Enhancing prediction of deep-seated Cu-Mo porphyry deposit in Baohuashan: A comprehensive 2D inversion of AMT data

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SUMMARY

The increasing global demand for copper and molybdenum, essential for modern industry and green energy solutions, necessitates the exploration of new mineral resources, particularly at deeper levels. This study focuses on the Baohuashan area in Jiangsu Province, China, leveraging Audio Magnetotelluric (AMT) technology to explore Cu-Mo porphyry deposits in a complex geological terrain at depths exceeding 500 meters. Utilizing one long survey line with 25 AMT sites, we aimed to enhance the detection and visualization of resistivity anomalies indicative of potential Cu-Mo deposits where traditional exploration methods have struggled with depths beyond 500 meters. Advanced data processing techniques, including machine learning tools for dimensionality analysis and OCCAM two-dimensional inversion, were employed. The results revealed distinct medium-resistivity (~2500 Ω.m) structures corresponding to granodiorite porphyry and porphyry diorite likely hosting the Cu-Mo deposits associated with regional faults. These findings, validated by two proposed and executed drillholes, suggest significant mineralization potential previously undetected by conventional methods.

Keywords: Cu-Mo porphyry deposit, AMT, 2D inversion, data processing, mineralization prediction

INTRODUCTION

Copper and molybdenum (Cu-Mo) are essential metallic raw materials widely used in various industries, including construction, electrical and electronics, machinery manufacturing, and more. The demand for these resources is expected to increase with economic development and the transition towards green technologies (Stiefel et al., 2010). In China, these mineral deposits are predominantly found in major metallogenic belts such as the Circum-Pacific belt, Tethys Himalayan belt, and Central Asian belt (Lipeng et al., 2020, Guang-Ming et al., 2020). The Baohuashan area in the Middle and Lower Yangtze River metallogenic belt (MLYRMB) is an important yet less explored region for deep Cu-Mo porphyry deposits. Previous exploration techniques faced limitations in accurately charting extensive underground mineral resources, particularly below 500 meters depth. This study addresses these challenges by employing the AMT method to explore deep geological formations in Baohuashan, enhancing the discovery and utilization of these essential mineral resources through a machine learning processing tool.

METHODS

The AMT survey was conducted using one line (L22) oriented in N-S direction, 2400 m long, with 25 stations spaced of 100 m, covering an area with significant geological complexity. Data collection involved 4 channels (Ex, Ey, Hx, Hy) and frequencies ranging from 10 Hz to 10000 Hz utilizing high-precision AMT instrument GSEM-W10 produced by Giant Sequoia Artificial Intelligence Technology Co., Ltd (GSAI) (Pitiya et al, 2022). Before creating a subsurface model during the inversion process it is crucial to understand the level of distortion by applying the quality control (QC) of the data as shown in Figure 1 which presents some affected stations (Confidence < 0.95 %). Advanced machine learning tool called watex was used for data processing (Kouadio et al., 2023), including signal-to-noise identification, frequency interpolation, and adaptive-moving-average spatial filtering (Torres-Verdin and Bostick Jr, 1992) as mentioned in equation (1), were applied to refine the data before inversion (Figure 2). Phase tensor and geoelectric strike analyses were performed to ascertain the geological structure's dimensionality and highlighted the presence of structures mainly in 2D in the study area. The 2D inversion was conducted using OCCAM's algorithm incorporated in ZondMT2D software to produce a smooth model fitting the data within specific tolerances.

$$h(x) = \begin{cases} \frac{1}{W_H}\left(1+\cos\frac{2\pi x}{W_H}\right), |x| \le \frac{W_H}{2}, \\ 0, \quad |x| > \frac{W_H}{2} \end{cases} \quad (1)$$

Where W_H is the Hanning window width and *h(x)* is the Hanning function.

RESULTS AND DISCUSSION

The 2D AMT inversion models, revealed high-resistivity zones (>5000 Ω.m), medium-resistivity zones (~2500 Ω.m) and low resistivity-zone (<100 Ω.m). (Figure 3)

Indeed, the high-resistivity structure is believed to be caused by an intrusion rock and combined with geological data, borehole data it corresponds to granodiorite porphyry which hosts the majority of Cu-Mo porphyry mineralization in this area (Ord et al., 2012, Qi et al., 2021), and also defined as the main intrusion in the Ningzhen area. On the both side of the intrusion, there is a medium-resistivity zone defined as granodiorite porphyry presenting alteration characteristics and inferred to be granodiorite porphyry altered (Figure 4). The Cu-Mo porphyry deposits is most of the time disseminated and associated with porphyritic intrusions and characterized by medium-resistivity as discovered by Lee et al., (2018) and Qi et al., (2021) in Morrison porphyry Cu-Au (Mo) deposit in Cordillera Mountains in Canada and Cimabanshuo porphyry Cu (Mo) in Tibet respectively. Therefore, the Cu-Mo porphyry deposit is located in the medium-resistivity zone and has been confirmed by the 2 proposed drills(ZK221 and ZK222) which intercepted the ore body at around 300 m to more than 500 m with a Copper average grade of 0.50% and Molybdenum average grade of 0.04%(Figure 3). Furthermore, the low-resistivity at both ends of the area inferred to be regional faults F1(E-W), F2(NW-SE), and F15(NE-SW).

CONCLUSIONS

The application of the AMT method in the Baohuashan area successfully enhanced the prediction of deep-seated Cu-Mo porphyry deposits, revealing significant mineralization potential. The ore body has been located at the depth of 300 m to above 500 m, disseminated with some diorite porphyry. The integration of geophysical, and geological methods proved effective in characterizing and predicting mineralization in this complex geological environment. Further exploration using additional geophysical techniques, such as spread spectrum-induced polarization (SSIP), is recommended to obtain more reliable information on the anomalies and delineate potential metallogenic areas.

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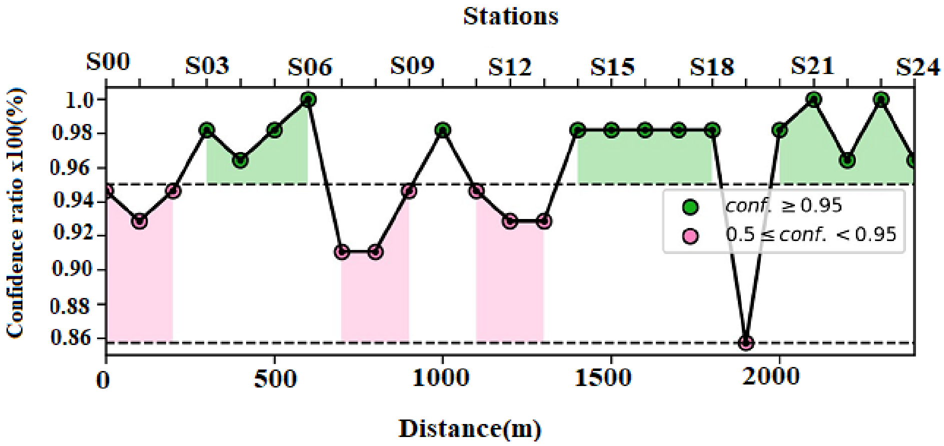

Figure 1. Visualization of a confidence plot derived from inaccuracies in resistivity data. The graphic suggests that data with a confidence interval (CI) of at least 95% is considered safe. However, data falling between 50% and 95% can be enhanced by recovering incomplete and lost signals at each station.

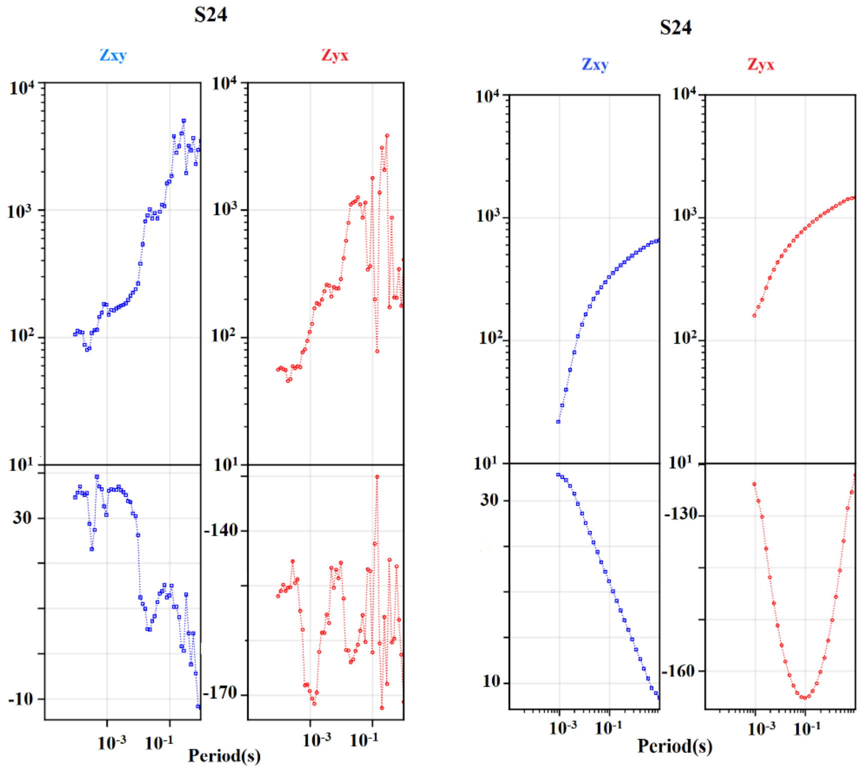

Figure 2. Illustration of one random example of a station (S24) affected by the static shift effect (left) and one shifted curve obtained after applying the correction(right). The shifted curves show an excellent allure and do not need any correction before inversion.

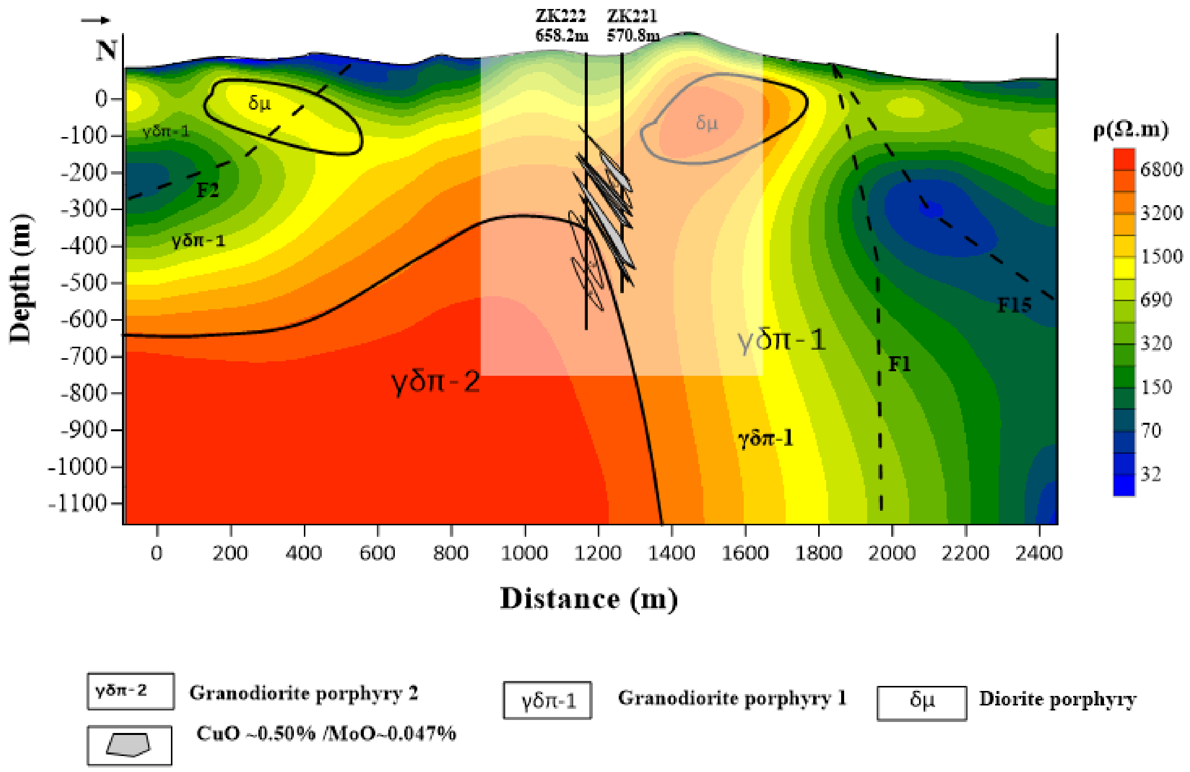

Figure 3. 2D AMT resistivity model overlay with Cu-Mo ore body unveiled by drilling. Cu ~0.50% / Mo ~ 0.047%

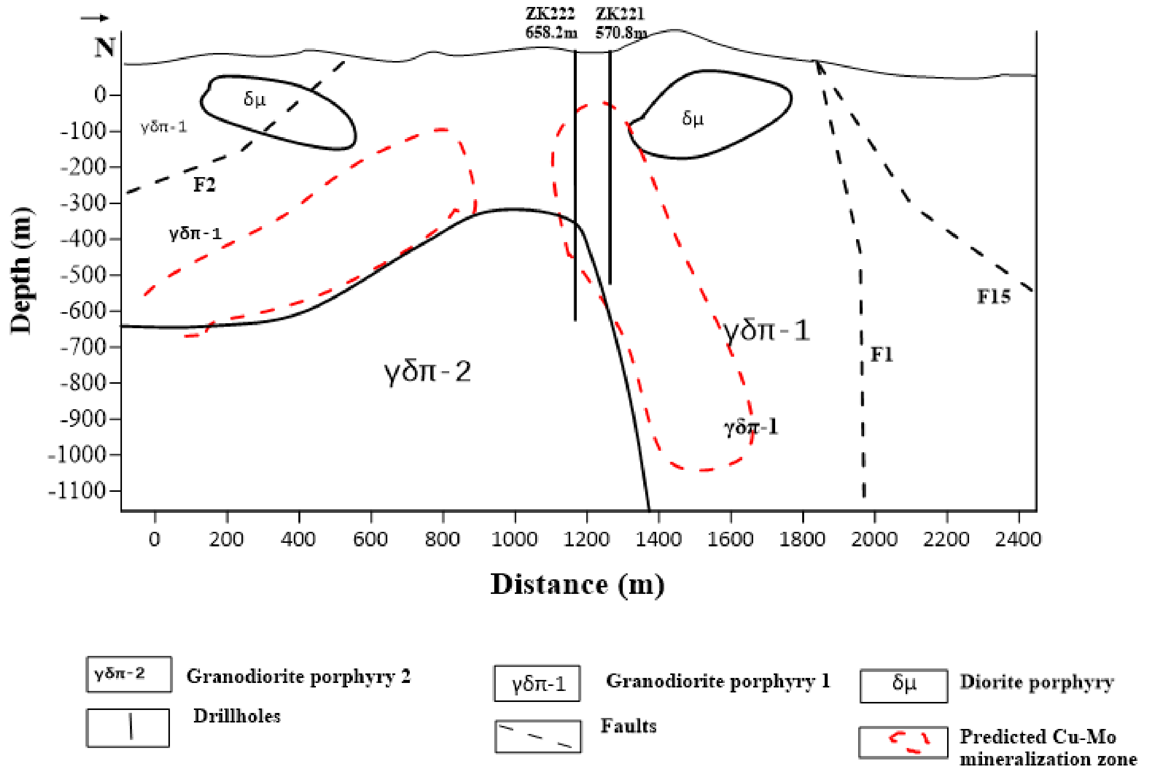

Figure 4. A comprehensive geological map obtained from regional geology, and drill holes data showing the ZK221 and ZK222 drill holes' positions and predicted ore body zone.