Application of airborne electromagnetic method in the exploration of Qingchengzi mine in Liaoning Province, China

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Abstract. Qingchengzi area of Liaoning Province is an important concentration of polymetallic minerals in China. But with the long-term mining, Qingchengzi mining area has become a crisis mine, and the prospecting and prediction in the mining area has become a key work. The resistivity data is closely related to the existence of minerals. We carried out the VTEM airborne electromagnetic observation in this area. The primary processing results show that the inversion result is very consistent with the existing geological information. The processing results of airborne electromagnetic data will provide an important guarantee for the electrical structure, fault distribution and structural framework in the ore concentration area, as well as the delineation of the mineral target area.

1. Introduction

Liaodong area is an important concentration area of polymetallic minerals, among which Qingchengzi area has more than 10 large and medium-sized lead-zinc deposits, 4 gold deposits, 1 silver deposit, many small deposits and mineralization points, which has become an important lead-zinc gold silver polymetallic ore concentration area in China. However, the mining of Qingchengzi mining area has a history of more than 400 years, and it has become a serious crisis mine. It is urgent to open up a new prospecting direction, and the prospecting prediction in the ore concentration area has become an important part of the future resource exploration work.

In order to carry out the prospecting and prediction in Qingchengzi mining area, we need the geophysical data of this area. However, due to the forest covered area, the conventional land exploration method is difficult to construct in this area, so the degree of exploration work in this area is low.

In this task, measuring the electrical resistivity of this area is important because it is sensitive to the presence of a number of important minerals.

Airborne electromagnetic method is based on aircraft, which can be used in complex terrain area, and it can obtain large area electrical exploration data with high density. Airborne time-domain electromagnetic (ATEM) survey is a commonly used geophysical method for problems associated with mineral exploration, ground water and geologic mapping.

Using the VTEM method of time domain, the ATEM exploration is carried out in Qingchengzi concentration area, covering the whole concentration area. The reliable raw data are acquired, and through data processing, the preliminary resistivity inversion results of key mining areas are obtained. The results can provide an important guarantee for the study and evaluation of the electrical structure, fault distribution and structural framework in the depth of 800 m, as well as the delineation of mineral target areas.
2. Geologic settings

Qingchengzi ore concentration area is located in Dandong area of Eastern Liaoning Province, China, and in Jiaoliao rift valley of North China block. Jiaoliao rift is located between Longgang block in the north and langlin block in the South (North Korea). It spreads in NE direction, and starts from Tanlu fault in the West and extends to the sea of Japan in the East. In space, it spreads in a narrow strip from east-west to northeast to northwest, as shown in Figure 1.

![Figure 1. Location of Qingchengzi mine concentration area](image)

The strata exposed in Qingchengzi Ore Concentration Area are mainly Gaojiayu formation, Dashiqiao formation and Gaixian formation of Liahe Group of Paleoproterozoic, and the Mesozoic Xiaoling formation can be seen locally. Gaojiayu formation consists of graphite bearing marble, hornblende schist, sillimanite mica schist and marble; Dashiqiao formation consists of dolomitic marble, mica banded marble, tremolite marble with thin-layer granulite, garnet mica schist and sillimanite mica schist; Gaixian formation consists of mica schist, sillimanite mica schist, garnet mica schist, tremolite schist with thin-layer marble Rock composition.

The anticlines and synclines in the area are mainly NW and NE oriented. The fault structure is mainly NW and NE trending, mainly including Qingchengzi fault, Jianshanzi fault and damoling fault. Among them, Qingchengzi fault controls the distribution of lead-zinc deposits in Qingchengzi mining area, Jianshanzi fault controls the distribution of a series of gold and silver deposits, such as Baiyun, lindaogou and xiaotongjiabaozi, as shown in Figure 2.
3. Data collection

Time-domain electromagnetics (TEM) is a controlled-source geophysical method that maps the resistivity distribution of the sub-surface by applying Faraday’s law of induction. This is accomplished by applying a time-varying current through the transmitter loop, which generates a time-varying magnetic field referred to as the primary magnetic field. The response from the secondary magnetic field, which decays over time, is measured by the receiver coil after the primary magnetic field has been turned off.

The VTEM helicopter time-domain EM system, first introduced in 2002 and known for its low noise, large dipole moment and deep investigation, is used for exploration. The diameter of the transmitting coil is 26m, the area is 2124m2, the transmitting waveform is trapezoidal wave, the transmitting current is 200A, the diameter of the receiving coil is 1.2m, the effective area is 113.04m2, and 48 time channel data are collected. The observation of 120 north-south lines and the measurement of 2 East-West lines have been completed. The total length of the line is 2352km. The completed survey lines are shown as the blue line in Figure 2.

4. Data processing

Because the amount of data collected in the field is very large, considering the problem of calculation amount, we use laterally constrained inversion (LCI) inversion algorithm [1-2] to carry out data inversion calculation. 1D LCI scheme is capable of performing inversion of very large data sets. The primary parameters of the earth model are resistivities and thicknesses. The models are connected laterally by requiring approximate identity between neighboring parameters, typically resistivity and depth, within a specified variance. The lateral constraints can be considered as a priori information on the geological variability within the area where the measurements are taken. A series of soundings is inverted as one system providing layered and laterally smooth model sections.

5. Results

The following figure shows the fitting results between the inversion model and the raw data near the mining area. It can be seen that the quality of the original data here is good and the fitting results are also good.
Due to the large amount of data, we divided the original data and selected L1450 line close to the gold mine for inversion calculation. The inversion profile of the whole line is shown in Figure 4.

Line L1450 passes through many noise interference areas. Although the current emitted by VTEM is large, some strong interference areas still cannot acquire effective late time data. Therefore, the number of channels involved in inversion is not the same for each measuring point of the whole profile, and the depth of inversion is quite different. And in the area of strong noise (near 17.5km), VTEM cannot get effective data even in the early time, so there is no inversion result in this area.

On the whole, the inversion profile can clearly show the changes of underground resistivity, the peak position shows the characteristics of high resistivity, while the Valley shows the characteristics of low resistivity.

We selected several nearby lines for LCI inversion, and put the results together for horizontal slice. Figure 5 shows the horizontal slice result of 50m underground. In the inversion, we do not have lateral constraints on each line, but we can see that each line is consistent very well, which verifies the reliability of each line. By comparing the horizontal resistivity slices with the existing geological data, it is found that the inversion resistivity is very consistent with the geological boundary, and the inversion results clearly show the electrical characteristics of different geological bodies.

Figure 3. Fitting results of typical survey site

Figure 4. Inversion result of line L1450

Figure 5. Comparison between inversion results and geological information
6. Discussion and conclusion
Compared with conventional land exploration methods, airborne electromagnetic method can enter into the mountain areas that are difficult to enter by surface electromagnetic method for exploration, and can collect high-density data covering the whole survey area.

In this paper, the LCI preliminary inversion of VTEM data in Qingchengzi mine are realized. The inversion results show that the data fit well and the inversion resistivity profile depth can reach 800m. The preliminary results of the survey line data near the gold deposit show that the resistivity horizontal section and the resistivity profile obtained are in good agreement with the known geological information, and the inversion results can clearly indicate the location of the known geological body. These results can provide valuable data for the lithologic inference and interpretation of the ore concentration area. They are significant for the identification of the distribution characteristics of the rock mass in the area.

However, the interference of power lines and human activities is serious. It is very difficult to distinguish the interference from the ore body anomaly. So the data need to be further processed in detail, and the inversion result data need to be further analyzed and interpreted in combination with the corresponding geological information and other geophysical data.

References
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