Analysis and Research on Mineral Hyperspectral Features

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Abstract. Hyperspectral Remote Sensing Technology in geological prospecting, spectral feature information extraction and other aspects have made significant progress, and a lot of achievements. Compared with the traditional geological survey, mapping prospecting, geological mapping using hyperspectral have low cost, low consumption, so using hyperspectral remote sensing data have the potential prospects of innovative traditional survey methods. The main object of study is about the western Junggar Basin west to Xiemisitai of East. Experiment on the rock of weathered and fresh face about field spectra, indoor control spectra. Dates of spectral reflectance weathered face and a fresh face comparative analysis have showed that spectral characteristics of weathering rocks and minerals has little effect, but effect its impact on the size of the reflectance. The relationship between mineral elements and mineral composition and spectral characteristics of the samples have investigated between and extract the spectral characteristics and spectral indices of different samples, extract alteration information hyperspectral data providing.

1 Background and Study area

With the rapid sustainable development of our economy, the national economy the demand for mineral resources and energy is increasing. At the same time, surface exposed, burial and the number of known types of deposits added a significant reduction in proven reserves of shallow, making it difficult to meet the needs of traditional prospecting methods. Mining exploration and mining practice at home and abroad has proved that the crisis mine called "resource depletion" is often not enough due to the geological exploration, resource potential has not been fully tapped, and within a certain period of mine and there are around deep resource potential to be tapped, there is an urgent need for large-scale, rapid exploration of mineral resources, to explore new ways of using new methods and techniques to enhance deep mines and peripheral prospecting prediction, the selection focused prospecting targets, provide a scientific basis for the development of sustainable mining . Wall rock alteration is progressively enriched mineralization into minerals left imprinted, most altered rocks and rock types, structure, colours, etc. are obvious differences that determine the characteristics of these rocks reflection spectrum differences, and in particular the formation of the alteration characteristic spectral band spectrum[1,6,9]. By applying a high spectral characteristic spectral data to identify mineral extraction feature wall rock alteration is an effective method of prospecting. At present, the theory of remote sensing information extraction of mineralization and alteration numerous, in which the study of multi-spectral data of principal component analysis and other analytical methods are mostly applied research hyperspectral data in terms of mineralization alteration information extraction has also made some progress.

In this study, hyperspectral remote sensing alteration information extraction technology research as a starting point, through the analysis of the spectral characteristics of altered minerals, alteration of iron ore extracted information in the study area; geological data, mineralization of the region Prediction provide data support and technical support. Electromagnetic and surface rocks, geological play a role, resulting in its characteristic spectral remote sensing Extraction of mineralization alteration information provides a physical basis, with the development of remote sensing imaging technology and digital image processing technology, the use of remote sensing technology with multiple sources geoscience information extraction mine alteration of information is increasingly being applied to practical geological work[2,8]. Multispectral self-limiting because the spectral resolution, it is difficult to feature unique rich spectrum information to distinguish. With hyperspectral technology matures, related geological and remote sensing experts have done a lot of work in geological prospecting, spectral feature information extraction, etc., as more and more complete feature standard spectral library (USGS, JPL Mineral Spectral library, Chinese typical feature standard spectra databases, etc.), the new hyperspectral data processing and analysis methods, which laid the foundation for the further application of high spectrum[3-5].

Hyperspectral imaging spectrometer remote sensing technology will breakdown spectroscopy imaging techniques and technology together, compared with multispectral, hyperspectral remote sensing data has the following characteristics: a large amount of data, the correlation between the higher band, data redundancy higher margin [7]. Hyperspectral remote sensing space, there are a wealth of information, radiation information, three-dimensional information spectrum, between time resolution and spatial resolution has more advantages, high spectral remote sensing can be improved from the spectral resolution remote sensing images. Therefore, in the field of geological study, combined with hyperspectral remote sensing technology can not only widen the field of applications of space remote sensing, the study may also have the advantage of bare rock area, the effect will be more prominent.

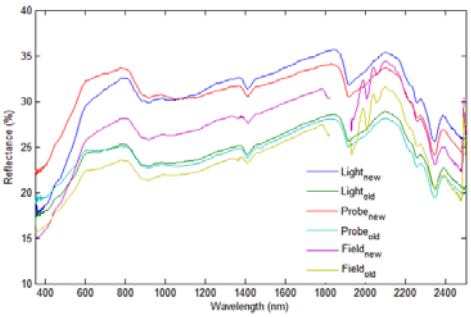

Figure1. Absorption spectra of rock samples

Study area is located in the northern part of Xinjiang border about the western Junggar Basin west to Xiemisitai of East. Administrative division has belonged under the jurisdiction of the Ili Kazak Autonomous Prefecture Tacheng. The main research areas are Mongolian Autonomous County of Hoboksar from about 40 km southwest of the county. Geographical coordinates the approximate range: E85 ° 00'-85 ° 45 ', N46 ° 33'-46 ° 44'. The key field survey area have located in E45 ° 55'43.16 "-46 ° 51'34.24", N85 ° 43'57.21 "-85 ° 48'57.21".

2 Research methods

The spectral reflectance of each sample measured weathered faces and fresh faces have analyzed to find out the correlation coefficient between the spectral reflectance. Further information and provide the basis for the extraction of mineral alteration information. To see their spectral absorption band (absorption band depth) shown in Figure 1 about spectral changes of fresh faces and weathered surface of rock samples.

The results have showed that fresh surface reflectance than the high weathering face. Three methods of measuring the fresh surface spectral reflectance difference have greater than the weathered surface reflectance. Probe and Light spectrum have closed approaching of especially spectrum measured weathered face and their higher reflectance than field. Due to the influence of air moisture, Field measured spectrum in 1820 nm-1920 nm noisy (shown in this spectrum have been removed), in addition to 1920 nm spectrum after no Light Probe and spectral smoothing; Probe measured spectrum than Light and Field to be "flat" Some: 800 nm and 2100 nm two peaks slope smaller.

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Table1. ND index weathered faces and fresh faces

Weathering face

	λ1	λ2	Light			Probe			Field		
			R^2	RMSE	CV(%)	R^2	RMSE	CV(%)	R^2	RMSE	CV(%)
K	370	880	0.21	0.76	85.51	0.19	0.76	85.89	0.21	0.76	85.35
Ca	900	1870	0.20	6.43	103.27	0.18	6.70	107.47	0.20	6.75	108.35
Cr	1890	1910	0.19	1.49	67.51	0.17	1.51	68.53	0.18	1.51	68.62
Fe	2210	2260	0.44	1.09	48.30	0.41	1.15	50.92	0.36	1.18	52.08
Cu	1480	2480	0.21	0.57	78.74	0.22	0.61	83.86	0.26	0.59	81.07
As	1860	1910	0.20	3.52	90.25	0.20	3.49	89.53	0.21	3.54	90.74
Sb	1860	1910	0.21	1.92	74.76	0.17	2.01	78.32	0.20	1.96	76.35

Fresh faces

	λ1	λ2	Light			Probe			Field		
			R^2	RMSE	CV(%)	R^2	RMSE	CV(%)	R^2	RMSE	CV(%)
K	2320	2350	0.20	0.76	85.28	0.19	0.78	87.99	0.18	0.79	88.63
Ca	2320	2350	0.21	7.14	114.53	0.21	7.14	114.57	0.17	7.31	117.28
Cr	2330	2340	0.24	1.47	67.02	0.23	1.59	72.15	0.21	1.56	70.76
Fe	2220	2250	0.48	1.08	47.95	0.42	1.16	51.53	0.39	1.12	49.61
Cu	1900	2250	0.28	0.59	80.71	0.28	0.58	79.55	0.26	0.65	89.01
As	1430	1480	0.17	3.33	85.29	0.21	3.43	87.99	0.22	3.34	85.57
Sb	2380	2400	0.19	1.98	77.20	0.21	2.00	77.85	0.20	2.01	78.06

According to the measured data are shown in Table 1. Correlation analysis have been seen to do the different elements have their own sensitive bands. Although the correlation has not high, but the description of the individual bands has not enough information to derive the content of the element. ND types with spectral indices (such as the SR and D other types of index have been tried, the results are not good ND), Fe highest estimation accuracy, R2 can reach about 0.4, and the highest content of Fe is not the highest element content Ca element estimation accuracy but the worst (RMSE maximum), which shows the different elements of the spectral inversion, the higher retrieval accuracy is not the content

of the element as possible, the spectral reflection of the different elements are different[10,14].

Comparison between the results of various methods of observation, such as remote sensing images extracted from hyperspectral data from these sampling points, compare the actual time will reduce the number of precision applications. Compare weathered face and the new face of the samples from: There are significant differences in the spectral index and precision are also differences.

3 Rock extracted spectral index

Rock spectral index extract spectral index have usually a combination of two or more spectral bands from, it has a powerful tool widely used to identify the characteristics of surface features. Many studies have developed a different band combination index for vegetation cover information extraction, crop yield assessment and land use change, etc. High spectral index is the use of two or more narrow spectral bands, spectral index a ratio, subtraction or multiplying combinations formed. And multi-spectral broad-band spectral indices of different, high spectral narrow band spectral index can take full advantage of the characteristics of having a narrow spectral band spectral continuity and hyperspectral data, very effective use of subtle features continuous spectrum of surface features, composition of surface features quantitative analysis components, so as the development of hyperspectral technology, hyperspectral index has been widely used. This study will explore the application of high spectral index and to obtain a large area of rock erosion change parameters for the application of hyperspectral remote sensing data provide a theoretical basis. There are seven kinds of high spectral index from the most simple to the more complex R index DDn index (Table 2).

Hyperspectral index have used in this study can be divided into the following three categories:

(1)Single band or two bands of reflectance index difference (R)

(2)Simple index or reflectance ratio improved simple ratio index (SR, mSR)

(3)Normalized Difference Index or modified normalized difference index (ND, mND)

Determine the best rock and mineral spectrum index have consisted two parts: (1) for each index involved in testing to find the optimal spectrum band; (2) to determine the relationship between the spectral index and the linear regression equation. Band spacing 1 nm, the correlation coefficient was the biggest band combination the best band combination, which can be considered the band combination is the index of some alteration minerals sensitive band. Samples have randomly divided into two groups, two-thirds of the sample composition modelling. Sample set used to build the regression model to estimate the remaining third of the sample have been composed of test sample set used to validate the regression model has been established[11-13].

Table 2. Common hyper spectral index

Hyperspectral Index	Types of	Meaning	Formula
R	Reflectivity	Reflectivity	$\rho\lambda1$
D	Derivative	First Derivative	$\rho\lambda1-\rho\lambda2$
SR	Reflectivity	Simple ratio	$\rho\lambda2/\rho\lambda1$
ND	Reflectivity	Normalized Difference	$(\rho\lambda1-\rho\lambda2)/(\rho\lambda1+\rho\lambda2)$
mSR	Reflectivity	Simple ratio improved	$(\rho\lambda1-\rho\lambda2)/(\rho\lambda1+\rho\lambda2-2\rho\lambda3)$
mND	Reflectivity	Improved normalized difference	$(\rho\lambda1-\rho\lambda3)/(\rho\lambda2-\rho\lambda3)$
DDn	Reflectivity	Double difference	$2\rho\lambda1-\rho(\lambda1-\lambda2)-\rho(\lambda1+\lambda2)$

$\lambda1$, $\lambda2$ and $\lambda3$ represents wavelength

4 Conclusion

In this context, more attention alteration minerals in the visible - performance characteristics of the near-infrared spectral bands in its inherent physical, structural properties at a certain spatial scale integrated contact.

Spectral characteristics of altered minerals, or strictly speaking, have the surface called "pixel" in response to the sensor characteristic wavelength varies, not only by its inherent chemical composition and physical composition of the decision, but also by an important influence factors that Effect structure, that have the constituent components of the relationship between, including physical, chemical, biological and even spatial geometry that has (mathematical) relationship, and these relations, more performance for the mutual effect[14].

In addition, remote sensing images are always the target in a certain state and instantaneous information, the empty position sensor records, and is the object of a passive reaction after by environmental factors (such as the well-known sun, atmosphere, sensors) on the nature of the image signal, Therefore, the image data characteristic element of performance in addition to that decisive influence inherent composition and structure, but also by transient environmental conditions [15].

Therefore, the image we obtained demonstrated by the digital signature, is at a certain time, space environment, their internal composition and structure inherent in a comprehensive response to the results of optical radiation to the target object. And certainly, the object itself as well as sports and action mechanism between it and environmental physics, chemistry, biochemistry is a scientific basis for this article is empty environment. These factors are organically linked images. But the former is internal, the latter are external factors affecting the formation of the latter by the former in the final analysis is to act as the environmental impact in the final analysis is the interaction between substances.

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References

[1] Frank J.A. van Ruitenbeeka, Wim H. Bakkera, Harald M.A. van der Werffa, Tanja E. Zegersb, Jelmer H.P. Oosthoekc, d, Zulfa A. Omera, Stuart H. Marshe, f, Freek D. van der Meera. Planetary and Space Science, 101(2014)

[2] Cui Jing, Yan Bokunb, Wang Runshengb, Tian Fengd, Zhao Yingjund, Liu Dechangd, Yang Sumingb, Shen Wei. International Journal of Applied Earth Observation and Geoinformation, 33(2014)

[3] Clark R. N., Swayze G., Gorelick G. Proceedings of the, JPL Publication, 1991

[4] D. Rokos, D. Argialas, R. Mavrantza, K. St.-Seymour, C. Vamvoukakis,M. Kouli,S. Lamera, H. Paraskevas, I. Karfakis, G. Denes.Structural. Natural Resources Research, 9(2000)

[5] Rajesh H. M. Ore Geology Reviews, 33,(2008).

[6] Timothy M. Kusky, Talaat M. Ramadan. Journal of African Earth Sciences, 35 (2002)

[7] Kruse F. A., Lefkoff A. B., Bordman J. W.Remote Sensing of Environment, 44, (1993)

[8] Mohamed G Abdelsalam, Robert J Stern, Woldegabriel G Berhane. Journal of African Earth Sciences, 30(2000)

[9] L.C Rowana, J.K. Crowleya, R.G Schmidta, C.M Agerb, J.C Mars. Journal of Geochemical Exploration,68(2000)

[10] Anko Börnera, Lorenz Wiesta, Peter Kellerb, Ralf Reulkea, Rolf Richtera, Michael Schaepmanb, Daniel Schläpfer. ISPRS Journal of Photogrammetry and Remote Sensing,55(2001)

[11] Asunción Riaza, Peter Strobl, Ulrich Beisl, Andrea Hausold, Andreas Müller. International Journal of Applied Earth Observation and Geoinformation,3(2001)

[12] Laurel Kirklanda, Kenneth Herrc, Eric Keimc, Paul Adamsc, John Salisbury, John Hackwell, Allan Treiman. Remote Sensing of Environment,80(2002)

[13] Brian S. Penn. Computers Geosciences,28(2002)

[14] Beth A Staffileno, Ann F Minnick, Andrius Dumasius, Steven M Hollenberg. Journal of the American College of Cardiology,43(2003)

[15] Ahmed Mohamed Husseina, Samer Malak Botrosa, Shereen A. Saleh. The Egyptian Journal of Radiology and Nuclear Medicine,3(2015)