The Extraction of Altered Minerals by use of Hyperspectral and Aster Data and Their Comparison Research in Beketan, Altyn

H Yi*, J Q Li, G L Ren, M Yang, H H Han, T Gao and J L Yang
Xi'an Center of Geological Survey, Geological Survey of China, Xi'an, China
E-mail: joy200299@163.com

Abstract. Hyperspectral remote sensing technology has played an important role in the field of geological application in recent years. Based on the reflectance of typical altered minerals and the spectral characteristics of rocks, we tried to identify and extract the altered minerals such as calcite, dolomite, epidote, chlorite, mica, limonite, hematite, etc. by using of CASI/SASI data in Beketan, Altyn. Moreover, we extracted Mg-OH/CO$_3^{2-}$/Al-OH/Fe$_3^+/Ferric oxide$ from Aster data by the ratio method. Combined with known geological background and the field investigation, we found that the extracted altered mineral information was consistent with the actual distribution of the field. The altered mineral information extracted by Hyperspectral data displayed more mineral distribution in details. It showed that the hyperspectral remote sensing technology could provide accurate hydrothermal altered mineral information which is helpful for geological mapping work.

1. Introduction
Hyperspectral remote sensing technology has been widely used in geological, mineral resources, and related environment survey because of its high spectral resolution and high spatial resolution since 1980s [1-3]. Extracting alteration minerals and identifying lithology by remote sensing spectral information is very important in remote sensing geology field. In this paper, we extracted the altered minerals information and Fe$_3^+/Al-OH/Mg-OH/CO_3^{2-}$ by Hyperspectral data and Aster data. Accorded with the geological background, we evaluated the result of different data.

2. Data Parameters and their preprocessing
The hyperspectral data used in this paper was acquired by airborne hyperspectral imager CASI/SASI and Table 1 presents its Parameters [4]. Data acquisition time: July to August 2012; time of flight: 11 to 16; the weather: sunny, low cloud cover, visibility > 20 km.

High spatial resolution (1m) DEM data which was obtaining by laser radar are applied to CASI/SASI data Ortho-rectification, and then the hyperspectral data of different strips were assembled and carried out geometric correction. We superposed CASI and SASI together, with all the CASI bands reserved while the bands of SASI which had the same range of CASI’s or were deeply influenced by water vapor were removed. After the atmospheric correction of overlay data, we got the high spectrum data that has been processed [5].

The Aster data has eight bands whose wavelength from 0.52- 2.43 $\mu$m. Its acquisition time: October 2016; area cloud cover pct: <1%. We reprocessed the aster data such as removing its border, inversing the reflectivity, removing the interference features and carrying out geometric correction, etc.
After that, the Aster data can be used to extract alteration information.

### Table 1

| Parameters                  | CASI          | SASI          |
|-----------------------------|---------------|---------------|
| Band range                  | 380-1050 nm   | 950-2450 nm   |
| Number of pixels per line   | 1470          | 640           |
| Continuous spectral channel | 288           | 100           |
| Spectral bandwidth          | 2.3 nm        | 15 nm         |
| Frame rate                  | 14            | 100           |
| Spatial resolution          | 0.9 m         | 2.2 m         |

3. **Geology Background**

Figure 1 shows the geology environment in Beketan, Alty. The exposed stratas are Jixianian Period Jinyanshan Group (Jxj) and Cambrian - Ordovician Hongliugou Ophiolite (∈ Ohm). The former stratum contains calcirudite(cal), dolomitic marble(dolmb), sandstone(ss) while the other consists of schist(sch), phyllite(ph), limestone(ls), siliceous rock(si). In this region, the fault structure develops well, they are mainly distributed in the nearly east-west and northeast directions. There are also intensive Magmatism, and the magmatic rocks are mainly ultrabasic rocks, diabase, and granite which were formed in the Caledonian period.

![Figure 1 The geological map of Beketan in Alty area.](image)

1. Quaternary; 2. Hongliugou Ophiolite; 3. Jinyanshan Group; 4. schist/phyllite; 5. limestone; 6. siliceous
rock; 7. calcirudite; 8. dolomitic marble; 9. sandstone; 10. granite; 11. diabase; 12. ultrabasic rocks; 13. fault; 14. geological boundary.

4. Alteration mineral information extraction

4.1. Spectral characteristics of typical altered minerals

Table 2 shows different spectrum curves of typical alteration minerals in USGS spectra library [6]. The mineral spectra of Mg-OH and carbonate are characterized by the maximum absorption spectrum bands of 2300 ~ 2400 nm, which is also a significant sign for the identification of Mg-OH containing minerals [7-8]. Its representative minerals are calcite, dolomite, epidote, chlorite, etc. The recognition spectrum bands of minerals containing Al-OH is located between 2165 ~ 2215 nm, and the representative minerals are muscovite and illite. The identification spectrum bands of minerals containing Fe$^{3+}$ is located near 600 ~ 900 nm, whose representative minerals are limonite, hematite, etc.

Figure 2 Typical alteration minerals spectral curves in USGS Spectral library.

4.2. Spectral characteristics of typical altered minerals

The alteration mineral information was extracted according to the absorption spectrum bands of different minerals. For Aster data, (band 7 + band 9) / band 8 was used to extract Mg-OH / CO$_3^{2-}$ information, (band 5 + band 7) / band 8 to extract Al-OH information, band 2 / band 1 to extract Fe$^{3+}$ and band 4 / band 3 to extract ferric oxides information.

Figure 3 (a)(c)(e) shows the ionic groups anomaly information extracted by Aster data, and Figure 3 (b)(d)(e) presents corresponding altered mineral information extracted by hyperspectral data. Mg-OH/ CO$_3^{2-}$ anomalies in Figure 3 (a) mainly show planar or banded distribution in dolomitic marble of Jxj strata, a few anomalies distributed in schist and phyllite of ∈ Ohm strata. In Figure 3 (b), four kinds of minerals that containing Mg-OH or CO$_3^{2-}$ are extracted. Calcite and dolomite basically exhibit the same distribution of dolomite marble of Jxj strata. Besides, chlorite and epidote are not only distributed in the schist and phyllite of ∈ Ohm strata but also in the dolomite marble of Jxj strata. As shown in Figure 3 (c), Al-OH anomalies present planar distribution in the schist and phyllite of ∈ Ohm strata and granite. A few scattered points corresponding to the Al-OH anomalies are distributed in the white image area of the dolomite marble of Jxj strata. From Figure 3 (d), high-Al muscovite mainly present scattered point or banded distribution in the dolomite marble of Jxj strata. While low-Al muscovite mostly presents planar distribution in the schist and phyllite of ∈ Ohm strata and granite, however, a few anomalies are strip distributed in the dolomite marble of Jxj strata, which is very
agreement with that extracted by Aster. It shows that Fe$^{3+}$ anomalies in Figure 3 (e) exhibit planar and strip distribution in the dolomite marble of Jxj strata. Ferric oxide anomalies present scatter point distribution in the schist and phyllite of Ohm strata and granite. Limonite/hematite are mainly distributed in the Jxj strata with the most widely development in the dolomitic marble, followed by in the calcirudite (see Figure 3(f)).

![Figure 3](image)

Figure 3 The distribution of Altered mineral/ionic groups abnormaly in Beketan, Altn.
5. Conclusions

Based on the analysis of the reflectance spectrum curve features of the typical altered minerals in USGS spectra library, we extracted the altered minerals such as calcite, dolomite, epidote, chlorite, moscovite, limonite, hematite, etc. by using of CASI/SASI data in Beketan, Altyn. Moreover, we extracted Mg-OH/CO$_3^{2-}$/Al-OH/Fe$^{3+}$/Ferric oxide from Aster data by the ratio method.

Through the analysis of known geological background, Mg-OH/CO$_3^{2-}$ anomalies exhibit the same distribution of carbonate stratum. In the corresponding hyperspectral extraction results, calcite, dolomite, and Mg-OH/CO$_3^{2-}$ anomalies are similarly distributed. Epidote and chlorite are mainly distributed in the carbonate stratum and metamorphic strata. Al-OH anomalies display the same distribution as the metamorphic strata and granite body. Local Al-OH anomalies also developed in carbonate stratum. Low-Al moscovite show the similar anomaly distribution as the Al-OH anomalies. However, high-Al moscovite are mostly developed in the carbonate stratum. Fe$^{3+}$ anomalies are mainly distributed in the carbonate stratum. Ferric oxide anomalies are mainly distributed in the metamorphic rock and granite. Limonite/hematite presents the similar distribution as Fe$^{3+}$ anomalies.

This study indicates that based on the reflectance spectrum curve features, we extracted Aster remote sensing anomaly and the altered minerals distribution information of CASI/SASI data, which is very agreement with actual geological background. Because of the advantage of its spectrum resolution of CASI/SASI data, the extracted results are relatively more accurate compared with the traditional method, which is playing an important role in the geological mapping work.

Acknowledgement

Financial support was provided by China geological survey (No. 12120113044900). We thank CNNC Beijing Research Institute of Uranium Geology for providing CASI/SASI data.

References:

[1] Li Z Z, Yang R H, Dang F X, Zhang X F, Tan B X, Zhao H J 2009 The hyperspectral remote sensing technology and its application Geoscience Bulletin of China 28 pp 270-277
[2] Zhang Z C, Zhang X J, Hu D G 2011 Application of Hyperspectral Remote Sensing on Mineral Exploration in Dongdatan District of East Kunlun, Qinghai Province Geoscience 25 pp 759-767
[3] Wang K, Gu X F, Yu T 2013 Classification of hyperspectral remote sensing images using frequency spectrum similarity Sci China Tech Sci 56 pp 980-988
[4] Ren G L, Yang J L, Yang M 2013 Application of Hyperspectral Remote Sensing Anomaly Information on Metallogenic Prediction in the Jintanzi-Mingjingou Area of Beishan, Gansu Province Geotectonica et Metallogenia 37 pp 765-776
[5] Yang Y J, Zhao Y J, Qin K 2013 Application of Hyperspectral Remote Sensing Anomaly Information on Metallogenic Prediction in the Jintanzi-Mingjingou Area of Beishan, Gansu Province Science and Technology Review 31 pp 65-67
[6] Li M M, Xing L X, Pan J 2011 Research of Combinatory Analysis Method in Altered Information Extraction Remote Sensing Technonlogy and Application 26 pp 303-308
[7] Lv F J, Hao Y S, Shi J 2009 Alteration Remote Sensing Anomaly Extraction Based on Aster Remote Sensing Data Acta Geoscientica Sinica 30 pp 271-276
[8] Gan F P, Wang R S, Ma A N 2003 Integration for Extracting and Mineral Analysis Models for Geological Application Using Remote Sensing Data Journal of Remote Sensing 7 pp 207-214