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An Integrated Approach for Extraction of Carbonate Rocks Based on Landsat OLI Data: a Case Study around Stone Forest, Southwest China – Upgrading for Land-use Planning Purposes

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An Integrated Approach for Extraction of Carbonate Rocks Based on Landsat OLI Data: a Case Study around Stone Forest, Southwest China – Upgrading for Land-use Planning Purposes

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Abstract. Geological remote sensing information extraction of the lithology has always been the hotspot and difficulty in remote sensing applications. Carbonate rocks covered more than 3.4 million km^2 in China. The study area is located around Stone Forest, which is World Natural Heritage. Sedimentary rocks distributes mainly in the area, and their spectral characteristics are complex and difficult to be recognized by remote sensing. Landsat OLI data was selected as the information source. The false color synthesis, principal component change, band ratio and other processing technologies of OLI data were applied to the lithological enhancement identification of carbonate rocks. Selected information will be used to improve the quality of the land-use planning.

1. Introduction

Remote sensing lithology extraction has always been the hotspot and difficulty in remote sensing applications. Remote sensing lithology identification includes multi-spectral lithology information extraction represented by Landsat and ASTER data, hyperspectral lithology identification represented by hyperspectral Hyperion data, and sub-meter-level high-resolution data lithology extraction represented by Quickbird and Worldview data in some studies [1]. Li Benshi et al. used Landsat data to identify Triassic - Jurassic strata in Changshou District, Chongqing [2]. By applying Hyperion data and field spectral collection, Bi Xiaojia et al. conducted an experimental study on lithology mapping in the study area [3]. Wang Pingping et al. used Worldview 2 data to study the method of lithologic enhancement [4].

In this paper, Landsat OLI was used as the data source to carry out lithology identification research in the stone forest area. In this study, false-color synthesis, principal component analysis, band calculation and other methods are mainly used to enhance the contrast between different features in the study area, so as to achieve the purpose of enhancing lithology and provide a method for the identification of carbonate rocks in the southwest area with complex topography.

2. Geological background of the study area

The research area is located in Shilin County, Yunnan Province in China （108°18′-103°30′ E, 24°37′-24°57′ N）. Shilin karst development zone is located at the southwest end of Yantze Platform, Eastern Yunnan Platform fold belt, Qujingtai fold belt and Niutou Mountain uplift, between Shizong-Mile fault and Xiaojiang fault. The two deep faults and Niutou Mountain ancient uplift base control the sedimentary formation, sea-land alternations, basin evolution and geomorphologic development in this area. Faults are well developed in this area, and the fold structure is mostly wide and gentle fold, and the tectonic lines are mainly south-to-north and north-to-south. The strata from Cambrian to quaternary are exposed except Ordovician deficiency and Mesozoic are rarely exposed, especially Permian carbonate rocks [5].

3. Data source and image preprocessing

Landsat 8-OLI/TIRS image data were used in this study, and the band characteristics of the data source were shown in Table 1. The imaging time of remote sensing image used in this study was February 7, 2018. The image data was characterized by less cloud, no snow and little noise, etc., and the imaging effect was good.

ENVI software is used to preprocess the image, including atmospheric correction, geometric correction, image clipping and other processes.

Table 1. Features of Landsat-8 satellite data

Band Name	Bandeidth (μm)	Resolution (m)	Main Application areas
1-Coastal aerosol	0.433-0.453	30	Mainly used for coastal zone monitoring.
2-Blue	0.450-0.515	30	Used for water penetration, distinguishing soil and vegetation.
3-Green	0.525-0.600	30	Used to identify vegetation.
4-Red	0.630-0.680	30	Used to observe the road, bare soil, vegetation species, etc.
5-Near Infrared	0.845-0.885	30	Belongs to the near infrared band, is the chlorophyll emission belt. It is used to identify vegetation types and ground texture information.
6-SWIR 1	1.560-1.660	30	It is used to identify roads, bare soil, identify vegetation and monitor vegetation information change.
7-SWIR 2	2.100-2.300	30	Used to identify rocks, minerals, and vegetation cover and moist soil.
8-Panchromatic	0.500-0.680	15	It belongs to panchromatic band with high spatial resolution. Used for image sharpening.
9-Cirrus	1.360-1.390	30	It contains characteristics of strong water vapor absorption. Can be used for cloud detection.
10-Thermal Infrared 1	10.30-11.30	100	It is used for sensing targets of thermal radiation.
11-Thermal Infrared 2	11.5-12.50	100	

4. Methods

Through a lot of image enhancement processing, the visual effect of the image is improved to identify the lithology. In this study, false color synthesis, PCA and band ratio method were used to enhance lithologic information.

4.1. False color composition

False color synthesis of different bands can enhance different features. Different band synthesis of Landsat OLI has different enhancement effects on ground features. RGB combination is a combination of true color images synthesized in bands 4, 3 and 2, which are most similar to the display effect of human eyes and are used to identify various ground object types. However, the color is unsaturated, the image is flat and has little information. It is a true color composite image in figure 1 . The images with RGB combination of bands 7, 5 and 4 are false color composite images. In this image, the B7 band, which can reflect lithology and mineralization alteration information, is selected as red, and the B5 and B4 bands are combined together, so it contains a lot of information and can effectively highlight geological information, as shown in figure 2.
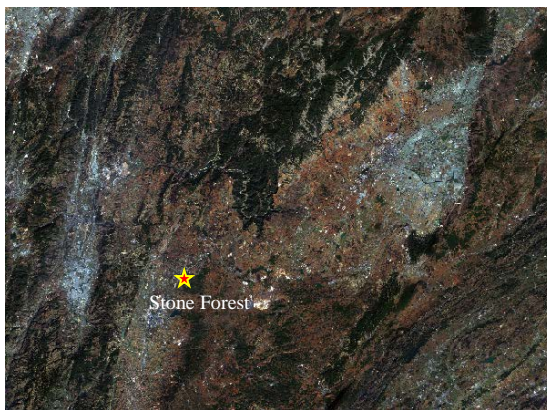

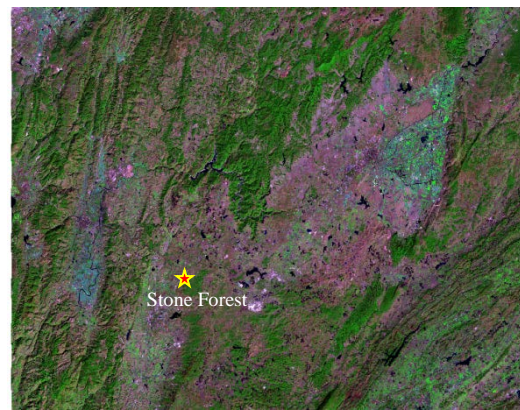**Figure 1.** True color composite image   **Figure 2.** Band754 Composite image

It can be seen from the comparison between Figure 1 and Figure 2 that the false color composite image can better enhance the lithology information and is more conducive to visual discrimination.

4.2. Principal Component Analysis (PCA)

The bands of multi-spectral images are often highly correlated, and principal component analysis (PCA) is a method to remove redundant information between bands and compress multi-band image information to a few conversion bands that are more effective than the original band. As can be seen from the characteristic values of principal component analysis in figure 3, PC1, PC2 and PC3 components have very large characteristic values. Selecting PC1, PC2 and PC3 to synthesize RGB images can better reflect the lithologic information of the study area and enhance the lithologic information. Selecting PC1, PC2 and PC3 to synthesize RGB image, as shown in figure 4. The color is very saturated and the texture information is significantly enhanced.
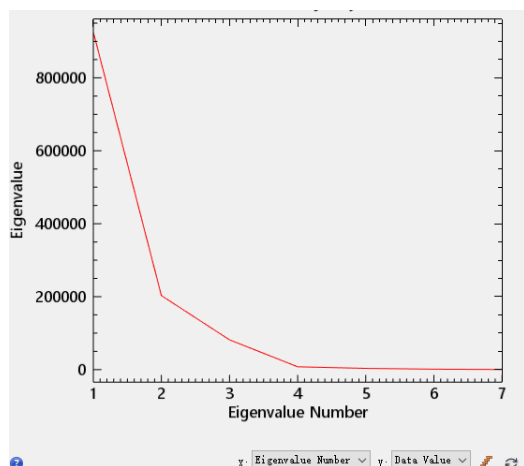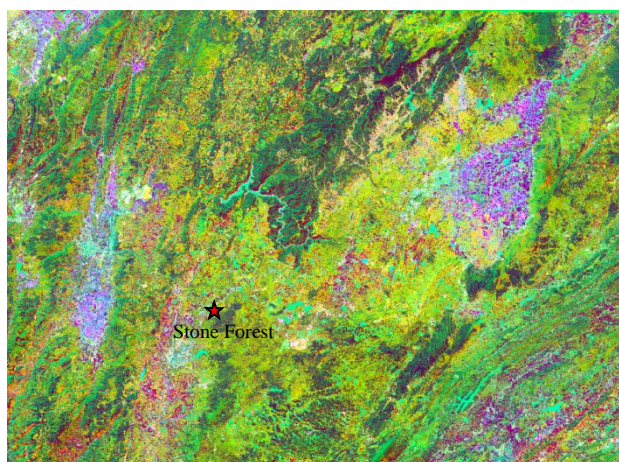
Figure 3. Eigenvalues of PCA

Figure 4. PC1, PC2, PC3 false color composite image

4.3. Band ratio

Calculating the ratio of bands can enhance the spectral difference between bands and reduce the influence of topography. Band 5 is mainly used to identify vegetation types with obvious surface texture information. Band 7 is mainly used to identify rocks and minerals. Band5/Band7 ratio can be used for reinforced clays and carbonate rocks. Band5/Band1 can show the change of iron ion content and enhance iron ore content. In this study, Band5/Band7, Band5/Band1 and Band7/Band3 are used to synthesize false color images to enhance lithology, as shown in figure 5.
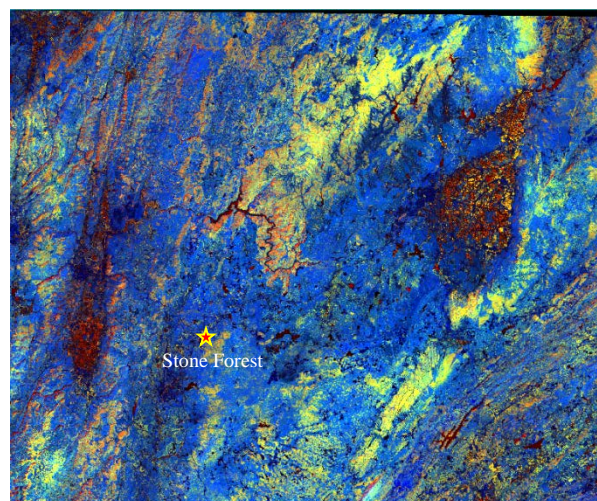

Figure 5. False color composite of Band5/Band7, Band5/Band1, Band7/Band3

5. Conclusions

In this paper, false color synthesis, PCA transformation and ratio method are used to obtain better results in lithologic enhancement in Shilin area. According to the application of different bands in different aspects, Band7, Band5 and Band4 are selected to synthesize false color images, which can effectively highlight geological information.Principal component analysis was performed on remote sensing images in the study area. Since the first three principal components contained the most information in all bands, PC1, PC2 and PC3 were used for false color synthesis to highlight

lithological information. Finally, the ratio of bands was used to enhance the spectral difference between bands, and Band5/Band7, Band5/Band1, and Band7/Band3 were selected as composite images, which further enhanced the texture information of the images and provided research ideas and methods for the identification of carbonate rocks in the southwest area.

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