High resolution remote sensing and potential analysis of iron ore prospecting——Taking Datong Township, West KunLun Area for example

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Abstract. By the high resolution remote sensing anomaly verification, two magnetite ore belt was first found in the paleoproterozoic Kulangnagu group complex (Pt1K) at Datong township area. Which located in the southeast of West KunLu Taxkorgan iron deposit prospect area. The magnetite presents ribbon, lenticular, hosted in quartz schist with marble stratum. Based on the regional stratigraphic paleogeographic environment, primary rock formation, ore controlling environment geological background analysis, think that the Kulangnagu group complex have the potential to find metamorphosed sedimentary iron ore. Based on the analysis of high resolution remote sensing, combined with geochemical and geophysical data, we discussed the ore prospecting area and put forward two magnetite favorable prospecting area, one at the south of Datong township area, another at the southeast of Bulunmusha township, given the direction for the next step of prospecting.

In the previous work, contact metasomatic or hydrothermal jade deposit, hydrothermal molybdenum deposit have been found in Kulangnagu group complex [1][2]. But, few rich magnetite were reported. Only in the 1:25 million regional geological survey, some laminated magnetite quartzite are recorded in the measured geological profile, but no more detailed expositions were carried out. In 2010-2011, by the remote sensing anomaly inspection, one banded iron formation (BIF) belt ware found in the southern part of Datong town area by the authors, then two magnetite ore belt was first found in the BIF belt. Based on the analysis of the high resolution remote sensing, starting from the ancient geographical environment, primary rock formation, ore controlling environment and remote sensing anomaly characteristics, combined with the geological characteristics of magnetite ore, this paper discussed the origin and spatial distribution of the magnetite ore in Datong Township, West Kunlun.to provide basis for the next prospecting direction.

1 Regional Geology
Kulangnagu group complex belonging to the Western Kunlun stratigraphic division, Widely distributed in Northern Kunlun, Qiaerlong Township, Bulunmusha Township, Datong Township, Xihexiu Township and other places. Especially, in the south of Datong Township, Kulanglagu River area, North of Kudi and North of Saitula, it’s well outcropped and look like a long belt [1][3]. The area between the Kegang fault zone and Kang Xiwa fault zone is the study area in this paper (Figure 1).
In the High resolution image (True color, composited by bands 5-3-2), the magnetite ore body’s color is light gray, texture clear. Along the extension of texture direction (North to West) can see the dark, white and brown strips obviously. And NW parallel faults are well developed. According to result of remote sensing image interpretation, the lithology unit of this area has the image characteristics of quartz schist and marble, the ore belts were located in the area of ductile brittle shear zone. A intrusive rock appear on the south side of the shear zone.

Through the field verification, the rocks has well-developed joints, strongly crushing and alteration. their deep parts has been mylonization. Caused by the tensile shear, the dark mineral in the invasion rocks have been oriented arrangement, part of the intrusive rocks have become felsic mylonite. There have some later granite intrusion in the rocks, and the vein's alterations are well-developed. This shows that the late hydrothermal activities were strong.

In Datong area, Kulangnagu group complex’s lithology is mainly crystalline schist, such as dark gray-black biotite quartz schist, gray mica quartz schist, grey-black quartzite, laminated magnetic quartz, white marble. The magnetite quartzite laminae is obvious, and the fold, crumpled structure are obviously on hand specimen scale. The original rock of the BIF and its surrounding rocks in Kulangnagu group complex is a set of clastic rocks (mainly argillaceous sandstone) - carbonate rocks intercalated with basic volcano rocks. The Datong magnetite ore produced in the banded iron quartzite section along the formation strike, has the feature of syngenetic sedimentary mineralization, By the late (Caledonian) magmatic activity, the magnetite ore bodies reformed by hydrothermal alternation and further enrichment [1][4].

2 Geological Characteristics of Iron Deposits
2.1 The Output Characteristics of Magnetite Ore Seam
The Datong Magnetite Deposits located at about 1.5 kilometers south of the township government, Taxkorgan Tajik Autonomous County, two magnetite ore outcrop was found, one is the southern Datong magnet mineralized bodies, the other is the Yilifa magnet mineralized bodies. The surrounding rock of the mineralized bodies are grey - black mica quartz schist intercalated with marble, the strike of the strata is relatively stable, the occurrence of the strata is $40 \angle 70$. At the Part of the quartzite intercalated with mica quartz schist near the marble, where developed some lamellar magnetite quartzite and magnetite ore. The thickness of the laminated magnetite quartzite is about 300 meters. The thickness of the magnetite ore body is 10-20cm, and the maximum thickness is up to 100cm. Presenting single layer or multiple layers output. In local area, the magnet mineralized bodies shaped as lenticular, pod, cystic. In the ore belt, the mineralization is not continuous, intercalated with several layers of different thickness of iron quartzite. The mineralization of the upper part of is strong, the iron ore layer has large thickness, stable occurrence and good continuity. The average grade of iron is 18%.

The ore bodies are controlled clearly by strata and interlayer fault (figure 2). The magnetite veins are banded, its width varies greatly, mainly in 2-20mm. The main gangue minerals are quartz. In overall, the ore body shows a continuous stripe, but the light and dark stripes are interspersed with each other and the theirs thickness changes greatly, this may reflect the more turbulent sedimentary environment at that time.

![Fig.2 Magnetite ore belt and its Geological section in Datong Town](image)

Fig.2 Magnetite ore belt and its Geological section in Datong Town
a- Irregular banded and layered magnetite ore bodies (Yilifa magnet mineralized points), b- Banded magnetite ore bodies(Yilifa magnet mineralized points), c- Contact relationship between magnetite ore bodies and mica quartz schist (southern Datong Town), d- Section of magnet mineralized points, Mt- Magnetite, ibr- Itabirit, qs- Quartz schist, 1- Quartz monzodiorite, 2- Quartzite, 3- Quartz schist, 4- Biotite schist, 5- Marble, 6- Magnetite ore bodies, 036 and 037- Sample number.

2.2 Texture, structure, mineralogical composition of the magnetite ore
Ore mineralogical composition: ore minerals are mainly magnetite and a small amount of hematite. The main gangue mineral are quartz and a small amount of plagioclase, mica, hornblende, diopside, tremolite, calcite, chlorite, pyrite etc.
Ore texture: mainly allotriomorphic - hypidiomorphic granular texture, a small amount of Granoblastic texture, hypidiomorphic granular and allotriomorphic granoblastic texture.

Ore structure: The structure of the ore is mainly banded (or lamellar), dense block, local disseminated, vein etc. Iron minerals and quartz chequered with black and white, with obvious banded, striped, fine lines structure characteristics, form the Banded Iron Formation (BIF). The compact massive rich ore are mainly produced in the stratum of high silica content. The magnetite is mainly concentrated in the transition zone that from the pelitic rocks to the sandy rocks. The ore structure and enrichment characteristics are similar to Tashikuergan "Pamir type iron ore". Show the characteristics of the marine sedimentary deposit that affected by the change of sedimentary environment [5][6].

Wall rock alteration: skarn, chloritization, sericitization, limonitization, pyritization.

3 Remote sensing anomaly characteristics
The color of the high resolution remote sensing image (worldview-2 true color image, band5,3,2) of Datong magnetite ore area is light gray, texture clear, in the ore belt, there have dark gray, white and brown strips. NW trending parallel joint fissure development, indicates that the area has experienced brittle ductile shear tectonic activity.

By using principal component analysis method to extracted the -OH and Fe oxide anomaly from Landsat ETM dat (a middle resolution multi spectral data), only weak -OH anomaly displayed in this region. Field investigation has proved that the -OH anomaly Mainly caused by the marble belt. By using ratio method (B5/B2) to extracted the Fe oxide anomaly from Worldview-2 data (a high resolution multi spectral data ) the result shows that the Fe anomaly is obviously in this area (Figure 3). There have strong Fe oxide anomaly development in the magnetite belts. Shown that the high resolution Fe oxide anomaly and the iron ore belts have a good agreement.

In the Fe oxide anomaly map, the Fe oxide anomaly have a zonal distribution of north west direction. From the north to the south, there have 3 Fe oxide anomaly zones. a few meters to tens of meters wide, extends several hundred meters to several kilometers. Field verification shows that the Fe oxide anomaly zone is mainly caused by the banded magnetite quartzite.

4 Mineralization potential analysis
In western Kunlun, a large number of BIF type magnetite were found in Paleoproterozoic bulunkuole group complex and Changcheng Period Saitula group complex[8].

The rock assemblage characteristics and metamorphic degree of palaeoproterozoic Kulangnagu group complex same as palaeoproterozoic Bulunkuole group complex and Changcheng Period Saitula group complex. They are the primary Precambrian metamorphic basement strata in Tashikuergan area. Therefore, the found banded iron formation (BIF) and magnetite strips indicate that Kulangnagu group complex has metallic conditions of magnetite, with important prospecting indicator significance.

By high resolution remote sensing interpretation, the writer thinks that, there are several stable banded magnetite quartzite stratum in Kuruke Langan, Datong and Bulunmusha area. They magnetite quartzite stratum have obviously image characteristics, its thickness of 200-1000m, extending the length of about 10-25 km. in Datong area, anomaly investigation has confirmed that there have magnetite quartz formation and have found 1m thickness of magnetite ore. It can be concluded that, Kulangnagu group complex have a certain magnetite ore prospecting potential.

5 Conclusions
High resolution remote sensing technology provides powerful help for the geological survey in the Western hard and dangerous areas [7]. Worldview-2 images have high spatial resolution and high spectral resolution in the visible and short wave infrared region (V-NIR), and more accurate iron containing altered minerals information could be extracted and identified, such as limonite, jarosite, goethite, chlorite and etc[8].

Some BIF in Kulangnagu group complex, its iron ore body has experienced several stages, such as the original volcanic sedimentary mineralization, the further enrichment of the regional metamorphism, the
reenrichment of the late magmatic hydrothermal activity and the transformation of ductile brittle deformation.

![Image of Worldview-2 image and its high resolution Fe oxide anomaly in south Dotong area]

**Fig. 3** worldview-2 image and its high resolution Fe oxide anomaly in south Dotong area
1- Fe anomaly, 2- Limonite spectral (field), 3- Worldview-2 image spectral, 4- Limonite spectral (USGS)

The discovery of banded iron formations in Kulangnagu group complex, has provided a new prospecting direction for the iron ore prospecting work in the western Kunlun area. Recommendations would carry out large scale aeromagnetic surveys or geochemical exploration works, increasing the degree of geological work, further evaluated of magnetite ore prospecting potential for Kulangnagu group complex in Datong area.

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