ORE-SEARCH INFORMATION USING ASTER DATA IN BASHIBULAKE URANIUM DEPOSIT AREA IN XINJIANG

Yang Xu, Liu De-Chang, Zhang Jie-Lin

Beijing research institute of uranium geology, Beijing 100029, China, - yangxu_mail@yeah.net

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ABSTRACT

Uranium deposit has a very important status in our national defiance and economy qua a kind of strategic mineral resources. It is the main work for the department of scientific research and yields survey to explore and evaluate the uranium resource. The Bashibulake uranium deposit area which is located in north of Tarim Basin is an important uranium mineralized region among Mesozoic basins in our country. In this study, an Advanced Space borne Thermal Emission and Reflection Radiometer (ASTER) was used to extract the ore-searching information of uranium deposit in Bashibulake area. By using effective methods of image processing, the information of ore-bearing bed, ore-control structure and mineralized alteration has been extracted successfully. The results show a high consistency with the survey field. The aim of this study is to explore practicability of Aster data for prospecting minerals, and to broaden the thinking of ore-searching at similar areas.

1. INTRODUCTION

As a kind of strategic ore deposit, uranium deposit plays a very important role in the development of national economy and national defense. The information related to the forming, alteration and enrichment of uranium deposit is what is called ore-search information. Under the direction of ore-forming theory of uranium deposit, the geological information (such as ore-bearing bed, pay structure) and mineralized information (such as alteration zone, altered mineral) were extracted by the methods of remote sensing image analysis. In addition, combining ore-forming information with basic geologic date, geochemical exploration and geophysical property will provide higher accuracy data that can be used as a basis for forecasting target area and prospective valuation.

Bashibulake ore as a kind of biggish size uranium deposit in our country was found in 1960s. It belongs to land pitch's mineral. It lies in the strata of Cretaceous period. The whole mineral bed was controlled within the spreading of 700m from east to west and 1000m from north to south. Based on oil prospecting reference and similarly spatial distribution of known uranium spots, all mineralization in this area may be closely related to the oil oxide-land pitch (Liu Dechang, 2007).

Probably the most popular remote sensing data which be used to extract mineral ore-searching information are low or moderate resolution satellite data, such as ETM, MODIS and ASTER. Multispectral satellite remote sensors such as ASTER are providing more and more high spectral and spatial resolutions for remote sensing geology study. It is hot topic to use multi-spectral resolution satellite data to extract mineral information at home and abroad (Jensen, 1996; Crósta, 1993; Adams, 2004).

In this study, ASTER multi-spectral stereoscopic data covering the Bashibulake area have been used as research data source. Based on the feature of the bands and geologic setting of the research area, digital image processing techniques developed recently have been adapted to improve the ability of image interpreter. To successfully extract ore-searching information closely related to uranium deposit by this way will provide important reference of applying to multi-spectral resolution satellite data in region geological exploration in both theory and practice.

2. ORE-SEARCHING INFORMATION OF URANIUM DEPOSIT

The studies of using remote sensing image to extract the ore-search are as follows:

The first is extraction of ore-bearing bed's information. Enhancement and extraction of producing information is absolutely necessary to search uranium deposit for it is the most important carrier for mineral. The second is extraction of fault belt controlled by structure. After systematically studying remote sensing image of almost all of known sandstone uranium deposits, there is an important conclusion that at least one fault-belt structure-controlled must be in existence in those areas. But it is very difficult to spot these fault structures because of badly being covered by Quaternary system. Only special methods of image processing can enhance and extract structure's information. The third is extraction of alteration information. Mineral alteration is not only the main ground preparation of mineralization but also the important factor which can give direct advice to mineralization.

3. IMAGE PROCESSING

The 14 bands of the Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) data cover the visible and near infrared (VNIR; 3 bands with 15m spatial resolution), shortwave infrared (SWIR; 6 bands with 30m spatial resolution), and thermal infrared (TIR; 5 bands with 90m spatial resolution) and allow for 364 Red-Green-Blue (RGB) color combinations (Rossi,2003) . The Optimum Index Factor (OIF) and

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determinants techniques are statistical approaches to rank all possible RGB color combinations. RGB color combinations with high OIF and determinants values are expected to have the maximum extractable spectral information since they use bands with the least redundancy in the remote sensing data. In addition, there are a few methods of image processing used to extract ore-searching information, such as bands ratios, principal component analysis, image fusing, and linear pixel unmixing and object-oriented information extraction and so on. For extracting uranium-searching information, special methods will been selected based on analyzing spectrum and texture feature in imagery. As far as this study is concerned, the methods of image processing used to extract structure and strata's information include RGB transform, bands ratios, principal components analysis (PCA) and mask piecewise-linear HIS(MPH) .

4. EXTRACTION OF ORE-SEARCHING INFORMATION IN BASHIBULAKE URANIUM DEPOSIT

In the first place, a visual interpretation of ASTER image is performed by spotting a number of the supposed geologic units based on shape, tone, linearity and spatial patterns. The primary aim of this research is to extract the information related to sandstone uranium deposit from multi-resolution remote sensing imagery.

The OIF and determinants results are qualitatively evaluated against reflectance spectra curves of common rock types and minerals (Chavez, 2001). All common rock types and minerals in the study area have spectral reflectance features in band 1. Alteration information related to ferric oxide has spectral reflectance features in band 3, and kaolinite and calcite have spectral reflectance features in bands 7. Hence, examination of spectral curves of geological materials supports the OIF and determinants analyses results that ranked the 7-3-1 as the one with the highest extractable spectral information in the study area. Geological situation in the study will be understand very well by means of decorrelation stretch the RGB 7-3-1 image.

4.1 Extraction of ore-control faults

The faults which are located at the edge of Bashibulake basin are also called Suluqieleike faults. They have very obvious features of fragmentation. It has been seen that the faults develop between Proterozoic group and Cretaceous system. The strata in both sides are not accordant and have obvious difference in field. From spatial development of all known uranium deposit and mineral spots, it can be judged that all uranium mineralization just lie in the fault at the edge of Bashibulake basin. Hence, Extraction of ore-control faults has very important significance (Loughlin, 1991; Alparone, 2004). Principal Component transform of 9 VNIR+SWIR bands have been used and then PCA2-5-6 which selected as the color composition RGB (Fig. 1)shows good result for discrimination of the fracture in deep green: there are clearly spatial feature and characteristic linear which develop along NWW.

4.2 Extraction of ore-bearing target stratum

Bashibulake uranium deposit lies in Wuqia county, Xinjiang province. It is a narrow zone between geosynclinal's fold of Tiansan and west Qunlun Mountains. This narrow zone is one multi-synclinal basin which is called Bashibulake basin. There are the strata of Proterozoic and Paleozoic group at north basin. The former is a suit of strata of crystalline schist which is the main uranium source, the latter are clastic rocks and carbonate rocks. Both made up of basin's basement. Capping bed of basin are the strata of Mesozoic and Cenozoic earthen. The main ore-bearing target stratum is Cretaceous system[13].

The primary target stratum is in Cretaceous period in this area. Compared to other strata, it has some different feature of color and texture in image, and can not been directly identified though. Band ratios 5/8, 4/6 and 6/7 (Jing, 2005; Aiazzi, 2002; Holk, 2003) are used to identify strata components of Cretaceous system to trace along-strike continuation in the Bashibulake area. The color composition R (5/8) G (4/6) B (6/7) shows Cretaceous system enhanced in white, with Proterozoic group over it in purple and New Tertiary system under it in white (Fig. 2). Their spatial feature and borderlines between them are very clear.

4.3 Extraction of alteration information

The phenomenon of mineral alteration is quite evident (Iida, 1993). Through our research work, it is confirmed that the alteration which almost is fading may be caused by deoxidization of oil and gas (Huang Xianfang, 2007). The primordial Cretaceous system in this area was red, but it has become gray for the effect of gas-oil deoxidization. In the field, there are many phenomena that the gray alteration replaces the red sandstones. Then some of gray alteration deoxidized by oil and gas come through being oxygenated again over the earth and become yellow or light yellow sandstone. Near by the fault, the range of oxide-sandstone are in turn yellow firstly, and then transitional bed both yellow and red. It is the spatial development feature of alteration bed that may be controlled by the fault at the edge of Bashibulake basin (Fig. 3). The most important altered mineral is Pyrite, Hematite, Calcite and Kaolinite (Liu Dechang, 2007).

In this study, several combined image methods basing on statistical, spectral and color space transforming are used to extract the alteration information. At the first, most of geologic background and noisy must been removed in the statistical space by the means of masking. Then mineral alteration belt which is located in BASHBULAKE uranium deposit have been extracted through spectral transformation. Cretaceous system strata in gray as alteration target which was observed in field have been enhanced in white and distinguished from primordial red ones through HIS transformation (Fig.4). Besides, the result of extraction of alteration information related to OH^- and CO^{3+} shows a high consistency with the field survey (Fig.5). The both are very important to guide the next step of exploration.
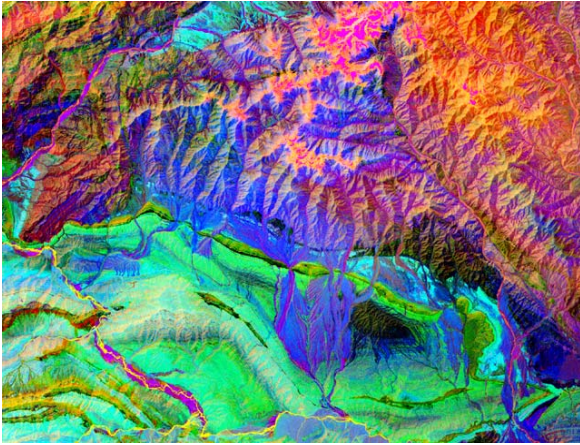
Figure 1 Extraction of Ore-bearing target stratum
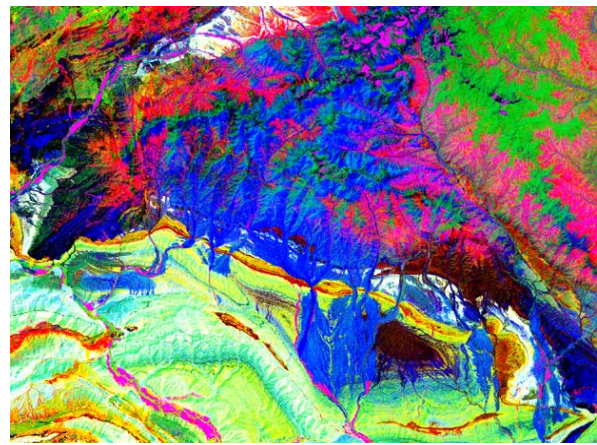(PCA2-5-6in RGB)Decorrelation stretch)

Figure 2 Extraction of ore-control fault
(5/8- 4/6-6/7 in RGB)

Figure 3 Spatial development feature of alteration bed of Bashibulake in field
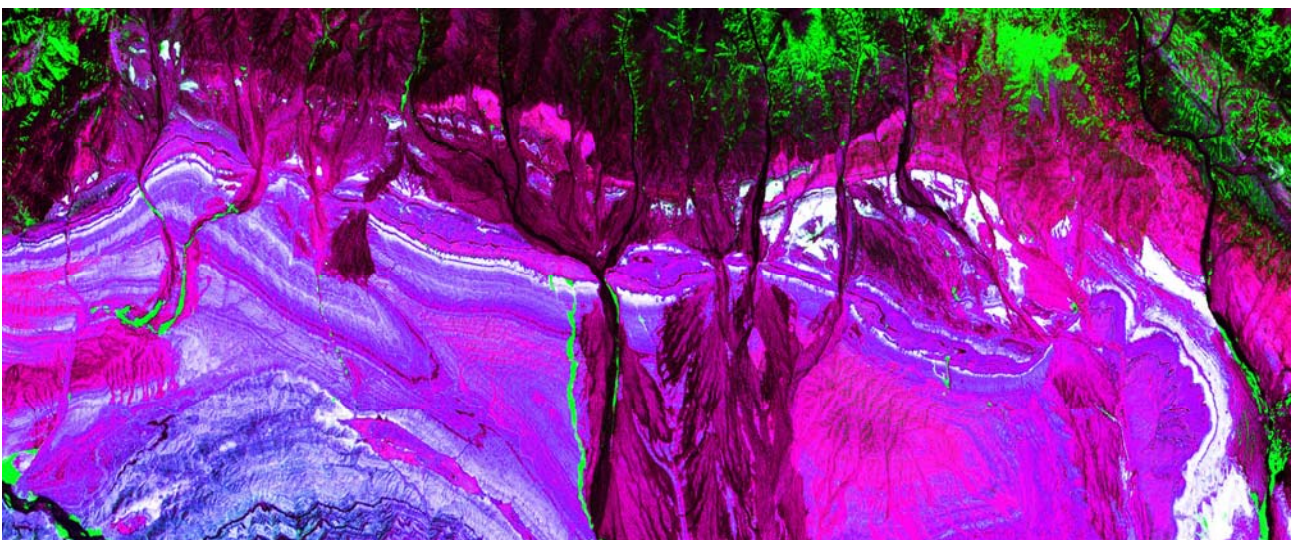

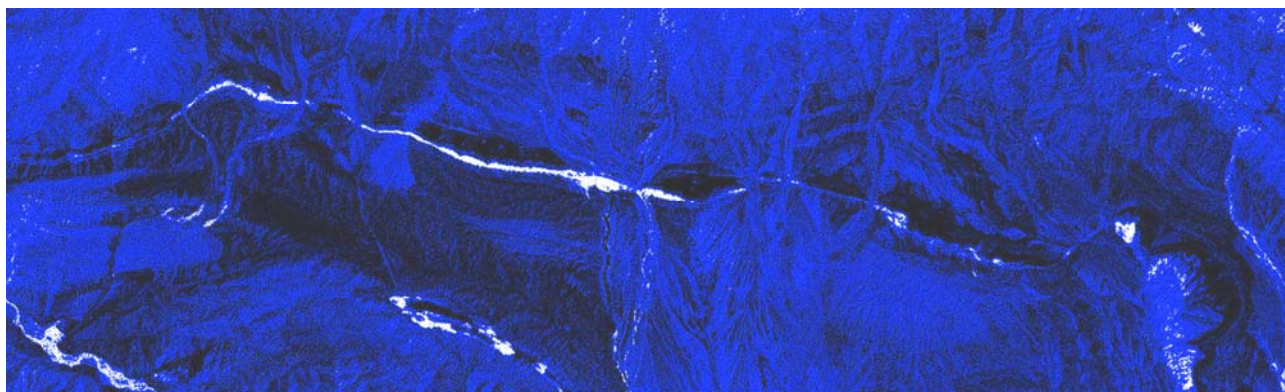Figure 4 Extraction of alteration information related to ferric oxide

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* Corresponding author. Tel.: 86-010-64967331; fax: 86-010-64967331；E-mail address: yangxu_mail@yeah.net

Figure 5 Extraction of alteration information related to OH$^-$ and CO^{3+}

5.   CONCLUSIONS

The results of ASTER image processing shows good correlation with field data for the Bashibulake uranium deposit. The methods of image processing which include band ratio, PCA, HIS, Mask and other spectral transformations were used to enhance and extract ore-searching information successfully. ASTER image processing thus prove to be a powerful tool in the initial steps of uranium deposit exploration because they provide higher accuracy data then ETM so that can be used as a basis for detecting ore-searching information.

The mineralized alteration information in Bashibulake area may be closely related to sandstone uranium mineralization. Hence, validly enhancing and extracting mineralized alteration information have important meaning both in theory and practice for the next steps of extending exploration.

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