

Analysis of chemical components and spectral characteristics of rock

Wei Wang, Jinlin Wang, Kefa Zhou, Zhixin Zhang, Shuguang Zhou, Shihui Du-qian

Xinjiang Research Center for Mineral Resources, Xinjiang Institute of Ecology and Geography, Chinese Academy of Sciences, Urumqi, Xinjiang 830011, China
Xinjiang Key Laboratory of Mineral Resources and Digital Geology, Urumqi, Xinjiang 830011, China

Abstract: The old surface and the fresh surface of the rock samples have been subjected to field spectrum test what should be compared indoor control spectrum test, and the mineral element test of the sample and the observation of the sample under thin film have been carried out. The spectral reflectance of old surface and fresh surface shows that the old effect has little effect on the spectral characteristics of rock minerals which affects the size of the reflectance. The difference are between the mineral elements and the spectral characteristics of the samples. The spectral characteristics and spectral indices of different samples have ex-tracted and the data have extracted for hyper-spectral data extraction of alteration information.

1 General Instructions

In order to analyze the presence or absence of each mineral element which consists with minerals effect on the spectral characteristics of the altered mineral. Typical 81 samples are selected from 313 samples and each sample 36 values of the main element content. Randomly selected a fresh surface and a weathering surface from each sample, in each of the fresh surface and the weathering surface to play more than 5 elements of the composition points, each face 5 points of the elemental content of the average value of the sample to estimate the composition of the data. Among the 36 elements have LE, P, S, Cl, K, Ca, Ti, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, As, Se, Rb, Sr, Zr, Mo, Ag, Cu, As, Sb. The 36 elements are measured for the average 92.97% accounting for only 7 elements: K, Ca, Cr, Fe, Cu, As, Sb. In the data, the average of Ca in 81 samples are the highest and are followed by Fe, as shown in Table 1.

2 Research Method

The spectral changes between the weathering surface and the fresh surface of the 81 rock samples are compared with the chemical composition of the rock samples. The samples have been measured by the spectrometer of the outdoor spectrum and indoor spectral data band comparison chart. Probe: spectrometer comes with the light source, the probe close to the stone measured spectrum; Light: dark room using tungsten lamp as light source; Field: outdoor sun. The stone is a fresh side of the stone. The results show that the reflectivity of the fresh surface is higher than that of the weathering surface. The reflectivity of the fresh surface spectrum of the three methods is larger than that of the weathering surface. The spectra of Probe and Light are close, Of the weathering surface of the spectrum, their reflectivity is higher than the Field; due to the impact of air moisture, Field spectrum measured in the



1820 nm-1920 nm noise is very large (the figure has been removed this spectrum), another 1920 nm Spectrum does not have a smooth spectrum of Probe and Light; the spectrum of the probe is "flat" compared to Light and Field: the peaks of 800 nm and 2100 nm are smaller, and the sensitive bands of seven major mineral elements See Figure1.

3 Mineral Spectral Index Extraction

The spectral index is usually a combination of two or more spectral bands, and is a powerful tool for extensively identifying features. Many studies have developed indices for different combinations of bands for vegetation cover information extraction, crop yield assessment, and land use change. Hyper-spectral index is a spectral index formed by a combination of two or more narrow spectral bands, in a combined manner of addition, subtraction, or multiplication. Unlike the multi-spectral broad-band spectral index, the hyper-spectral narrow-band spectral.

Table 1 81 samples 7 elements of the proportion of the composition of the elements

	K	Ca	Cr	Fe	Cu	As	Sb	Total1	Total2
Mean	0.89	6.23	2.20	2.26	0.73	3.90	2.57	18.79	20.21
Min	0.00	0.00	0.00	0.24	0.00	0.00	0.00	0.56	0.77
Max	4.90	59.43	7.13	8.37	4.66	27.65	10.72	61.02	63.25
SD	1.26	13.30	2.18	1.62	1.2	6.15	3.15	13.54	13.87
CV	1.42	2.14	0.99	0.72	1.40	1.58	1.22	0.72	0.69

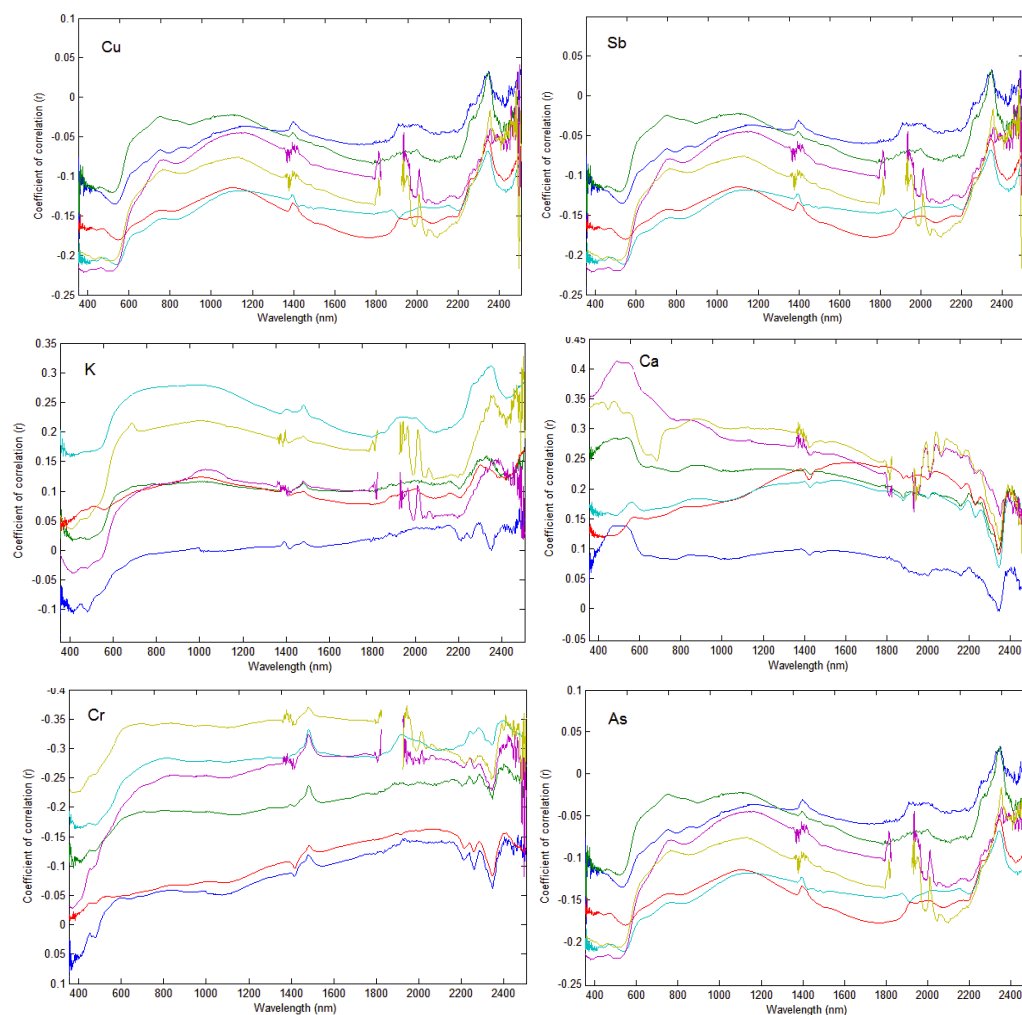
Table 2 Common Hyper-Spectral Index

Hyper	Index type	Meaning	Formula
R	Reflectivity	Reflectivity	$\rho\lambda 1$
D	Derivative	First Deriva-	$\rho\lambda 1 - \rho\lambda 2$
SR	Derivative	Simple ratio	$\rho\lambda 2 / \rho\lambda 1$
ND	Derivative	Normalized	$(\rho\lambda 1 - \rho\lambda 2) / (\rho\lambda 1 + \rho\lambda 2)$
mSR	Derivative	Improved sim-	$(\rho\lambda 1 - \rho\lambda 2) / (\rho\lambda 1 + \rho\lambda 2 - 2\rho\lambda 3)$
mND	Derivative	Improved	$(\rho\lambda 1 - \rho\lambda 3) / (\rho\lambda 2 - \rho\lambda 3)$
DDn	Derivative	Double differ-	$2\rho\lambda 1 - \rho(\lambda 1 - \lambda 2) - \rho(\lambda 1 + \lambda 2)$

Index can make full use of the hyper-spectral data with spectral continuity and narrow spectral band characteristics by Clark R. N., Swayze G. [1]. It is very effective to use the fine feature of the continuous spectrum of objects by Coble P.G. [2]. The hyper-spectral index has been widely used with the development of hyper-spectral technology. In this study, hyper-spectral exponential probes will be used to provide a theoretical basis for the application of hyper-spectral remote sensing data to obtain large-scale rock alteration parameters by Coble P.G., Green S.A., Blough N.V., Gagosian R.B. [3]. There are seven hyper-spectral indices from the simplest R-index to the more complex DDn index, to see Table2.

In Table 2, the signals are reflected by the elements in the spectrum are affected by their contents, and the roughness of the rock surface also affects the spectral inversion element content. The correlation analysis shows that the different elements have their own sensitive bands, although the correlation coefficient is not high, but the information of a single band is not enough to derive the element content, with the ND type spectral index (other types such as SR and D index have been tested, the results are no ND good). Fe is the highest accuracy of the estimated, R^2 can reach 0.4 or so, and Fe is not the highest content of the elements, the highest content of the element Ca estimation accuracy but the worst (RMSE maximum), which shows spectral inversion of different elements, not the higher the

content of the elements of the inversion accuracy is better. The spectrum of different elements of the reflection are different. The signals are reflected by the elements in the spectrum. The signals are affected by their contents, and the roughness of the rock surface also affects the spectral inversion element content. The correlation analysis shows that the different elements have their own sensitive bands, although the correlation coefficient is not high, but the information of a single band is not enough to derive the element content, with the ND type spectral index (other types such as SR and D index have been tested, the results are no ND good). According to the analysis of 36 elements in the sample, only seven elements were obtained: K, Ca, Cr, Fe, Cu, As and Sb were dominant, accounting for 92.97% of the 36 elements. Figure 1 shows that in the details of the details, different rock samples, pop shape differences are obvious, whether it is fresh or weathering surface, in the 1950-2350. According to Figure 1, we show that the seven elements of the reflection coefficient peak comparison Nm band. Weathering surface spectral curve is slightly different, weathering surface in the range of 350-1790 nm, there is no difference, but in the 1950-2500 nm this band.



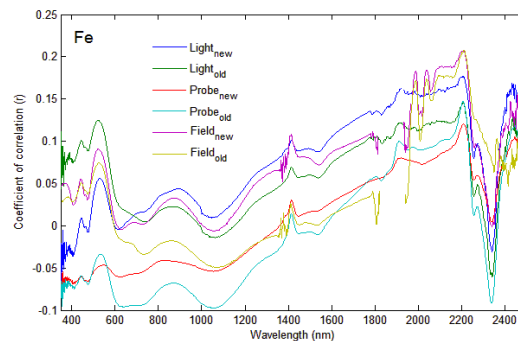


Figure1 Comparison of the seven main elements of the reflection coefficient peak

Its spectral characteristics of significant differences. Despite limitations of the instrument itself, resulting in the 1790-1934 nm within the range of abnormal reflectivity (mainly the instrument undercurrent and environment impact, resulting in abnormal reflectivity), the band within the spectral parameters of each sample are removed.

4 Results and Discussion

The spectral reflectance of weathering surface and fresh surface shows that the weathering effect has little effect on the spectral characteristics of rock minerals, only affects the size of the reflectance. The difference between the mineral elements and the mineral elements and the spectral characteristics of the samples by Jiang F., Sen-Chun Lee F., Wang X., Dai D. [4]. The spectral characteristics and spectral indices of different samples have extracted and the data have extracted for hyper-spectral data extraction of alteration information by K. St.-Seymour. [5].

The spectral data of the rock mineral samples have been sampled by the ASD Field Spec FR weather meter spectrometer in the sunlight, the spotlights and the tungsten light source have combined with the sample information data, the microscopic observation data and the mineral element measurement data to construct the rock mineral samples by Kruse F. [6]. The spectral data of the rock mineral samples are combined with the standard data of the USGS library, and the spectral data are subjected to the envelope and other treatments. The spectral characteristics of Hyper-spectral characteristics of the iron mineralized alteration minerals in the study area are analyzed by Karabashev G.S. [7]. The overall effect is ideal, there is further research and application value. The application of hyper-spectral remote sensing technology in geological prospecting and extraction of spectral information of metamorphism has made obvious progress and a lot of results by Kukavica, M. Ziane. [8] and Matthews B.J.H., Jones A.C. Theodorou N.K. Tudhope A.W. [9].

5 Conclusions

To compare with traditional geological survey, prospecting and mapping methods, low spectral geological mapping has low cost and low consumption. So the using of Hyper-spectral remote sensing data is a potential for innovative traditional methods of investigation by Nagorniy I.G., Mayor A.Y., Salyuk P.A., Krikun V.A. [10] and Parlanti E., Worz K., Geoffroy L., Lamotte M. [11]. The weathering and fresh surfaces of rock samples have been subjected to field spectroscopy tests, indoor control spectroscopy tests, and measurement of mineral element testing of the samples. The spectral reflectance of weathering surface and fresh surface shows that the weathering effect has little effect on the spectral characteristics of rock minerals, only affects the size of the reflectance by Rajesh H. M. [12] and Timothy M. [13]. Difference between the mineral elements and the mineral elements and the spectral characteristics of the samples. Spectral characteristics and spectral indices of different samples have been extracted, which have been provided effective data for Hyper-spectral data extraction of alteration information.

In this study, we have extracted the spectral characteristics and corresponding spectral indices of

various alteration minerals in the study area, and have analyzed the spectral characteristics of iron mineralized alteration minerals in the study area. The follow-up work will use WRBD algorithm to extract the characteristic spectra. Spectral data of each pixel of HJ-1-A are extracted and matched, and the distribution of iron mineralization in the study area is extracted and the preliminary field verification is carried out. Overall effect is ideal. There is further research and application value.

This work has been supported by the Natural Science Foundation of China (U1503291) and Xinjiang Uygur Autonomous Major Project (201330121-2).

References

- [1] Clark R. N., Swayze G. (1991). Proceedings of the Third Airborne Visible/Infrared Imaging Spectrometer (AVRIS) Work shop [M], JPL Publication.
- [2] Coble P.G. (1996). Characterization of marine and terrestrial DOM in seawater using excitation-emission matrix spectroscopy. *Marine Chemistry*.51:325-346.
- [3] Coble P.G., Green S.A., Blough N.V., Gagosian R.B. (1990).Characterization of dissolved organic matter in the Black Sea by fluorescence spectroscopy *Nature*. 348:432-435.
- [4] Jiang F., Sen-Chun Lee F., Wang X., Dai D., 2008.The application of Excitation/Emission Matrix spectroscopy combined with multivariate analysis for the characterization and source identification of dissolved organic matter in seawater of Bohai Sea, China. *Marine Chemistry*.110: 109-119.
- [5] K. St.-Seymour. (2000). Structural Analysis for Gold Mineralization Using Remote Sensing and Geochemical Techniques in a GIS Environment: Island of Lesbos, Hellas [J]. *Natural Resources Research*, 9(4):45—49.
- [6] Kruse F. (1993).The spectral image processing system(SIPS)-interactive visualization and analysis of imaging spectrometer data [J].*Remote Sensing of Environment*,(44):145-163.
- [7] Karabashev G.S. (1987).Fluorescence in the ocean.Leningrad. *Gidrometeoizdat*. 200.
- [8] Kukavica, M. Ziane. (2006).One component regularity for the Navier–Stokes equations *Nonlinearity*, 19(2):453–469.
- [9] Matthews B.J.H., Jones A.C. Theodorou N.K. Tudhope A.W. (1996). Excitation-emission-matrix fluorescence spectroscopy applied to humic acid bands in coral reefs. *Marine Chemistry*. 55:317-332.
- [10] Nagorniy I.G., Mayor A.Y., Salyuk P.A., Krikun V.A. (2015). Mobile hyper spectral optical complex for under satellite ocean research. *Proceedings of SPIE - The International Society for Optical Engineering*. 21st International Symposium Atmospheric and Ocean Optics: Atmospheric Physics. V.9680-96804.
- [11] Parlanti E., Worz K., Geoffroy L., Lamotte M. (2000). Dissolved organic matter fluorescence spectroscopy as a tool to estimate biological activity in a coastal zone submitted to anthropogenic inputs. *Organic Geochemistry*.31:1756-1781.
- [12] Rajesh H. M. (2008). Mapping Proterozoic unconformity-related uranium deposits in the Rock-hole area, Northern Territory, Australia using Landsat ETM+. *Ore Geology Reviews*, (33): 382-396.
- [13] Timothy M. (2002). Structural controls on Neoproterozoic mineralization in the South Eastern Desert, Egypt: an integrated field, Landsat TM, and SIR-C/X SAR approach [J]. *Journal of African Earth Sciences*, (35):107-121.