OBJECT IDENTIFICATION BASED ON MULTI-REMOTE SENSING IMAGES IN THE LACKING AREA OF 1:50 000 TOPOGRAPHIC MAP OF TIBETAN PLATEAU

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ABSTRACT:

The lacking of 1:50000 topographic maps in western China is inconvenient to the national economic development. The rapid development of space technology, computer technology and information technology provides technological support for the remote sensing application. In addition, the enhancement of ability of obtaining hyper-resolution data provides data for feature extraction of ground objects. This paper employs SPOT5 RS image, based on the schema standard of 1:50000 topographic maps, to interpret the Qixiangcuo region in the Tibetan Plateau. The results indicate that the SPOT5 can meet the needs for 1:50000 topographic mapping. In order to further improve the interpretation multi-temporal and multi-resolution image are suggested to be used to interpret ground objects in 1:50000 topographic maps.

1. INTRODUCTION

1:50000 topographic maps are indispensable fundamental geographical information which can be used in national economic construction, geologiccal investigation and surveys, environment protection, water and biological resources exploration and national security. In western China, around $200*10^4$ Km^2 area in Sorth Xinjiang desert region, Tibetan Plateau and the Traverse Mountains region does not have 1:50000 topographic maps due to the weather condition, environment limitation, traffic inconvenience as well as the restrictions of the mapping technology and equipment in the past. The lacking of these maps not only restricts region economic and social development, the traffic and water conservancy construction, natural resources and mineral surveys, but also seriously impacts the economic development and national security of the western region of China. Along with the implementation of the western exploitation and the national sustainable development strategy, the development of the western infrastructure, resources survey and exploitation, ecological construction, environmental protection, the development of modern digital military directive system, antiterrorism and maintenance of the border security, the western scientific and cultural progress etc, all urgently need the 1:50000 topographic maps. Due to the need of large data sets for mapping 1:50000 topographic maps, high data acquisition technology is required. Especially for the routhless area, the spot reconnaissance is more difficult. In recent years, the rapid development and the popularization of remote sensing (RS) technology makes it possible to solve this problem. Using RS images as the data source to update the topographic map is increasingly used in land resources survey and monitoring (Jiang, 2001;Wang et al., 2002; Feng et al., 2004; Jiang et al., 2004).

In recent 20 years, the RS application has been highly improved by means of the development of space technology, computer technology and information technology (Liu et al., 1997; Lin et al., 2003; Zeng, 2004). Different RS images have different characteristics in feature extraction. SPOT-5 satellite was launched on May 4th, 2002 by the French Ariane 4 launch vehicles. It is the last one of French Space Agency SPOTS satellite series which is obviously different from the former 4 satellites. There are two HRG and a HRS instruments on it and it mainly provides 2.5m panchromatic image and 10m multispectral data. The characteristics of each satellite channel are shown in Table 1 and Figure 1. Currently, SPOT images are the main RS images used by the National Ministry of Land and Resources on large-scale national resource construction, the land use investigation, the digital territory project, the updating of soil resource and the land-use information system (Li, 2000; Deng et al., 2005).

Sensor	Band	Ground Resolution	Spectral range
SPOT5	Panchromatic	2.5m	0.48-0.71 μm
	B1:Green	10m	0.50-0.59 μm
	B2:Red	10m	0.61-0.68 μm
	B3:Near Infrared (NIR)	10m	0.78-0.89 μm
	B4:Short wavelength infrared (SWIR)	20m	1.58-1.75 μm

Table 1. SPOT5 data spectral bands and resolution

2. THE OVERVIEW OF STUDY AREA

The central part of the lacking area of 1:50000 topographic maps is Tibetan Plateau which is the highest one in the three-class ladder. It is bordered by the Pamirs in the west, Traverse-Mountains in the east, the Himalayas in the south, the Kunlun Mountain, Aerjin Mountain, and Qilian Mountain in the north. It covers the area from N 42°45′ to N67°10′ in latitude and from E81°00′ to E106°00′ in longitude. It is 2500km in length of EW and 1200km in width of SN. The area is $230 \times 10^4 km^2$. In addition, the terrain of Tibetan Plateau is high because the average altitude is higher than 4500m and it is sloped from northwest to southeast.

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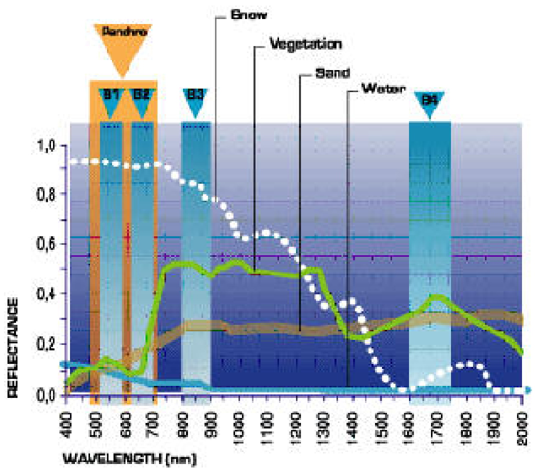


Figure 1. The band model of SPOT5 data spectral characteristic

The uplift of Tibetan Plateau changes the atmospheric circulation in mid-latitude westerly, forming the Plateau monsoon climate. The temperature is low due to the limitation of altitude. Therefore the average temperature is below zero in most area. The average temperature in the south is higher than that in the north at the same altitude. The annual average temperature is gradually reduced along the southeast to the northwest. The annual precipitation in Tibetan Plateau is relatively less and the rainfall mainly concentrated in May to September, accounting for 80%~95% of the annual precipitation. Winter is dry season and the precipitation occupies 5~20% of the annual. There are more thunderstorms and hailstone in the rainy season. In addition, Tibetan Plateau is the largest ice, snow and cold area in mid-low latitude region of the world. There is 4.7×10^4 Km^2 covered by glacier accounting for 80% glacier area in China, and frozen soil covers 150×10^4 Km^2. The glaciers and snow lines change regularly, while the distribution of frozen soil is significant different. Continental glaciers are distributed in the central and northern plateau, while oceanic glaciers are distributed in the southeast and southern plateau. The permafrost area is general in Kailash area which has continuous permafrost zone, The rest area is island and seasonal permafrost (Liu et al., 1997).

The uplift of Tibetan Plateau also significantly affects the soil forming process and its geographic distribution. It has alpine soil which is the most comprehensive agrotype in China. The regular zonal distribution reflects that hydrothermal conditions gradually decrease from southeast to northwest, biological effect becomes weaker and soil development degree tends to original. The natural vertical zones are from the edge of the plateau to the hinterland within plateau. Along with location difference, the natural vertical zones have different base bands, their structure becomes simple, and the number of the zones decreases. In addition, the south of East Himalayas is one of the richest rainfall regions due to the impact of southwest monsoon,, therefore forms a vertical distributing series based on yellow latosol and yellow lateritic red soil. The southeast Tibet mountain gorge area mainly has yellow brown soil. It forms a vertical distributing series of which the sub-alpine grassland soil is the lowest level in north mid-Himalayas as well as upstream and middle stream area of Brahmaputra. The deep valleys of east Traverse-Mountains is dry and hot, therefore form a soil vertical distributing series of which brown soil is the bottom. In the eastern part of north-Tibet, the climate is clammy and therefore it develops as alpine meadow soil. On the plateau surface, the climate in south-eastern is cold and dry therefore it forms as alpine steppe soil. The central plateau develops alpine desert grassland soil. In northwest, the weather becomes drier and colder therefore the accumulation of the humus becomes weaker. The bottom layer is permafrost soil and therefore forms alpine desert soil (Zhang et al. 1982).

Qixiangcuo area which lies in northern Tibet and northwest of Naqu region was selected as the case study area. It covers the area from N32°11′ to N32°41′ in latitude and from E89°38′ to E90°17′ in longitude and belongs to the shuang lake special region which is an administrative region established in 1976 to develop the depopulated area in northern Tibet. This area has a vast territory and its residents live extremely scattered. Qixiangcuo area which is gentle with open grassland locates at Qiangtan Plateau lake basin. Its terrain is higher in the north than the south, and mostly are dry-cold and semi-desert meadows. The average altitude is about 4800m. The Kunlun Mountains, Tanggula Mountains, Kekexili Mountains, Dongbule Mountains etc. are located in this area. There are a lot of lakes and Qixiangcuo is one of the famous lakes (Zhang et al. 1982; Wang et al., 2005).

3. RS DATA PROCESSING AND INTERPRETATION

3.1 Image data

A SPOT5 multispectral image with 10m resolution in March, 2004 and a panchromatic image with 2.5m resolution in November, 2003 were selected as the case study data for this interpretation task.

3.2 Image processing

3.2.1 Geometric correction

In order to match the two images in the interpretation process, the geometric correction was adjusted first. Both of the original images didn’t have precise geometric correction, therefore the correction process was followed as below. First, the images were corrected separately using a reference image to unify them to the same geographic coordinate. Second, the two images were proofed by the precise geometric correction. In practical operation, a precisely corrected ETM image of September, 1999 was used as the geographic reference image, polynomial model (cubic) was selected as the geometric correction model, and the nearest neighbourhood interpolation was used in resampling to correct two images separately. The correction results show that the correction errors of two images are controlled within one pixel. In the geometric registration, the same model used in the geometric correction was used as registration model, and the nearest neighbourhood interpolation was used in resampling, the registration error was also controlled in one pixel (Meng, 2000).

3.2.2 Image synthesis

In order to have both high spatial resolution and multispectral feature, the panchromatic image with high spatial resolution and multispectral image were merged using PCA transformation, i.e. using the high spatial resolution image to instead the first principal component after multispectral image transformation. The true colour image could not be fused due to the lacking the Blue band in SPOT5. The 4, 3, 2 bands of the fusion image were used to fuse the pseudo colour image according to the purpose of the interpretation (see Figure 2).

Figure 2. Pseudo-colour image of 4, 3, 2 bands of SPOT5 in Qixiangcuo area in Tibet

3.3 Image interpretation

3.3.1 Classification system

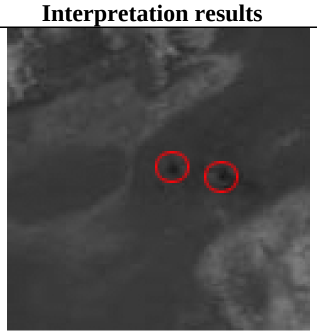
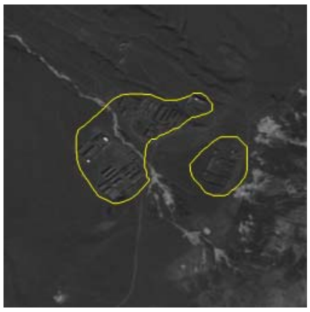
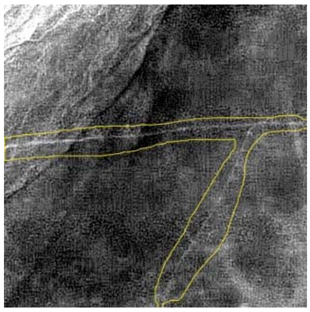
The standard for terrain classification of the interpretation results is the 1:50000 topographic mapping schema.

3.3.2 Interpretation method

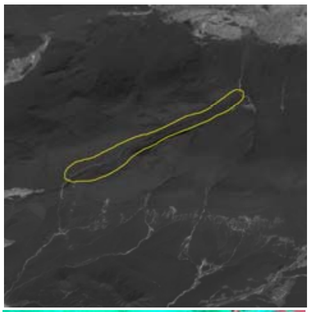
The interpretation mainly uses visual interpretation. using the image (colour) hue, shadows, size shape, texture, pattern, location and combination to interpret elements, and ultimately determine the feature types.

3.3.3 Interpretation results

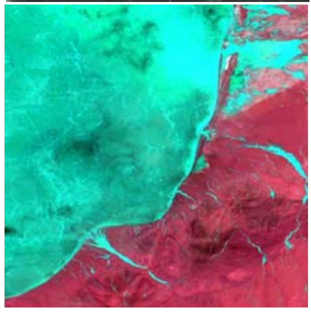
10 ground object types were extracted according to their image characteristics (see Table 2, Figure 3).

Ground object types	Interpretation results
Pastoral tents: The recognition of the pastoral tents mainly based on their shape and size on the image. They are difficult to be recognized on the 10m resolution multispectral image. However, on 2.5m resolution panchromatic image, the tents have regularly hexagonal shape and therefore they could be clearly recognized, but the residence month is uncertain.	
Normal houses: The extraction of normal houses depends on their shape, size, texture, pattern and combination to judge. Similar to the pastoral tents, they are difficult to be recognized on multispectral image. But on panchromatic image, these houses are shown as regular polygons with the regular shape and clear texture; therefore they can be clearly recognized.	
Roads for transporting: The interpretation mainly depends on their shape. On multispectral image, the roads are fuzzy and sometimes are mixed with the background; therefore they can't be completely extracted. While on panchromatic image, they are clear and can be distinguished from the background.	

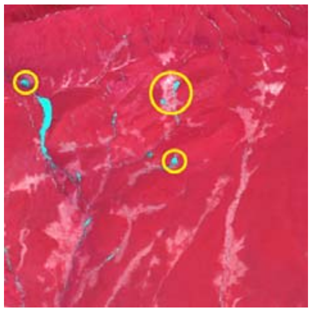
Village roads: The extraction of the village roads is similar to the extraction of the roads for transporting. However, they need be distinguished due to they have similar image characteristics. It is difficult to separate them only using RS images. In practice, it is necessary to rely on original information (such as traffic maps) to manual distinction. According to the characteristics of Tibetan Plateau, the suggestion is to change the scheme to express them as the passable section.



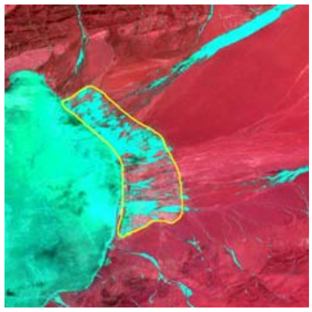
Rivers, lakes and reservoirs: They mainly depend on colour, shape and size to recognize. On the pseudo-colour image (synthesis of multispectral 4, 3, 2 bands), the water is bright blue and could be easily distinguished from the surrounding ground objects. Besides, the border of lakes and the riverway of rivers are clear, therefore they can be easily identified.



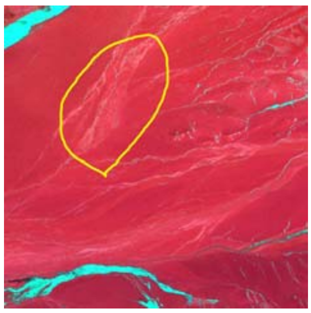
Springs: The Springs identification mainly depends on their position, shape, colour and size. They are mostly located at the end of river branches with irregular polygon. They are smaller than lakes, and have similar colour with water.



Swamps: The swamps extraction mainly based on their position and colour to judge. Swamps usually located at the edge of lakes. They have both spectral characteristics of water and soil. However, due to they are not uniform mixing and water covers the swamps surface, the spectral characteristics are not shown as a unique spectrum from the arithmetic superposition of two spectral information. It is represented as two spectrums appear alternately in space and the water spectrum appears with a higher frequency.



Dry riverbeds, dry lakes: The rivers and lakes without water are classified as this type due to only single-temporal image was available. If multi-temporal images are available, the seasonal rivers and lakes could be distinguished. Dry riverbeds and lakes have the similar shape with swamps in images and they always intersect with swamps. In addition, their colour and texture are similar to gravel because they don't have water.



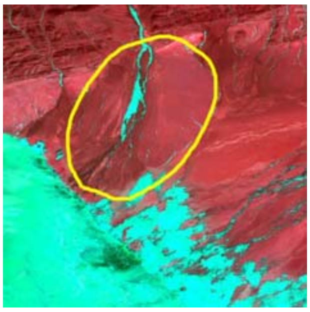
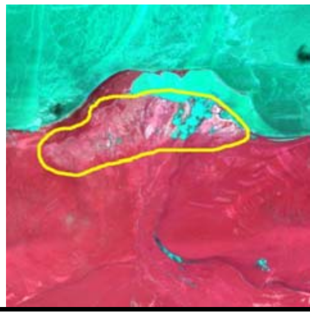
Gravel, gravel gobi: they are shown as celadon colour with uneven hue on the image of multispectral bands 4, 3, 2. The less the vegetation on the ground surface, the darker the colour.	
Saline lands: Saline lands have a high reflectivity, therefore they are shown as incanus on the image. The less the vegetation on the ground surface, the brighter the hue.	

Table 2 The contrast of the interpretation results and the image

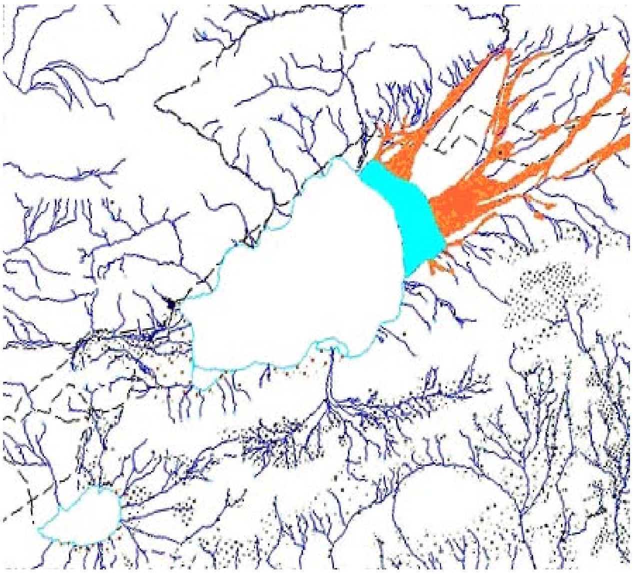


Figure 3. The interpretation results of 1:50000 topographic maps based on SPOT5 image in Xiangqicuo area in Tibet

4. CONCLUSION AND DISCUSSION

In this paper, the focus is on the 1:50000 topographic mapping using SPOT5 high resolution image. The visual interpretation method was employed to interpret 1:50000 topographic map of Qixiangcuo area in Tibet based on the reference of the former scientific achievements. The results show that SPOT5 images basically meet the needs of producing 1:50000 topographic maps. Using the combination of panchromatic images and multi-band images to extract the ground objects could get very good results. Through consult the experts of Tibetan Plateau scientific expedition, the experts believe that the interpretation method and results are satisfactory. Some Tibetan depopulated area is difficult to reach therefore using traditional surveying methods to mapping is largely limited. This research takes Qixiangcuo area as an example to set up operation specifications and implementation methods for the Lacking Area of 1:50 000 Topographic Map based on RS images.

Since the image of interpretation is single-temporal, some seasonal changes in ground objects could not be precisely judged. For example, the dry riverbeds and dry lakes can not be determined whether they are seasonal. In addition, the true color image could not be obtained due to the lack of the Blue band of SPOT 5, this is undoubtedly increase the difficulty and the error of visual interpretation. In addition, the extraction of vegetation is not satisfactory, which may be because the temporary phase and radiant correction of the image. It is difficult to recognize the soil material especially their borders due to their weaker spectral information caused by the interference of spectral information of vegetation which covers on the ground surface. The study area is in the depopulated area in Tibetan Plateau, and the investigation of natural environment of this area is rare in the past, therefore, this area has less background information, this has brought a certain degree of difficulty to the interpretation. Therefore, the omission and misjudge are inevitable. To further improve the accuracy of the interpretation of RS images, the multi-temporal and multi-resolution images can be employed, and adopt fusion method of different resolution images to obtain high precision maps (Liu, 1998; Lu et al., 2004).

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