equation (3) is the calculation formula for the 9-point weighted moving average used in this study:

\[
R_i = 0.04R_{i-4} + 0.08R_{i-3} + 0.12R_{i-2} + 0.16R_{i-1} + 0.2R_i \\
+ 0.16R_{i+1} + 0.12R_{i+2} + 0.08R_{i+3} + 0.04R_{i+4}
\]

(3)

After the spectral curve is processed, the curve becomes smooth, and the resulting new spectral curve is the overall trend line of the old spectral curve.

The effect of noise on the spectrum is not easily noticeable in RAWDN mode, but in Reflectance mode, the ratio of the two spectra will show the effect of noise more clearly [13]. Especially at the wavelength of 1790 nm-1934 nm, since the solar radiation is strongly absorbed by the moisture in the atmosphere, the reflection information here is weak, so the influence of noise is greatly amplified, which is also the fluctuation of the reflectivity of the field observation. Dramatic reasons. Through the removal of the band, the noise in the 1790 nm-1934 nm band is effectively removed during the smoothing process, which preserves the overall trend of the spectrum and better reflects the absorption characteristics of the spectrum.

Summary

Figure 1 is a comparison of the band spectra of the outdoor spectrum and the indoor spectral data measured by the spectrometer of 81 samples. Probe: the light source of the spectrometer, the spectrum of the probe attached to the stone; Light: the dark room uses the tungsten lamp as the light source; outdoor solar spectrum; old: measured stone weathered surface; new: measured stone fresh surface. The results show that the reflectivity of the fresh surface is higher than that of the weathered surface; the reflectivity of the fresh surface spectrum measured by the three methods is greater than that of the weathered surface; the spectra of Probe and Light are close, especially measured. The spectrum of the weathered surface, their reflectivity is higher than Field; due to the influence of air moisture, the field measured spectrum is very noisy at 1820 nm-1920 nm (this spectrum has been eliminated), and after 1920 nm The spectrum also has no spectral smoothing of Probe and Light; the spectrum measured by Probe is “flat” compared to Light and Field: the slopes of the 800 nm and 2100 nm peaks are smaller.

Figure 1. Average of spectral absorption bands of 81 rock samples.
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References

[1] Z. Zhou, P.J. Scales, D.V. Boger Chemical and physical control of the rheology of concentrated metal oxide suspensions. Chem. Eng. Sci., 56 (2001), pp. 2901-2920, 10.1016/S0009-2509(00)00473-5

[2] A. Ambikapathi, T.H. Chan, C.H. Lin, C.Y. Chi. Convex geometry based outlier-insensitive estimation of number of end members in hyper spectral images, Signal. 1 (2012)1–20.

[3] P.J. Du, J.S. Xia, Z.H. Xu, K. Tan, H.J. Su, Bao. Review of hyper spectral remote sensing image classification. J. Remote Sens., 20 (2) (2016), pp. 236–256.

[4] C.C. Chang, C.J. Lin. LIBSVM: a library for support vector machines. ACM Trans. Intell. Syst. Technol. (TIST), 2 (3) (2011)27.

[5] B.W. Chen, C.Y. Chen, J.F. Wang. Smart homecare surveillance system: Behavior identification based on state-transition support vector machines and sound directivity pattern analysis. IEEE Trans. Syst. Man Cyber.: Syst., 43 (6) (2013), pp. 1279–1289.

[6] J.M. Bivouacs-Dias, A. Plaza, G. Camps-Valles, P. Schooners, N. Narbada, J. Chanson. Hyper spectral remote sensing data analysis.

[7] B.W. Chen, W. Jib. Intelligent marketing in smart cities: Crowd sourced data for geo-conquesting. IT Prof., 18 (4) (2016)18–24.

[8] Y. Chen, N.M. Narbada, T.D. Tran. Hyper spectral image classification using dictionary-based sparse representation. IEEE Trans. Geosci. Remote Sens., 49 (10) (2011)3973–3985.

[9] B.W. Chen, A.C. Tsai, J.F. Wang. Structuralized context-aware content and scalable resolution support for wireless VoD services. IEEE Trans. Consum. Electron. 55 (2) (2009).

[10] J. Jiang, L. Huang, H. Li, L. Xiao. Hyper spectral image supervised classification via multi-view nuclear norm based 2D PCA feature extraction and kernel ELM., Geoscience and Remote Sensing Symposium (IGARSS), 2016 IEEE International, IEEE (2016), pp. 1496–1499

[11] F. Jiang, S. Rho, B.W. Chen, X. Du, D. Zhao Face hallucination and recognition in social network services. J. Super computer. 71 (6) (2015), pp. 2035–2049.

[12] J. Addai-Mensah Enhanced flocculation and dewatering of clay mineral dispersions Powder Technol., 179 (2007), pp. 73-78, 10.1016/j.powtec.2006.11.008

[13] B. Ndlovu, E. Forbes, S. Farrokhpay, M. Becker, D. Bradshaw, D. Deglon A preliminary rheological classification of phyllosilicate group minerals. Miner. Eng., 55 (2014), pp. 190-200, 10.1016/j.mineng.2013.06.004