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Application of Pseudo-random electrical exploration method in mineral exploration: a case study of skarn-type ore body

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Abstract: Skarn-type ore body containing rich mineral resources, which is a type of deposit with important industrial significance and a wide distribution, is formed by metasomatism of mineral gas-bearing hydrothermal fluids on or near the contact zone between intermediate-acid-medium-basic intrusive rocks and carbonate rocks. It is hard to obtain stable data by using conventional electrical prospecting method because of strong electromagnetic interference. A new pseudo-random method is used to do geological survey work in Northeast China for interference avoidance.

1. Introduction

The 1:5,000 geological profile survey uses a 1:10,000 geological grass survey map as the base map. The 1:5,000 geological section coincides with the magnetic survey section, and is arranged perpendicular to the long axis direction of the important anomaly verification area or the strike of the mineralized body as much as possible, and the total length of the section is 6.76km. The purpose of geological profile measurement is to interpret the geophysical anomaly, to compare and analyze the relationship between the anomaly and the geological body or structure, and to find out the cause of the anomaly [1-3].

The layout of the profile adopts the domestic Huace RTK global positioning instrument, and adopts the 1+2 mode (that is, one base station, two mobile stations) and real-time dynamic positioning technology (RTK) is used. RTK positioning technology is a real-time dynamic positioning technology based on carrier phase observations. It can provide real-time positioning results of the survey site in a specified coordinate system and achieve centimeter-level accuracy [4]. In the RTK operation mode, the base station transmits its observations and station coordinate information to the rover through the data link. The rover not only receives the data from the base station through the data link, but also collects GPS observation data. After the unknown number is fixed for the whole week, it performs real-time processing of each epoch to keep it tracked and monitored by the phase observations of more than four satellites. Necessary geometric figures, the instrument composes differential observations in the system for real-time processing, and at the same time provides centimeter-level positioning results. As a result, the error is average, and there is no error accumulation, so that the accuracy of the profile points in the whole area is highly uniform.

Geological structures, sampling locations, lithological boundary points and rock formations are all measured at fixed points using physical detection points. The lithology record is clear and objective, and the sample number is correct [5].

The geological profile is marked at the starting point of the profile along the object detection line. Geological observation points are generally arranged at the physical detection points. When there is a



good bedrock outcrop, perform key observations, follow-up observations along both sides of the survey line, mark obvious changes in topography, and record the data in the profile record book.

During the profile measurement, the measured data and observed geological phenomena have been recorded in the measured geological profile record book. The specific content includes rock name, rock characteristics, color, mineral composition, weathering, other physical characteristics, alteration and mineralization. Chemistry, rock (mineral) veins, geological structure, specimens, sample collection, etc[6]. Detailed observation records layer by layer, study stratigraphic lithology combination, basic sequence, top and bottom contact relationship; stratigraphic sequence, boundary layer type; systematically collect samples, and simultaneously carry out geological photographic sketching.

For the newly discovered mineralization clues and structural alteration rock belts newly discovered in the profile measurement, necessary follow-up inspections should be made in a timely manner, and relevant analysis samples should be collected.

All geological bodies with length $\geq 50\text{m}$ and width $\geq 5\text{m}$ should be plotted on the geological map. Important marker layers, mineral layers, mineralization alteration zones, etc., although the length is less than 50m and the width is less than 5m, are exaggerated and shown on the geological map. The sections are basically arranged perpendicular to the stratum, structural line, or the long axis of the geological body, and the length of each section is as far as possible to control the geological mapping unit of each rock type.

During the profile measurement, attention was paid to the division and research of the stratification, each stratification was observed, recorded and described in detail, and rock and mineral identification samples were systematically taken. After the completion of the profile measurement, the profile data was sorted in time. Through geophysical prospecting section work, preliminary understanding of the magmatic rock and structural characteristics in the exploration area was carried out, and the basic causes of geophysical prospecting anomalies were analyzed and researched [7]. The quality of the section conformed to the requirements of specifications and regulations.

Through the mine with complex electromagnetic interference as the research object, the pseudo-random electrical measurement is carried out. On the one hand, the data representation and denoising effect of pseudo-random electric field driven by system identification are studied, and the cross-correlation relationship between pseudo-random electric field signal and complex electromagnetic interference signal is preliminarily established. By using the autocorrelation characteristics of pseudo-random code, the electromagnetic interference out of band is shielded, and the anti-noise ability of different parameters of pseudo-random electrical method is summarized. On the other hand, it studies the recognition effect of pseudo-random for different geological bodies, especially the display of symmetry between ore body and surrounding rock. This technology can not only be applied in mineral exploration under complex electromagnetic interference conditions, but also can carry out fine exploration of urban underground space structure. At the same time, the technology provides a new technology, new method and new idea for the mine and urban geological exploration with widespread electromagnetic interference, and provides technical support and demonstration basis for the four-dimensional geophysical and electrical exploration.

Pseudo random electrical method technology has carried out experimental research work in crisis mines and urban geophysical prospecting, and the results show that pseudo-random electric field signal can achieve high-precision geoelectric measurement. On this basis, this study will refine the relevant scientific problems of pseudo-random signal and collect the geological characterization of electric field signal, clarify the research content and research objectives, and serve the transparent underground space work.

2. Methods

In this work, 1:10000 high-precision gravity profiles and induced polarization (IP) sounding method were carried out. The survey line direction was perpendicular to the direction of the main geological structures in the area. A GPS is used for three-dimensional positioning of gravity, magnetic and electrical measuring points. A new pseudo-random electrical method, combining conventional gravity prospecting

method, magnetic prospecting method, geochemical prospecting method and core analysis, is used to do an integrated geological survey for interpreting geophysical anomaly and looking for the skarn-type ore body.

2.1 Middle ladder sounding device

The measuring electrode distance Mn is fixed at 40 meters, the maximum supply electrode distance AB / 2 is 2000 meters, and the minimum supply electrode distance AB / 2 is 200 meters. The specific sizes of AB / 2 are: 200, 240, 280, 320, 360, 400, 440, 480, 520, 560, 600, 640, 680, 720, 760, 800, 840, 880, 920, 960, 1000, 1040, 1080, 1120, 1160, 1200, 1240, 1280, 1320, 1360, 1400, 1440, 1480, 1520, 1560, 1600, 1640, 1680, 1720, 1760, 1800, 2000. There are 42 polar distances.

Symmetrical four level sounding device is adopted for the measurement of small polar distance. The measuring polar distance Mn is fixed at 20m. The maximum power supply polar distance AB / 2 is equal to 200m, and the minimum power supply polar distance AB / 2 is equal to 20m. The specific size of AB / 2 is arranged as 20, 40, 60, 80, 120, 160 and 200.

2.2 Three-pole sounding method

The maximum power supply electrode distance of IP sounding design is $A_0 = 1400\text{m}$. Form of the device: in order to obtain more and more intensive survey data, especially for the collection of deep information, and to reflect the abnormal details as much as possible, after the test, the three pole sounding device is adopted, with the maximum polar distance A_0 of forward three poles = 1400m, and the maximum polar distance A_0 of reverse three poles = - 1400m. Starting from the forward maximum power supply pole $a = 1400\text{m}$ and ending at the reverse maximum pole distance $a = - 1400\text{m}$, each power supply pole is separated by 80m. After completing one pole distance measurement, move the pole again to carry out the same observation of the next pole distance.

2.3 Relationship between phase parameters and polarizability of interference method

The electric interference between industrial and mining enterprises and human activities in the west of the mining area is small. The provincial Geophysical Survey Institute carried out the high-power IP measurement here in 2013, which coincided with some areas of this anti-interference electrical method measurement. The overlapping part of the two methods was selected for linear analysis with the phase of the anti-interference electrical method and the polarizability of the high-power IP scanning surface, the results show that the phase of anti-interference electrical method has good linear fitting characteristics with the polarizability of high-power scanning surface, which satisfies the following equation.

Correlation equation $y = 0.124 * X + 1.092$

Number of data points used = 8651

Fit coef of determination, R-squared = 0.73

The comparison results show that the phase measured by anti-interference method can replace the polarizability of high-power IP scanning. The analysis of high-power IP polarizability and phase fitting degree of anti-interference electrical method is shown in Figure 1.

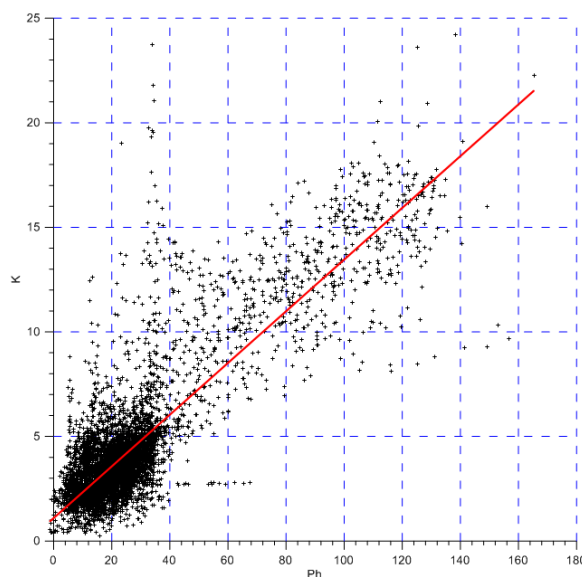


Figure. 1 Analysis of high power IP polarizability and phase fit of anti-interference electrical method

2.4 Comparison between anti-interference electrical method and other method

Figure 2 is the comparison between the anti-interference electrical method and other method (DJS-8A) for a same depth point. The result shows that the data obtained from the anti-interference electrical method is very stable, the curve is smooth, and the quality inspection is with high precision. The data obtained from other method (e.g., DJS-8A) is unstable.

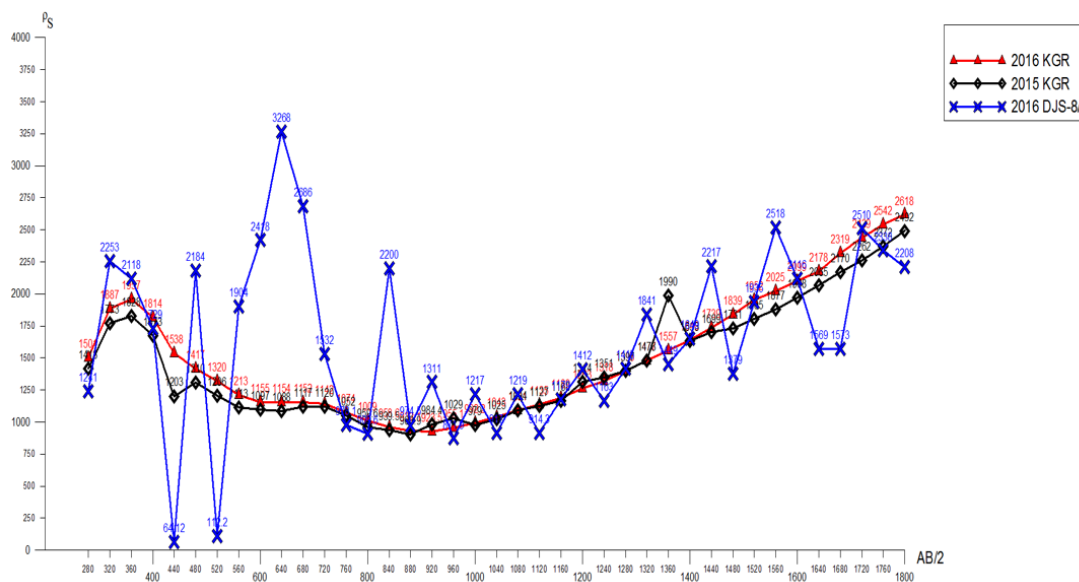


Figure.2 Comparison result between the anti-interference electrical method and other method (DJS-8A)

3. Results

It is proposed that a Cu-Pb-Zn-w deposit is the skarn-type ore body formed by the silicalite surface between the large-scale xenoliths of Tumenling formation with marble supported by granodiorite batholith. The next step of exploration is to look for marble at the edge of the high magnetic granodiorite, taking into account the possible injection type stratabound ore bodies in the periphery of the granodiorite. There is no ore around the weak magnetic coarse-grained granite.

A new pseudo-random electrical method, combining the conventional gravity prospecting method, magnetic prospecting method, geochemical prospecting method and core analysis, is used to do an integrated geological survey for interpreting geophysical anomaly and looking for the skarn-type ore body. Red part represents the skarn-type ore body is shown in Figure 3.

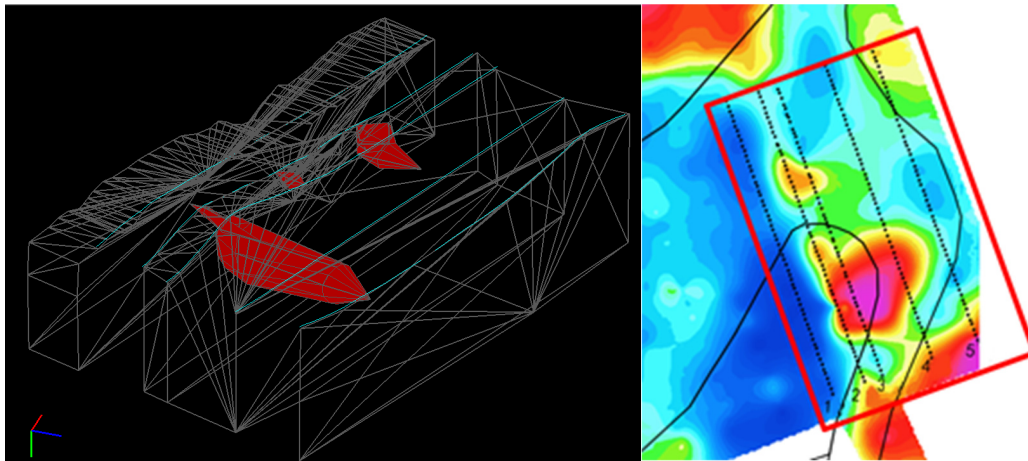


Figure 3. Inversion result: red part represents the skarn-type ore body

4. Conclusion

Many geophysical and geochemical exploration works have been carried out in this area. Due to the previous work of magnetic method, geochemical method, electrical method and so on, there are only photos, and no data has been collected. The project team digitized the previous data, sorted and analyzed them, and comprehensively studied and processed the usability and potential information of the previous data. The precise profile verified the existence of plane geophysical anomalies, reproduced IP anomalies, and further understood the spatial distribution characteristics of IP anomalies. Combined with the comprehensive information of geology, geochemical exploration, gravity, electrical method and drilling, the paper conducted in-depth analysis and research, and identified four abnormal areas with prospecting prospects.

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