Collaborative application of RADARSAT2 and GF-1 data to the study of Geological structure

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Abstract. Collaborative application of Radarsat-2 and GF-1 remote sensing data to study the geological structure for Lalingzaohuo area in east kunlun metallogenic belt has been done. On the basis of detailed analysis of the geological background, with the processing of radarsat-2 and GF-1 data, remote sensing fusion data is utilized to extract the structural framework for the research area. Our work has an important guiding significance to the mining prospecting work, which also has important practical significance for the enrichment to radarsat-2 and domestic high resolution remote sensing data in the field of geological prospecting.

Introduction

There are a lot of successful case studies for geological structure by using remote sensing data, and mainly conducted by optical remote sensing data in two aspects. One hand is to use moderate resolution ETM/Aster data to carry out a wide range of regional geological structure research[1-3], and the other hand is micro structure which is studied by using high resolution remote sensing data[4,5].These optical data have good application effects in high degree bare areas, but for the shallow coverage area, because of the ground vegetation and the Quaternary in the surface, which may weak or shield the spectral and spatial information of rock in some extent, and the geological structural outcrops are often not clear, and all of these factors lead to the application restrictions of the optical remote sensing images in shallow cover area. Synthetic aperture radar as a kind of active microwave remote sensing imaging technology has all day all-weather strong penetrability and high resolution characteristics, which has unique advantage in lithology, geological structure and the tectonic controlled metal ore deposit exploration, and radarsat-2 is the current relatively popular radar data. Since radarsat-2 satellite launch in 2007, its application in the field of land and resources focused on marine oil spill monitoring, crop monitoring, surface subsidence monitoring and emergency response[6], while geological formations and mineral resources applications rarely reported, only a few conducted a study of its application in geological structure[7,8]. With the development of the domestic high resolution satellite data acquisition technology, the spatial resolution of the domestic satellite data has reached meters level, such as GF-1 which panchromatic data has reached to 2 m.

In this paper, we choose the shallow coverage area in Lalingzaohuo in Qinghai East Kunlun Metallogenic Belt(EKMB), on the basis of detailed analysis of regional geological background, through the fusion processing of radarsat-2 and GF-1 data, and the structural framework in the study area have been extracted and enhanced. Our research has an important guiding significance to the prospecting work, and also enriching the application of radarsat-2 and domestic high resolution data in remote sensing geological prospecting.

Geological Background

The East Kunlun Metallogenic Belt is located in the northern part of the Tibetan Plateau (Fig. 1), with the Qaidam basin to the north and the Bayan Har terrane to the south. And it can be divided into three zones: northern (Qimantagh folded zone), middle (granite zone) and southern zones by major faults (i.e., South Kunlun Fault and Central Kunlun Fault). Our research area lies in the western part of EMKB, and there is a typical skarn- porphyry copper molybdenum deposit called middle reaches of Lalingzaohuo. Major structures in the research area include a series of NWW, NEE and NNW trending faults, with the NEE trending faults as a major. The rocks in the mine area consist of biotite plagioclase gneiss, biotite amphibole gneiss, biotite quartz schist and marble interlayered with amphibolite in Paleoproterozoic Jinshuikou group, and the marble interlayered with amphibolite as a source bed. The main intrusive rocks are late Triassic quartz diorite and granodiorite, which may provide a heat source for mineralization. Mineralization in the area are mainly molybdenite, peacock petrochemical pyrite and limonite and the alteration mainly silicification, skarnization and hornfels. The distributions of mine bodies are consistent with the regional tectonic, which is NW-SE trending. And it displays that the NW-SE fracture may be the main metallogenic epochs, which provide a good channel for hydrothermal migration and occurrence space [9,10].

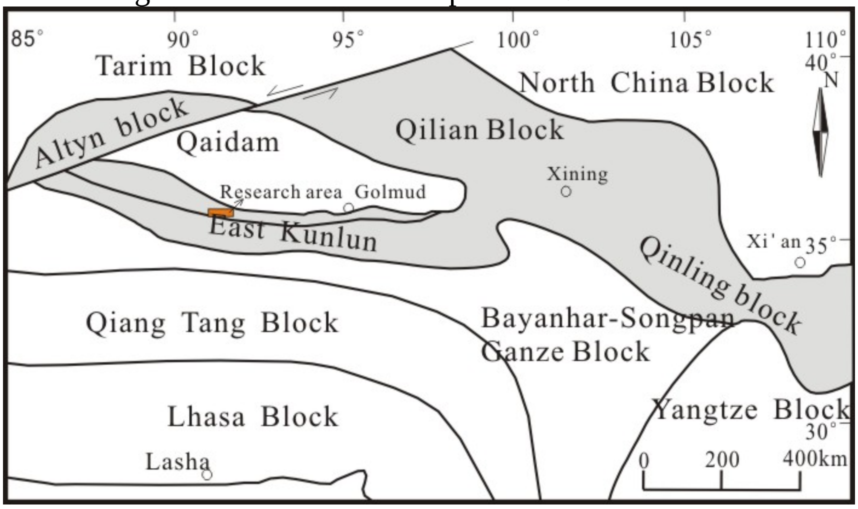

Fig.1 The location and major tectonic units of the research area

Introduction to the Data Source

Radarsat-2 data

RADARSAT-2 carries an advanced C-band SAR, and was launched in December 14th,2007 at Baikonur cosmodrome in Kazakhstan. It can provide 10 kinds of beam model, including two high resolution modes and 3 polarization modes. In this paper, we choose Ultra Fine mode which provide high resolution imagery at a single polarization[11](Table.1).

GF-1 data

The GF-1 satellite is equipped with two 2-m panchromatic/8-m multispectral cameras and four 16-m wide-field imagers (WFI). The swath width increases to 800 km when the four sensors are combined, which is approximately four times larger than that of the Landsat 8 OLI sensor. The temporal resolution of GF-1 is 4 days. GF-1 provides a higher spatial resolution and frequent revisit times for monitoring water quality[12].

Table1 the characteristics of images used in this study

Sensors	Mode	Polarization	Resolution（m）	Date of acquisition
Radarsat-2	Ultra Fine	VV	3	2014.8.18
GF-1	Multispectral/panchromatic		2	2013.9.27

Data Processing

Our research area lies in the western part of EKMB, the southwest of Golmud. We get the radarsat-2 VV polarization ultra fine type data, and the four coordinates are as follows:

(1)93°11'39.719"E,36°33'27.185"N;(2)93°24'50.766"E,36°31'20.083"N;(3)93°21'50.41"E,36°19'24.476"N;(4)93°8'40.448"E ,36°21'29.515"N。

Data processing with the radarsat-2

Geometric correction: As the radar image is side-view imaging, the geometric distortion is much more seriously compared with the star point imaging. There are many kinds of methods to do geometric correction: Polynomial correction method, Digital differential correction method and simulated image correction method. In this paper, we choose the simulated image correction method which is suitable for the large relief area.

Radiation correction and speckle noise removal: Radar image radiation distortion has caused great difficulties to the interpretation, classification and matching of SAR image, in this case, we must carry out the radiation correction. There are two factors that caused radar image radiation distortion which are radar imaging system and speckle noise from flare effect. Radiation distortion caused by radar imaging system can be eliminated by radiation calibration which is usually performed by a ground station. The speckle noise caused by the flare effect can be removed by visual smoothing before imaging and filtering after imaging. And we employed the K-average adaptive filtering method to do the radiation correction and speckle noise which demonstrated to be the best method.

Data processing with the GF-1 data

The accuracy of GF-1 data which was obtained from the ground station is low, and can't directly fusion with radarsat-2 image. In this paper we adopt the bilinear interpolation method to get the same spatial resolution images of the radarsat-2. Then the geometric precision correction is employed to adjust radarsat-2 and GF-1 image, and the error was controlled within 2m.

Fusion with the radardat-2 and GF-1 data

Multi-source information fusion can enhance the reliability and information complementarity of the data[13]. The GF-1 image reflects the relatively abundant spectral information and the radar image can reveal more structure information, and the integrated application of these data can reveal more information. Common image fusion methods are as follows: pixels weighted fusion, HIS color space transformation fusion, Feature fusion based on wavelet theory, the principal component transform and the Brovey transform fusion and so on[14]. In our study, we need to highlight the structure and ore information, and the principal component transform fusion method was employed, and the result is shown in Fig.2.

Fig.2 Radarsat-2 and GF-1 PCA fusion images for the research area

Interpretation of Geological Structures

Compared to the original GF-1 data, the fusion image retained the tonal information besides obviously better structural information, so that in geological interpretation aspect the fusion image is better than not fusion Radarsat-2/ GF-1 images, and also the linear structure information is especially significant enhanced.

In this paper, we carried out geological structure interpretation by the fusion image (Fig.3), and we can classify the linear structure into three periods by the cutting relations, the first period is nearly east-west fracture, the second phase is of the north west and the third is north east, which is consistent with the regional structure. And also the information of circular structures has been extracted, which may relate with the regional magmatic rocks or concealed rock mass.

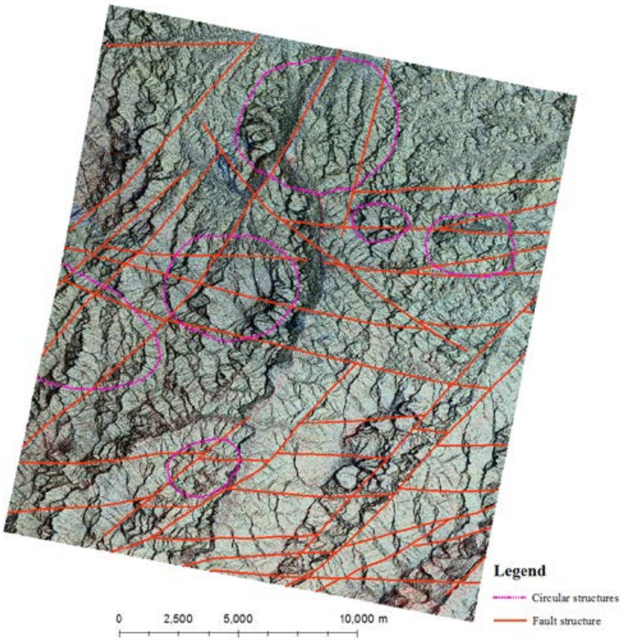

Fig.3 The structural interpretation for Radarsat-2 and GF-1 fusion image

Conclusions

By combined utilization of Radarsat-2 and domestic GF-1 high spatial resolution remote sensing data, the geological structure have been studied in Lalingzaohuo in East Kun metallogenic belt, and the main understandings are as follows:

(1) By adopting the principal component transformation fusion method for radarsat-2 and GF-1 data, and this method has been demonstrated as the best choice of keeping the image resolution and also highlighting structure information in our study area.

(2) We extract structure information by using the penetrating features of radarsat-2 and fusion data, and our research shows that the linear structure in the study area can be divided into three periods, the first period is nearly east-west fracture, the second phase is of the north west and the third is north east, which is consistent with the regional structure. And also the information of circular structures has been extracted, which may relate with the regional magmatic rocks or concealed rock mass.

(3)Radar data has a wide application prospect in structural geological in shallow coverage area.

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