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Exploration of the Pb-Zn deposit using IP/Resistivity methods: A case study in Sudöşeği (Simav-Kütahya)

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Profile

Abstract

The investigation of Pb-Zn deposits holds significant importance in fulfilling the worldwide need for lead and zinc, crucial elements utilized in a wide range of industries, including battery manufacturing and construction. Preliminary geological investigations conducted in the Sudöşeği region of Simav-Kütahya have revealed the existence of favorable conditions conducive to the occurrence of Pb-Zn mineralization. The Sudöşeği region located in Simav-Kütahya has been recognized as a highly prospective area for the occurrence of lead-zinc (Pb-Zn) mineral deposits. This study utilizes the induced polarization (IP) and resistivity methods to effectively characterize subsurface geological structures and evaluate the potential for a Pb-Zn deposit. Geophysical techniques provide valuable insights into the variations in conductivity and chargeability of the subsurface, thereby assisting in the identification of mineralized zones. The results of our study demonstrate noteworthy associations between atypical IP and resistivity patterns and established geological characteristics, thereby confirming the efficacy of this integrated methodology in the field of mineral exploration. Chargeability values were observed in profile L 100, which is one of the profiles where geophysical methods were employed. These values were identified as potential indicators of mineralization. This case study exemplifies the significant role played by IP and resistivity methods in the identification of Pb-Zn deposits, highlighting their effectiveness in improving resource assessment and extraction strategies.

Introduction

The geological community has been diligently pursuing effective techniques for the identification and evaluation of mineral deposits over an extended period of time. Traditional methods of exploration, such as geological mapping and drilling, possess certain limitations in terms of their extent of coverage, financial implications, and potential environmental consequences. As a result, geophysical methods have garnered considerable interest as valuable tools in the field of mineral exploration. Induced polarization (IP) and resistivity techniques have demonstrated their efficacy in the identification and characterization of subsurface mineral deposits. The investigation of Pb-Zn ore systems is of considerable importance owing to their substantial economic value and extensive geographical distribution. Copper, lead, and zinc are essential elements that play a critical role in a wide range of industries, including electronics, construction, and transportation. Hence, it is imperative to develop effective methodologies for the identification and assessment of these deposits in order to satisfy worldwide demand and enhance the efficient utilization of resources.

Electrical resistivity tomography (ERT) is a commonly employed geophysical technique utilized for the purpose of characterizing subsurface structures and gaining insights into geological formations [1-2]. The data obtained from this study offers significant insights into the spatial variation of electrical resistivity within the subsurface. Consequently, it facilitates the identification and characterization of diverse geological formations as well as potential areas of mineralization.

The utilization of induced polarization (IP) represents an additional geophysical methodology that offers significant contributions in the understanding of subsurface conditions. This technology possesses the capacity to identify minute conductive rocks that may not be easily detectable using alternative methodologies. The utilization of IP measurements enables the detection of sulfur in minerals, mineral deposits, and soils, while also providing insights into the polarizability of subsurface materials [3].

The integration of these methods yields a potent approach, as it enables the acquisition of data pertaining to both the electrical conductivity and polarizability characteristics of the materials present beneath the surface. This data can be utilized to ascertain regions where sulfide minerals are prone to occur, given that these minerals generally exhibit low resistivity and high chargeability.

Geological formations in which sulfide minerals are present commonly display characteristics of low resistivity and high chargeability [4-5]. The geophysical signatures observed in this study may serve as indicators of the existence of sulfide mineralization, specifically lead-zinc (Pb-Zn) deposits. Resistivity and induced polarization (IP) methods have been effectively employed in numerous studies pertaining to mineral exploration, specifically in the context of lead-zinc (Pb-Zn) exploration [6-7].

The mining of lead-zinc (Pb-Zn) in Türkiye has a rich historical background that can be traced back to the Roman era [8]. Initial geological investigations conducted in the Sudöşeği area of Simav-Kütahya have revealed the existence of conducive circumstances for the occurrence of lead-zinc mineralization [9]. These conditions encompass the occurrence of rocks containing lead and zinc, such as the Eğrigöz Plutonic Complex. Hydrothermal fluids capable of transporting lead and zinc ions are observed. The occurrence of structural traps, such as faults and fractures, can facilitate the entrapment of hydrothermal fluids, thereby contributing to the genesis of mineral deposits [9].

Based on the existing body of evidence, it is probable that the Sudöşeği region possesses the capacity to accommodate substantial lead-zinc mineralization. However, additional investigation and assessment are required in order to verify the existence of a mineral deposit and determine its economic viability. This study employs the induced polarization (IP) and resistivity methods in order to enhance our comprehension and demarcate potential ore deposits.

Material and Method

By employing the principle of induced polarization, the IP/Resistivity method is capable of delineating the spatial distribution of subsurface resistivity and chargeability. The true chargeability, denoted by the symbol (M"), refers to the ratio between the voltage obtained after the current supply is ceased and the voltage measured during the current supply. Typically, the range of values for this parameter lies within the interval of 0 to 1000 mV/V, and its unit of measurement is expressed as millivolts per volt (mV/V).

The resistivity method involves the utilization of a stainless steel electrode that is inserted into the ground to facilitate the injection of an electric current. Subsequently, two electrodes are strategically positioned at multiple locations to quantify the voltage differential present in the soil. The voltage that is measured is typically recorded in volts, often in millivolts. Similarly, the current that is applied is typically measured in amperes, commonly in milliamperes. The aforementioned numerical values, in conjunction with the geometric factor K of the electrode array, are employed to calculate the apparent resistivity (measured in ohm-meters) at the specific location of measurement. The assigned value is located beneath the middle of the electrode array system.

In the research field, a resistivity and IP measurement device with 84 electrodes, specifically an AGI brand, 8-channel system, was employed. The Pole-Dipole Gradient method was utilized to generate a total of 6 profiles, employing electrode spacing within the range of 25 meters. The line was generated utilizing a Magellan handheld GPS device, which possesses a positioning accuracy of 3 meters. The data that was gathered was subjected to analysis using the EarthImager 2D evaluation software. This study presents data from 2 profiles.

Geotomo's RES2DINV and RES3DNV programs were utilized to perform reverse resolution operations on the resistivity and chargability data, aiming to achieve a geological representation that is more accurate and in line with reality. The effects of topography were corrected using GPS elevation data obtained from the profiles in the process of reverse resolution. The report appendix contains graphs illustrating the charging and self-resistance profiles for the reverse solutions. The charts employed warm red-purple hues to depict elevated charging and self-resistance values, while cooler colors like green and blue were utilized to represent lower values. This study focuses on areas with high chargeability, which is considered to be important targets for metallic refinement.

Results

The L 100 profile was initially conducted in a highly controlled manner, during which corrosion phenomena were observed (Figure 1). Upon analyzing the charging interval that arises from the transformation of land data into geophysical sections, it is evident that two closure forms extend from scale 125 of the profile to scale 175. This extension is observed at the depth of the initial closure, specifically between 1060 and 1015. An observation was made of a unit exhibiting a high electrical permeability and a low self-resistance, positioned in a location where the resistance was favorable.

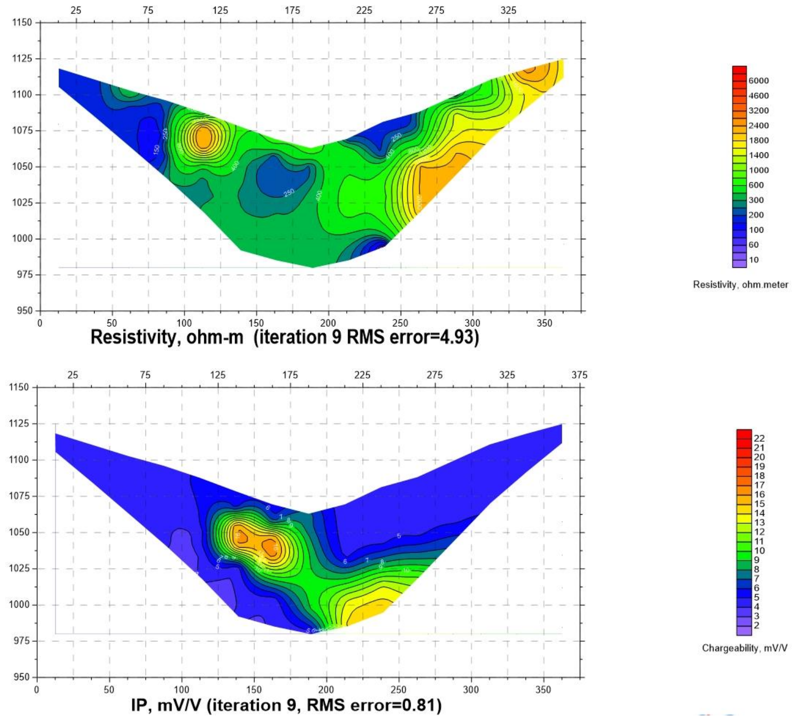

Figure 1. The inverted resistivity and IP sections with topography of the L100 profile.

The L 200 profile represents (Figure 2) a comprehensive examination of the region in which the fault is situated, conducted in a perpendicular manner. Upon examining the charging interval that arises from the conversion of land data into geophysical sections, it becomes evident that a charging anomaly is present. This anomaly is characterized by varying values observed between the measurement points 150-200. An anomaly has been detected within the measurement range of 150-200 points, specifically indicating a low charging value ranging from 1050 to 1000 cylinders. Furthermore, there has been an observation of a transmissible unit of resistance.

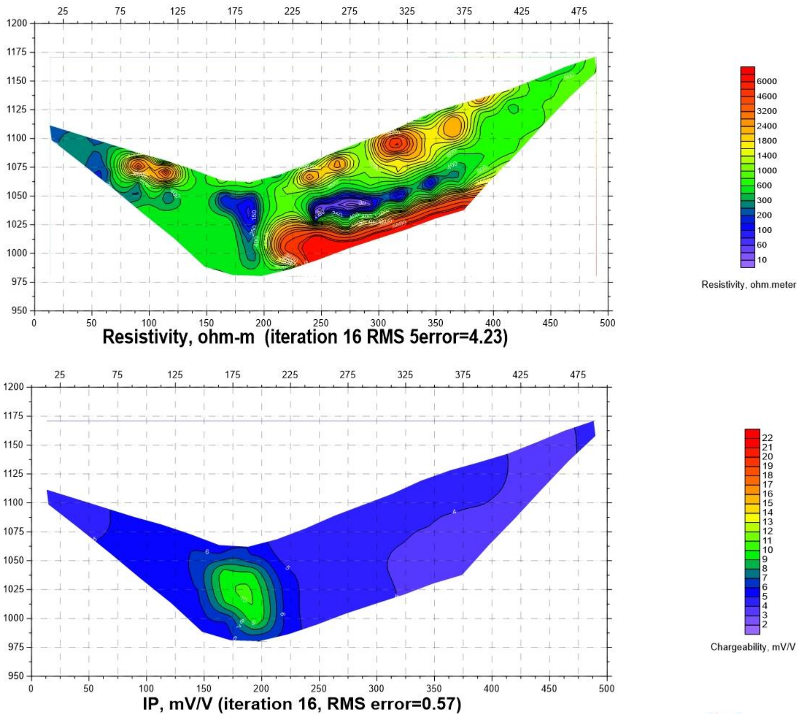

Figure 2. The inverted resistivity and IP sections with topography of the L200 profile.

Discussion

The induced polarization (IP) method provides valuable insights into the electrical chargeability of subsurface materials, enabling the identification of mineralized zones and alteration fronts that are commonly associated with lead-zinc (Pb-Zn) deposits. Through the analysis of the gradual decline in induced polarization, it is possible to deduce the existence of sulfide minerals that serve as indicators of mineralization. In contrast, the resistivity method offers insights into the distribution of electrical resistivity, enabling the delineation of geological structures and the identification of regions that may contain ore-bearing formations.

In the studies carried out, the profiles were determined to be poorly upright in the NW- SE direction, and the L 100 profile presented in this study observed the charging values and these values were also determined that there is a possibility of reversal.

The study conducted by Yalçın et al. [10] in the Kavşut region of Göksun-Kahramanmaraş is a significant example of utilizing the IP and resistivity methods to identify polymetallic enrichments. This research has valuable implications for the improvement of mineral exploration methodologies and the sustainable utilization of resources in the Kavşut area and beyond [10]. In a separate investigation, Yalçın and Canlı [11] likely sought to enhance comprehension of Pb-Zn mineralization in the Yahyalı region of Kayseri, Türkiye by employing geophysical techniques such as IP/RESISTIVITY. Their objective would have been to aid in resource assessment and promote sustainable mining practices.

Conclusion

This study provides a persuasive argument for the utilization of IP and resistivity techniques in the investigation of Pb-Zn deposits, specifically in the Sudöşeği area of Simav-Kütahya. The strong correlation observed between abnormal geophysical indicators and established geological characteristics highlights the effectiveness of this integrated methodology. Through the integration of IP and resistivity techniques, we have effectively delineated prospective mineralized zones, providing significant insights for the assessment of resources and the planning of extraction activities. The increasing global demand for lead and zinc necessitates the use of advanced geophysical methods, which play a vital role in the sustainable and responsible exploitation of mineral resources.

References

1. Loke, M.H., & Barker, R.D. (1996). Rapid least-squares inversion of apparent resistivity pseudo sections using a quasi-Newton method. Geophysical Prospecting, 44, 131-152. https://doi.org/10.1111/j.1365-2478.1996.tb00142.x
2. Dusabemariya, C., Qian, W., Bagaragaza, R., Faruwa, A., & Ali, M. (2020). Some experiences of resistivity and induced polarization methods on the exploration of sulfide: A Review. Journal of Geosciences and Environment Protection, 8, 68-92. https://doi.org/10.4236/gep.2020.811004
3. Olowofela, J.A., Ajani, O.O., & Oladunjoye, M.A. (2008). Application of induced polarization method to delineate sulphide ore deposit in Osina Area of Benue State, Nigeria. Ife Journal of Science, 10(1), 137-150.
4. Langore, L., Alikaj, P., & Gjovreku, D. (1989). Achievements in copper sulphide Exploration in Albania with IP and EM Methods. Geophysical Prospecting, 37, 975-991. https://doi.org/10.1111/j.1365-2478.1989.tb02243.x
5. Yoshioka, K., & Zhdanov, M.S. (2005). Three-dimensional nonlinear regularized inversion of the induced polarization data based on the cole-cole model. Physics of the Earth and Planetary Interiors, 150(1-3), 29-43. https://doi.org/10.1016/j.pepi.2004.08.034
6. Sono, P., Nthaba, B., Shemang, E.M., Kgosidintsi, B., & Seane, T. (2021). An integrated use of induced polarization and electrical resistivity imaging methods to delineate zones of potential gold mineralization in the Phitshane Molopo area, Southeast Botswana. Journal of African Earth Sciences, 174, 104060. https://doi.org/10.1016/j.jafrearsci.2020.104060
7. Moreira C.A., Lopes S.M., Schweig C., & Seixas A.R. (2012). Geoelectrical prospection of disseminated sulfide mineral occurrences in Camaquã Sedimentary Basin, Rio Grande do Sul State, Brazil. Revista Brasileira de Geofísica, 30, 169-179.
8. Hanilçi, N., Öztürk, H., & Kasapçı, C. (2019). Carbonate-hosted Pb-Zn deposits of Turkey. Chapter 10 In: Pirajno, F., Dönmez, C., Şahin, M.B. (Eds.), Mineral Resources of Turkey, Modern Approaches in Solid Earth Sciences. Springer Nature, Switzerland, 497–533. https://doi.org/10.1007/978-3-030-02950-0_10
9. Oyman, T. (2019). Epithermal Deposits of Turkey. Chapter 4 In: Pirajno, F., Dönmez, C., Şahin, M.B. (Eds.), Mineral Resources of Turkey, Modern Approaches in Solid Earth Sciences. Springer Nature, Switzerland, 159–223.
10. Yalçın, C., Canlı, H., Haznedaroğlu, K., & Akbulut, F. (2023). Investigating the Kavşut (Göksun-Kahramanmaraş) Cu-Pb-Zn deposit by using IP/Resistivity Methods. Advanced Engineering Days, 7, 73-76.
11. Yalçın, C., & Canlı, H. (2023). Investigating the Yahyalı (Kayseri, Türkiye) Pb-Zn deposit by using IP/Resistivity Methods. Advanced Engineering Days, 7, 69-72.