HYDROTHERMAL ALTERATION MAPPING USING ASTER DATA IN EAST KUNLUN MOUNTAINS, CHINA

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1. INTRODUCTION

Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) is an advanced optical sensor on the Terra satellite, including 14 channels ranging from visible near infrared (VNIR) to the thermal infrared (TIR) spectral region. Its spectrum resolution is high in the shortwave infrared scope so that it has a good ability to distinguish various clay-alteration minerals. Since 2000, ASTER multi-spectral data have been used in mineralogical and lithological studies, such as carrying out hydrothermal alteration mineral mapping, silicate, carbonate rocks mapping (Moghtaderi, 2004; Rowan, 2004; Inés Di Tommaso and Rubinstein, 2007; Ce′cile Gomez, 2004; Ninomiya, 1995, 2002, 2004). One part of these studies is to use hyperspectral data (with AVIRIS or Hymap airborne) in addition to ASTER 1B or Level 2 emissivity data; others studies only use the ASTER data with an initial geological map (Ce′cile Gomez, 2007).

Moghtaderi et al. (2004) have successfully detected alteration minerals in the Precambrian Chadormalu area by applying IARR (Internal Average Relative Reflectance), FCC (False Color Composite), Decorrelation-stretch, MNF (Minimum Noise Fraction Transform), correlated filter and MEM (Mathematical Evaluation Method) techniques on ASTER imageries. Inés Di Tommaso and Rubinstein (2004) use band combination, band ratio transformation and spectral-angle mapper processing (SAM) to carry on the initial steps of ore deposit exploration. Ce′cile Gomez et al. (2004) use the supervised classification realized from PCA results to make geological mapping. Based on analysis of SWIR and TIR spectral properties of typical rocks on the Earth, Ninomiya (2002,2004) has developed several mineral indices including the Quartz Index (QI), OH bearing altered minerals index (OHI), Alunite index (ALI), Carbonate Index (CI) and Mafic Index (MI) for detecting mineralogic or chemical composition of quartzose, OH bearing altered minerals, Alunite, carbonate and silicate rocks with ASTER-SWIR and ASTER-TIR data.Ninomiya (1995) proposed an algorithm to estimate the chemical SiO_2 content in the surface silicate rocks. Rowan (2004) uses ASTER ratio images, relative band-depth (RBD) images, matched-filter, and SAM to map the lithologies. In my country the geological mapping and the prospecting work using the ASTER data is also applied, but the achievements published publicly were not many. Yujun Zhang (2002) has developed an advanced system for the extraction of hydrothermal alteration assemblages using ETM+ (Enhanced Thematic Mapper) and ASTER (Advanced Space-borne Thermal Emission and Reflection radiometer) data, which is called the ‘De-interfered

Anomalous Principal Component Thresholding Technique'.

East Kunlun region is high and cold mountainous areas of western China. This region is characterized by bare rock, physical weathering and snow cover. By using a variety of commonly used methods, we carry out lithologic and hydrothermal alteration mapping in the study area (East Kunlun) and compare the effect of different methods. Finally, we use the alteration information to perform the mineralization forecast in combination with other data.

2. DATA PREPROCESSING

In the experiment we use the ASTERL1B data, which is radiometrically equivalent radiance at the sensor products. In order to facilitate the processing, we use VNIR 15m spatial resolution and TIR 90m spatial resolution registered to 30m resolution of SWIR. Mask treatment is to remove the impact of lake, clouds, vegetation on information extraction. For the following experiment processing, we process the data into three kinds. One is the radiance data, which is atmospherically uncorrected data and reduced the uncertainty influence which is introduced by the atmospheric correction process. The second is the reflectance data, using FLAASH atmospheric correction module to eliminate the effects of atmospheric scattering and water vapor in order to facilitate the use of hyperspectral identification approach to the ASTER data and carry on the comparison between the image data spectrum and the laboratory spectrum. The third is the emissivity data obtained by making thermal infrared atmospheric correction to TIR and applying the temperature information and emissivity separation algorithm. The emissivity data plays an influential role in the thermal infrared quantitative geological mapping.

3. HYDROTHERMAL ALTERATION INFORMATION EXTRACTION

Our study registers in the same line than the previous researches about ASTER. We look forward to estimating the potential of ASTER data in alteration mapping in East Kunlun Mountains, China. We take some commonly used alteration information extraction methods home and abroad for ASTER data to map alteration zones in study areas, and makes the comparative analysis. Here are those methods:

(1) The 'De-interfered Anomalous Principal Component Thresholding Technique' proposed by Yujun Zhang.

(2) The band ratio method.

(3) The false color composite (FCC) method.

(4) The Relative absorption Band-depth image method.

(5) The mineral index method proposed by Ninomiya.

(6) The hyperspectral mineral identification method.

We have various methods were compared. In the following figures, we just have lifted some comparisons of different methods, including Color composite, mineral index method, RBD image, SFF Hyperspectral identification method and MEM method.

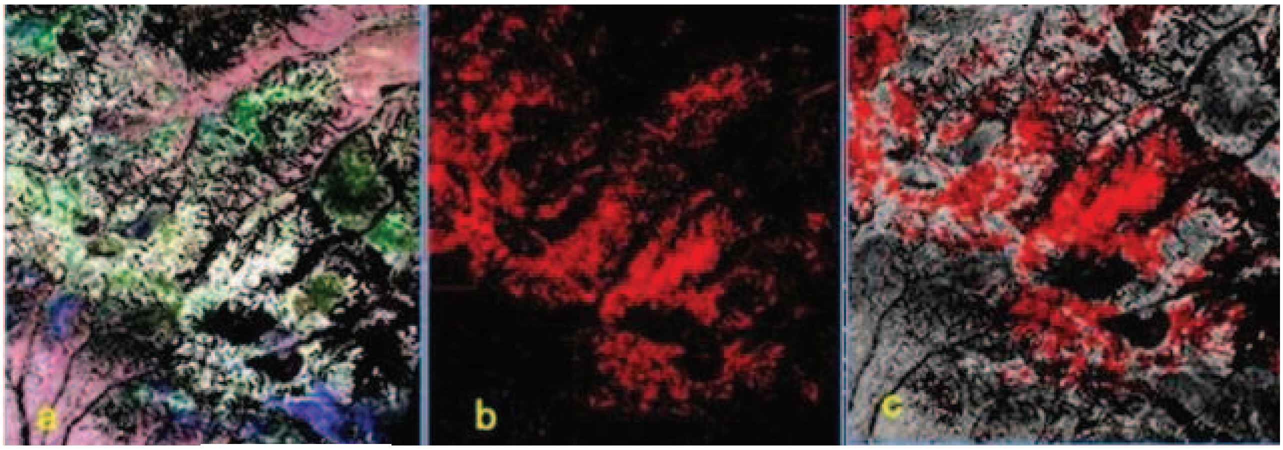

Fig .1. (a) Color composite using ASTER band ratio 4/5, 4/6, 4/7. White area shows OH absorption. (b) The result obtained from mineral index method. Red area shows OH absorption. (c) The result obtained from RBD image. Red area shows OH absorption.

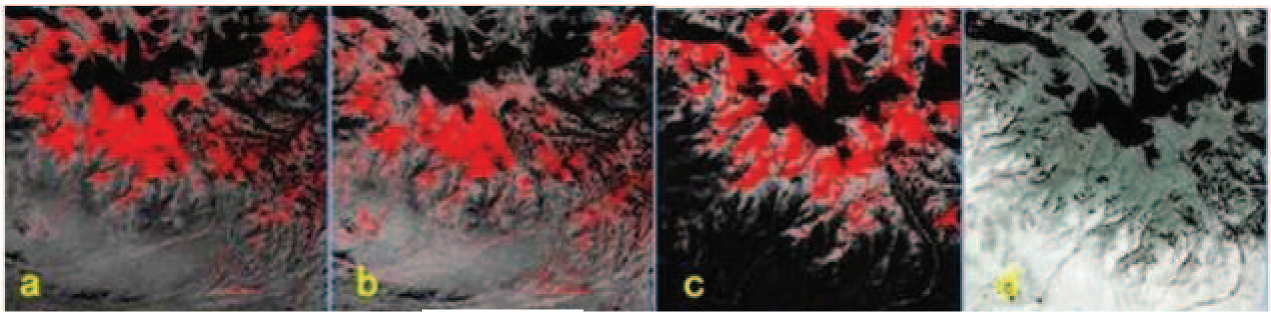

Fig .2. (a) The result obtained from mineral index method. The area in red shows a response of calcite. (b) The result obtained from SFF hyperspectral identification method. The area in red shows a response of calcite. (c) The result obtained from MEM method. The area in red shows a response of calcite. (d) The result obtained from Color composite. The area in cyan shows a response of calcite.

4. CONCLUSION

In the extraction of alteration information, the band ratio method is quite rough and just probably iris out some zones of alteration minerals. It is the basis of the color composite, RBD image and mineral index method, and its result can be used for improving the precision of the endmember selection when we use hyperspctral identification method. Color composite can make us see the distribution of various alteration minerals visually, but it is not easy to separate these minerals accurately. For example, the MEM processing method can separate the alteration information quite conveniently, but the result is not very accurate. The RBD image method and the mineral index method are quite similar, and they can distinguish a variety of minerals. The mineral index method is quite mature, and it gives the fixed threshold value to extract alteration information. The domestic commonly used De-interfered Anomalous Principal Component Thresholding Technique is quite mature in alteration information extraction with the TM/ETM+ data and also can apply to the ASTER data. The hyperspectral mineral identification method can separate the altered mineral alone; however, due to the limitation of ASTER data band numbers, we must conduct the research to the spectrum of each mineral and find a quite effective method to improve the discrimination effect, so that we can make full use of hyperspectral technology advantage.

5. REFERENCES

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