HYPERSPECTRAL DATA MINING FOR CHARACTERISING GRANITE TYPE URANIUM DEPOSITS IN SOUTH CHINA

ZHANG Jie-lin

Beijing Research Institute of Uranium Geology National Key Laboratory of Remote Sensing, Beijing, China - zhangjielin@sohu.com

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ABSTRACT:

Based on hyper spectral data mining techniques, field spectra data is used to study the diagnosable spectral signatures of uranium mineralization factors in this paper, and the spectral features of pluton, ore-controlling fault and hydrothermal alteration including alkali metasomatism, hematitization, chloritization and hydromicazation are acquired and analyzed, the diagnosable spectra identification symbol has been developed. Furthermore, the radioactive anomaly characteristics is the key symbol to distinguish the uranium deposits from other metallic ore deposits, the radionuclide including uranium, thorium, potassium and radium are relative abundant in the uranium deposits. The author uses integration technology of remote sensing imagery and aerial radioactivity data to extract the anomaly information which relate to uranium deposits, and the practical result is achieved. Above studies and experiences provide the new approaches to the exploration of uranium resources.

1. INTRODUCTION

Recently, with the development of Earth Observation System (EOS) and remote sensing physics theory, high resolution remote sensing technology including hyper spectral, high spatial and high time resolution have been widely applied to the exploration of resources, environment evaluation, disaster prevention, and so on (Clark, 1999; WANG, 1999; PU, 2000; ZHANG J-l, 2003). Concerning uranium geology, the exploration of uranium resources is becoming more and more difficult, so the new remote sensing technology is key study for the prospect of uranium deposits on the basis of uranium mineralization theory and modern earth observation system. China, Australia, Canada and United states of America actively developed many efficient technologies including manufacture of remote sensing sensor, high resolution data analyzing, new exploration method for concealed deposits and approach to forecast using advanced remote sensing technology (ZHANG J-l, 2006). Its main features are integration of exploration technology, synthesizing of geological analyzing and metallogenic forecast, and the new conception of information prospect for uranium resources is developed. This paper mainly discussed the application of hyper spectral technology to the Taoshan granite-type uranium deposits in south China.

2. HYPER SPECTAL CHARACTERISTIC OF METALLOGENIC FACTORS

Based on field geological survey and ground hyper spectral measurement using ASD FR Pro and 102F spectrometers, the spectal characteristic of metallogenic factors is acquired in Taoshan granite-type uranium deposits. those factors include pluton, ore-control fault and hydrothermal alteration, and the spectral wavelength range covers visible light(VIS), near infrared (NIR), shortwave infrared(SWIR) and thermal infrared (TIR). Used hyper spectral data mining technology, the spectral identifiable symbol is developed.

2.1 Geological setting

Taoshan granite-type uranium deposits locates Taoshan-Zhuguang uranium mineralization belt of Huanan uranium mineralization province in south china (Figure 1). The Taoshan pluton is complex polystage rock mass, including Caledonian, indosinian, and Yanshan period granite[6]. The structure features show two orientations faults of NNE and NE are relative more developed, and the scales are relative large. Those faults activate more frequently and control the magma activity and uranium mineralization.
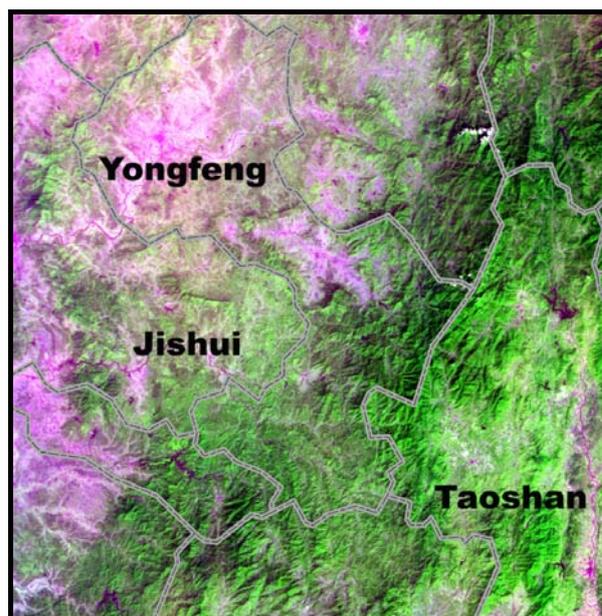
Figure 1. CBERS-02B image of Taoshan area

The NNE orientation faults include Dagu and Jiaoyuan which are west and east boundary of Taoshan pluton, it also control the occurring and developing of Taoshan pluton and Cretaceous period fault basin, including Luokou, Hanyuan and Ningdu. The NE orientation faults include Taoshan and Luokeng fault, and Taoshan fault is important mineralization controlling fault, it undergoes multi-time intensity activity and derives a series of small structure, all those provide vital condition for the hydrothermal solution uranium mineralization. The hydrothermal alteration include alkali metasomatism, hematitization, chloritization, silication, fluoritization and hydromicazation (YAN, 1996).

2.2 spectral and geological features of pluton

The geological and spectral features of four types of granite are discussed, and its different spectral parameters are listed. Based on that information, the genetic relationship between spectrum and chemical composition is discussed. The four types of granite are Daguzhai pluton (third phase of Yanshan period), Diaofeng pluton (second phase of Yanshan period), Huangpi pluton (first phase of Yanshan period) and Caijiang pluton (indosinian period).

The lithology of Daguzhai pluton is medium-grained biotite-granite and two-mica granite (Figure 2), and hydrothermal alteration including alkali metasomatism, hematitization and chloritization are well developed. It is main ore-bearing rock in this area. The lithology of Diaofeng pluton is medium-grained porphyritic biotite-granite, and the pegmatitization is developed, such as k-feldspar and white mica.

Figure 2. Field photo of Daguzhai pluton

Huangpi pluton is main composition of Taoshan complex polystage rock mass, its lithology is medium-grained and megagrained porphyritic biotite-granite, and alkali metasomatism, hematitization, chloritization, hydromicazation are also developed (Figure 3). The lithology of Caijiang pluton is megagrained porphyritic biotite-granite, the phenocryst of k-feldspar and biotite spread in certain direction (Figure 4).

The diagnosable absorption spectral features of four types granites are listed as following in VIS-NIR-SWIR-TIR wavelength (table 1 and figure 5).

Figure 3. Field photo of Huangpi pluton

Figure 4. Field photo of Caijiang pluton

The results show the spectral feature is caused by Fe^{3+}, Fe^{2+}, metal-OH and H_2O in VIS-NIR-SWIR. The wavelength of those locates 0.5-0.9um, 1.4um, 1.9um, 2.2-2.4um, and the spectral feature of rock-forming mineral, such as feldspar and quartz, locates 8-12um. Studies demonstrate spectral variance role exist from old to new period pluton. For example, the absorption spectral intensity of hydrothermal alteration become more strongly from Caijiang, Huangpi, Diaofeng to Daguzhai pluton. The flex-libration spectral band of Si-O locates 9-10um, and the wavelength shifts to short band from 9.5um to 9.22um, this means the contents of quartz increase from old to new period pluton, all those are verified by chemical analyzing in lab. According to those characteristic, the different types of granite and hydrothermal alteration can be identified in the remote sensing imagery, and it is powerful method for uranium exploration.

| Plutons	VIS-NIR-SWIR(um)	TIR(um)
Caijiang	0.53、1.9	9.5
Huangpi	0.53、0.86、1.4、1.9、2.2	9.22
Diaofeng	0.87、1.4、1.9、2.2	9.23
Daguzhai	0.87、1.4、1.9、2.21、2.35	9.28

Table 1. Spectral features of pluton
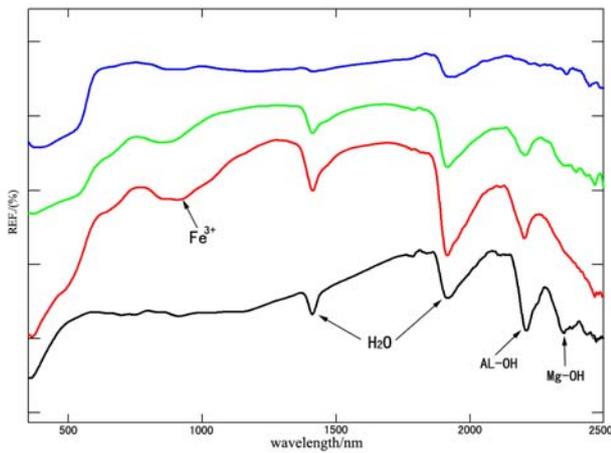
Figure 5. Comparison of spectrum curves of plutons (Pluton: Caijiang, Huangpi, Diaofeng, Daguzhai from up to down, the vertical axis is shifted from zero）

2.3 spectral and geological features of fault

Taoshan fault is the important mineralization controlling fault (YAN, 1996), the tectonic belt is filled with quartz vein, siliceous breccia and mylonite. The absorption spectral wavelength of fault is 2.2-2.3um which is caused by weathering, and 9.2-9.4um which is typical feature of quartz.

Figure 6. Photo showing the silicide of Taoshan fault

2.4 spectral and geological features of hydrothermal alteration zone

According to above demonstration, the hydrothermal alteration of Taoshan uranium deposits include alkali metasomatism, hematitization, chloritization, silication, fluoritization and hydromicazation. Above all, alkali metasomatism is especially developed, it comprise microclinization and albitization. Alkali metasomatite is favorable wall rock for uranium mineralization, and it can increase efficient porosity of pluton with concomitancy of hematitization and chloritization, it is useful for hydrothermal solution movement and uranium activation.
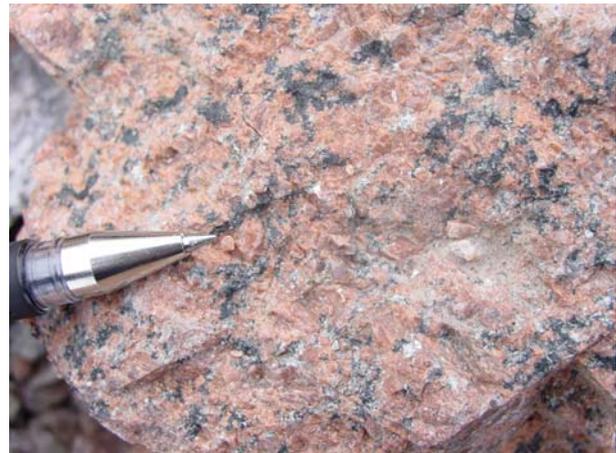
Figure 7. Field photo of alkali metasomatism alteration

The spectral analyzing results demonstrate that with the increase of alteration degree the absorption spectral intensity of Fe^{3+} gradually enlarges at 855nm, and the absorption slope increases at 550nm (Figure 8).
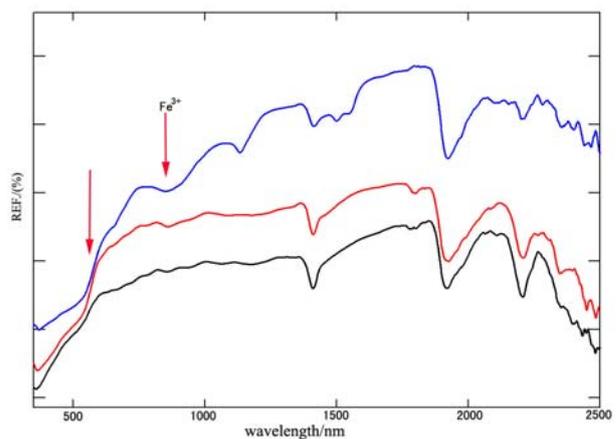

Figure 8. Comparison of reflectivity spectrum features of alkali metasomatism alteration. The degree of alteration decreased from up to down, the vertical axis is shifted from zero.

Furthermore, the absorption wavelength in thermal band shifts to long wave from 9.27um to 9.47um, the causation is the decrease of quartz (Figure 9)

On the basis of the spectral characteristics of hydrothermal alteration zone, ore controlling fault and ore-bearing rock in the VIS-NIR-SWIR-TIR, the single-band spectral parameter or combination of characteristics can be acquired, and the spatial distribution of uranium mineralization factors can be delineated using hyper spectral geological mapping, thus it provides the technical support for uranium prospecting.

3. INTEGRATION TECHNOLOGY

The radioactive anomaly characteristics is the key symbol to distinguish the uranium deposits from other metallic ore deposits, the radionuclide including uranium, thorium, potassium and radium are relative abundant in the uranium deposits, so the aerial radioactivity measurement technology is

a important and efficient geophysical method to the exploration of uranium resources. The author uses integration technology of remote sensing imagery and aerial radioactivity data to extract the anomaly information which relate to uranium deposits.
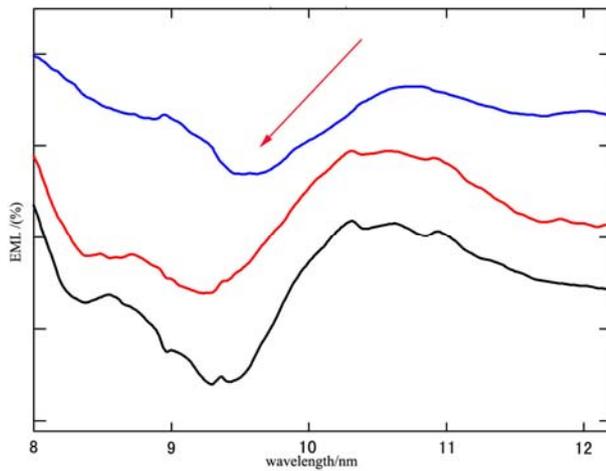

Figure 9. Comparison of emissivity spectrum features of alkali metasomatism alteration. The degree of alteration decreased from up to down, the vertical axis is shifted from zero.

Results show the content of uranium of Taoshan pluton is higher than environmental strata including Sinian-Cambrian system metamorphic rock and Cretaceous sedimentary rock, high radioactive anomaly information is identified and used to forecast the concealed uranium deposits.

4. CONCLUTIONS

Hyper spectral remote sensing is one of advanced technology of EOS, it has wide application to exploration of resources. Based on hyper spectral data mining techniques in this paper, the diagnosable spectral signatures of uranium mineralization factors are acquired and analyzed in Taoshan uranium deposits, and the diagnosable spectra identification symbol is developed.

Moreover, high spatial resolution remote sensing technology has widely used in land planning, disaster prevention and roadway engineering, but how to utilize it to resolve geological problem of Uranium exploration is key study in the future.

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