Indonesian Physical Review
Volume 07 Issue 03, September 2024
P-ISSN: 2615-1278, E-ISSN: 2614-7904

Estimating the Gold Mineralization Zone by Induced Polarization and Resistivity Method in X Village, Sumatera, Indonesia

Andi[1*], Nur Hidayat[2], Walhasbi Praditya[1], Rezal Prihatin[1]
[1] *Physics, UIN Sunan Kalijaga Yogyakarta, Indonesia*
[2] *Badan Riset dan Inovasi Nasional, Indonesia*

Corresponding Authors E-mail: andi@uin-suka.ac.id, nurh008@brin.go.id

Article Info

Article info:
Received: 23-02-2024
Revised: 16-08-2024
Accepted: 19-08-2024

Keywords:
Chargeability; Geoelectric Resistivity; Gold Mineralization Zone; Induced Polarization; Wenner

How To Cite:
A. Andi, N. Hidayat, W. Praditya and R. Prihatin, "Estimating the Gold Mineralization Zone by Induced Polarization and Resistivity Method in X Village, Sumatera, Indonesia," Indonesian Physical Review, vol. 7, no. 3, p 469-479

DOI:
https://doi.org/10.29303/ipr.v7i3.317

Abstract

This paper identifies the gold mineralization zone in X Village using the Induced Polarization and resistivity geoelectric method. The measurements were performed using the Wenner arrangement on six tracks, each separated by a distance of 235 meters and spaced 5 meters apart. The distribution of chargeability values was determined using the Induced Polarization method, while the distribution of resistivity values was determined using the resistivity geoelectric method at the research site. The identification results indicate that the suspected gold mineralization zone is on tracks 2 and 6. On track 2, the zone of suspected gold mineralization is suspected to be located 70-75 meters away from the starting point of measurement (point A). On track 6, it is located 65-75 meters away. The gold deposits are found in phyllite rocks that have undergone alteration, specifically philic, argillic, and silicified rock.

Introduction

Geologically, Indonesia is located at the intersection of three lithospheric plates, resulting in magmatic arcs along the plate boundaries. [1], [2], [3]. The formation of mineral deposits is caused by volcanic activity and ongoing sedimentation processes [2], [4], [5]. Minerals are compounds that contain crystalline elements obtained during geological processes. Gold is an example of a free element mineral with a distinctive yellow color and a hardness level of 2.5-3 mosh [6], [7], [8]. Gold is classified as a precious metal due to its high economic value.

According to the 2020 booklet released by the Ministry of Energy and Mineral Resources, Indonesia possesses 14.963.73 million tons of ore resources, 0.01 million tons of metal resources, 3.565.70 million tons of ore reserves, and 0.005 million tons of metal reserves. However, this considerable potential has not been fully utilized due to the limited exploration. The gold exploitation process cannot be carried out directly due to the low composition of gold in the deposition environment, typically around 2-30 g/ton [2]. Therefore, an exploration process is necessary to detect the presence of minerals indicating gold mineralization. These minerals are known as gold-bearing minerals. Gold-bearing minerals typically include iron sulfide minerals such as pyrite (FeS2), chalcopyrite (CuFeS2), troilite (FeS), and pyrrhotite (Fe1-xS) [2], [9], [10].

Mineral exploration can be conducted using geophysical methods, such as Induction Polarization (IP), geomagnetic, and microtremor methods [11], [12], [13], [14], [15], [16]. The IP method is commonly used to explore metallic minerals because the polarization process often occurs in a medium containing metallic minerals. An important indicator of this method is the changeability value, where high chargeability values characterize the presence of metal minerals [17], [18], [19], [20]. To enhance the mineral exploration results from the IP method, resistivity geoelectric measurements were conducted [20], [21], [22]. This method can identify subsurface rocks based on differences in their resistivity values. Both measurements used the Wenner configuration to obtain lateral variations in chargeability and resistivity values.

According to data from the Ministry of Energy and Mineral Resources, the island of Sumatra has 987.87 million tons of ore resources, 0.001 million tons of metal resources, 168.56 million tons of ore reserves, and 0.0004 million tons of metal reserves. One of the areas that has gold resources is X village, Sumatra. Geologically, the study area is located in the Barisan Formation (Pb) and Granitan Formation (Kgr). The lithology of the Barisan Formation consists of phyllite, slate, limestone, hornstone, and metagreywacke. The lithology found in the field is phyllite with a dark gray to metallic color. This lithology contains mica, quartz, and chlorite minerals. The lithology of the Granitan Formation (Kgr) ranges from granodiorite to granite with mafic mineral spots. The lithology found in the field is Granodiorite, which is a bright gray color. This lithology contains plagioclase, K-feldspar, and quartz minerals.

Given that the composition of gold in the depositional environment is minimal, the contribution of this research is more directed toward finding the gold resource. Finding the characteristics of rocks that contain gold-bearing minerals is one of the problems that will be solved at the research site located in X village. The study produced a 2D cross-section using the IP and resistivity Geoelectric methods. The 2D cross section was interpreted to estimate the distribution of gold in the research location. The results of this study are expected to be a guide in the process of exploration and exploitation of gold minerals as an effort to improve the economy of the local community.

Theory

The geoelectric method is one of the geophysical methods that utilizes electrical properties to interpret the Earth's subsurface. Geoelectric methods are divided into Resistivity, Induced Polarization (IP), and Self Potential (SP). The method used in this research is a combination of the resistivity method and the Polarization Induction method. The basic principle of both methods is to flow an electric current into the Earth and measure the resulting potential difference. The difference between these two methods lies in the measurement time of the potential difference. The resistivity method measures the potential difference when the electric current is injected. In contrast, the IP method measures the potential difference after the current injection is turned off. Ideally, the potential difference becomes zero when the current injection is turned off. However, the potential difference in certain mediums is not immediately zero [23]. This is due to the electrochemical processes in the polarized medium [24].

The measured polarization effect can be expressed in chargeability, Percent Frequency Effect (PFE), and Metal Factor (MF). In this study, the polarization effect is expressed in chargeability, which is calculated using equation (1) [25].

$$M = \frac{1}{V_p} \int_{t_1}^{t_2} V_s(t)\, dt \tag{1}$$

where V_p is the primary voltage and V_s secondary voltage

The configuration used when taking IP and resistivity measurements is the Wenner configuration. The Wenner configuration has the same electrode spacing as depicted in Figure 1.

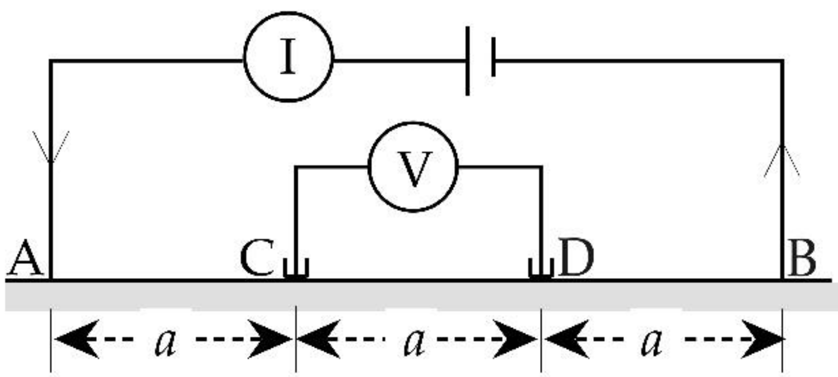

Figure 1. The Wenner configuration [25].

In this study, the spacing between electrodes was 5 m with a variation of n 1-15 (5 m - 75 m) with an expected penetration of 40 m deep. The apparent resistivity value in the Wenner configuration was calculated using equation (2) [25].

$$\rho_a = 2\pi a \frac{V}{I} \tag{2}$$

where V is the potential difference while I is the electric current strength.

Experimental Method

The research was conducted in the PT X area in the village of X. Geoelectric data was collected in six passes using a Wenner configuration with a stretch of 235 m. The measurements were taken with a northwest-southeast orientation, as shown on the track map in Figure 2. The tools used in the geoelectric survey are shown in Figure 3.

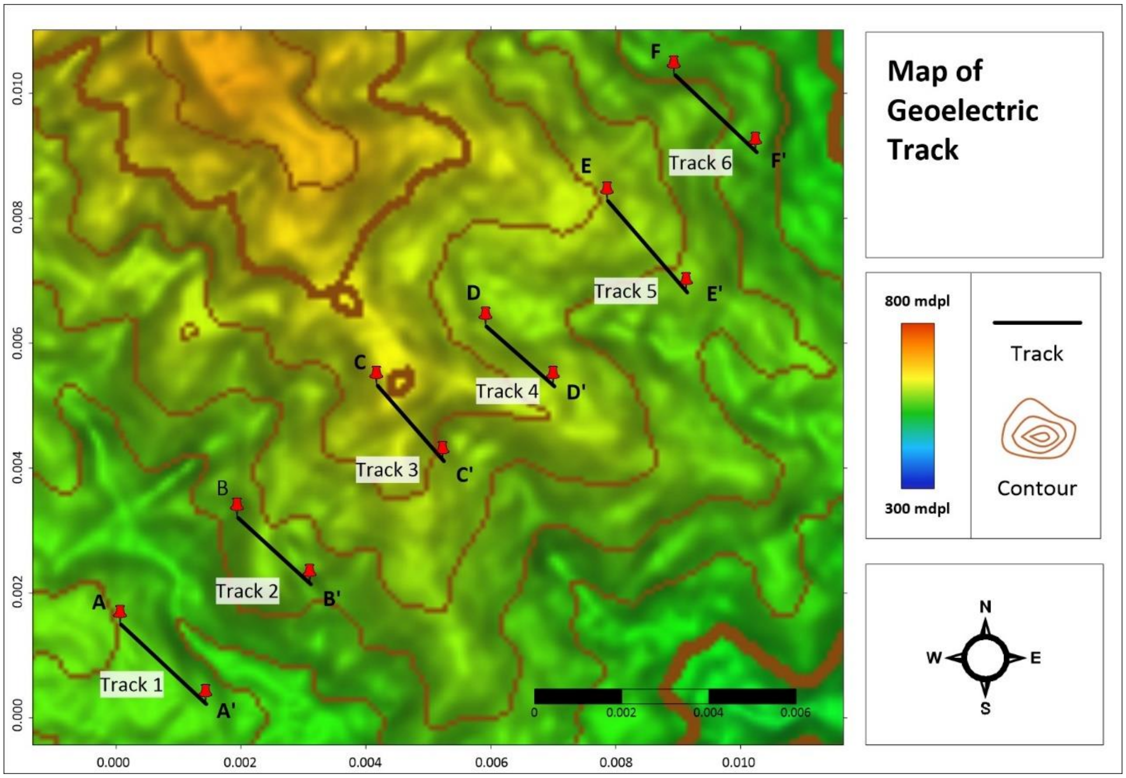

Figure 2. Map of Geoelectric Tracks

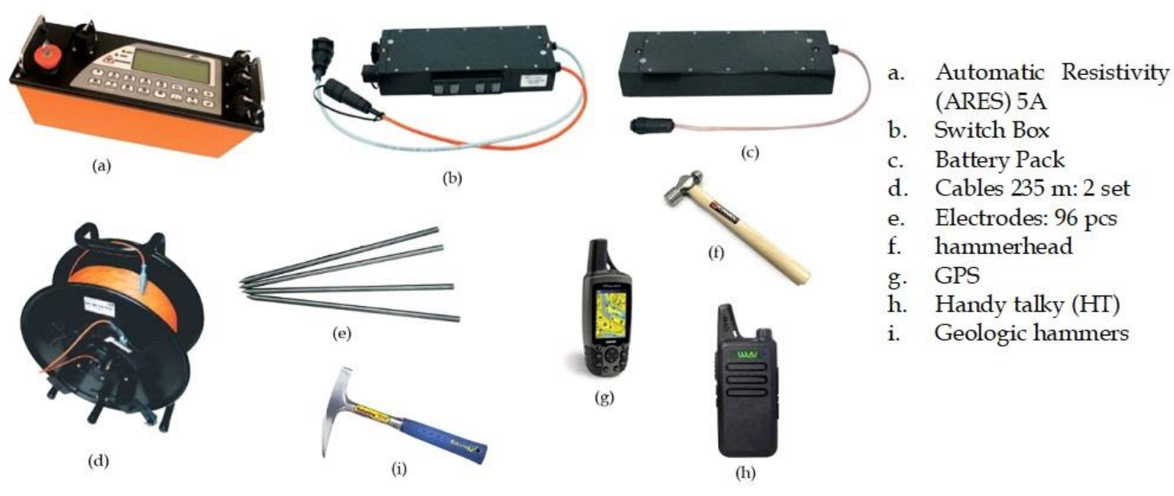

Figure 3. Geoelectric survey tools

The measurement results obtained data in the form of pseudo-resistivity and chargeability. Both data were modeled using Res2dinv software to obtain 2D profiles of chargeability and resistivity of subsurface rocks. The research area's resistivity profile, chargeability profile, and geological information are analyzed to determine the potential of gold minerals in the research location.

Result and Discussion

The 2D chargeability and resistivity profile models of track 1 to track 6 are shown in Figure 4 to Figure 9. From the interpretation results, the values in the study area are grouped into 3 scale groups, as shown in Table 1.

Table 1. Chargeability and Resistivity value scale

Chargeability (msec)	Resistivity (ohm.m)	Scale
< 52,1	< 628	Low
52,1-145	628-11.783	Medium
> 145	> 11.783	High

The classification results in Table 1 were used to interpret the 2D chargeability and resistivity profiles. Zones with low chargeability and low resistivity values are considered water-saturated layer zones. Zones with low chargeability and high resistivity values are volcanic rock zones. The zone with medium-high chargeability value and low-medium resistivity is an alteration zone. The zone with high chargeability and resistivity is a gold mineralization prospect.

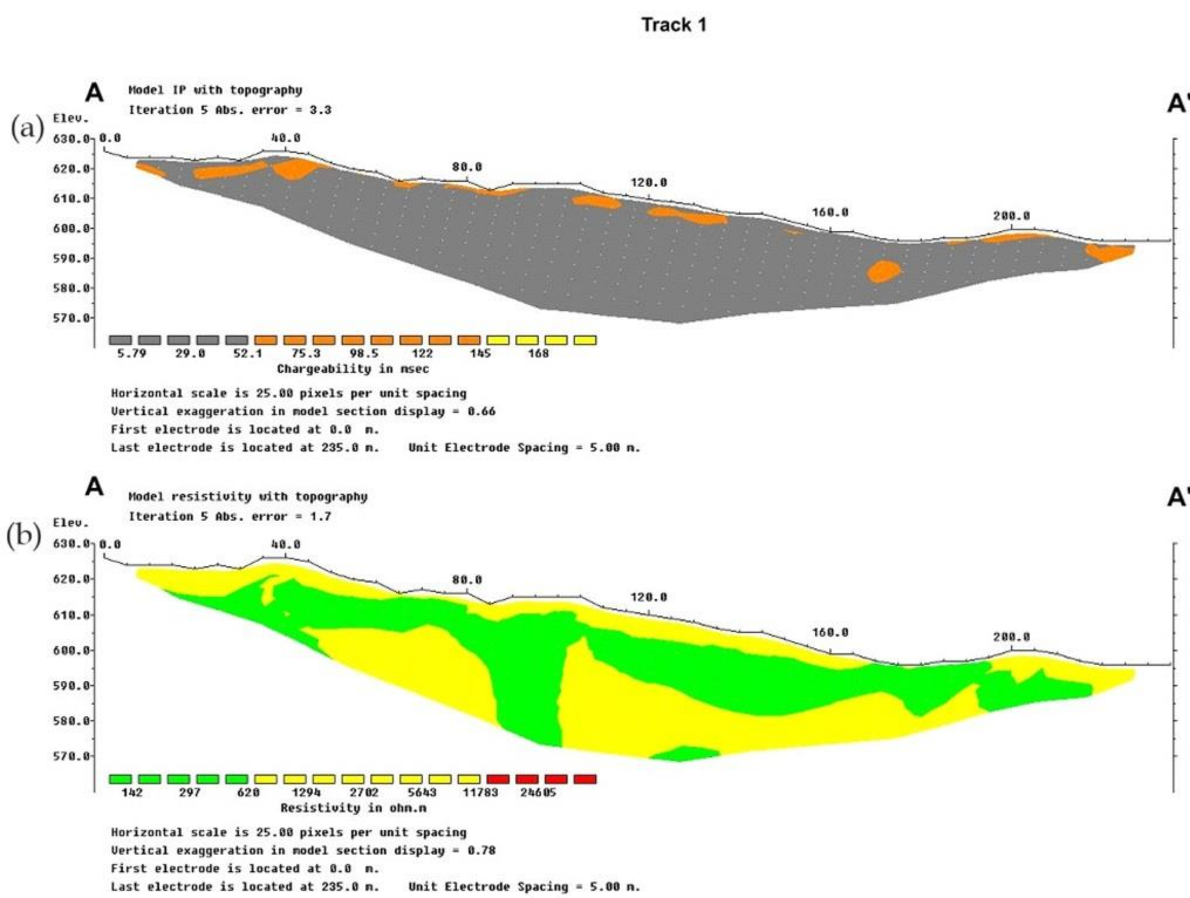

Figure 4. 2D profiles (a) Chargeability and (b) resistivity on track 1

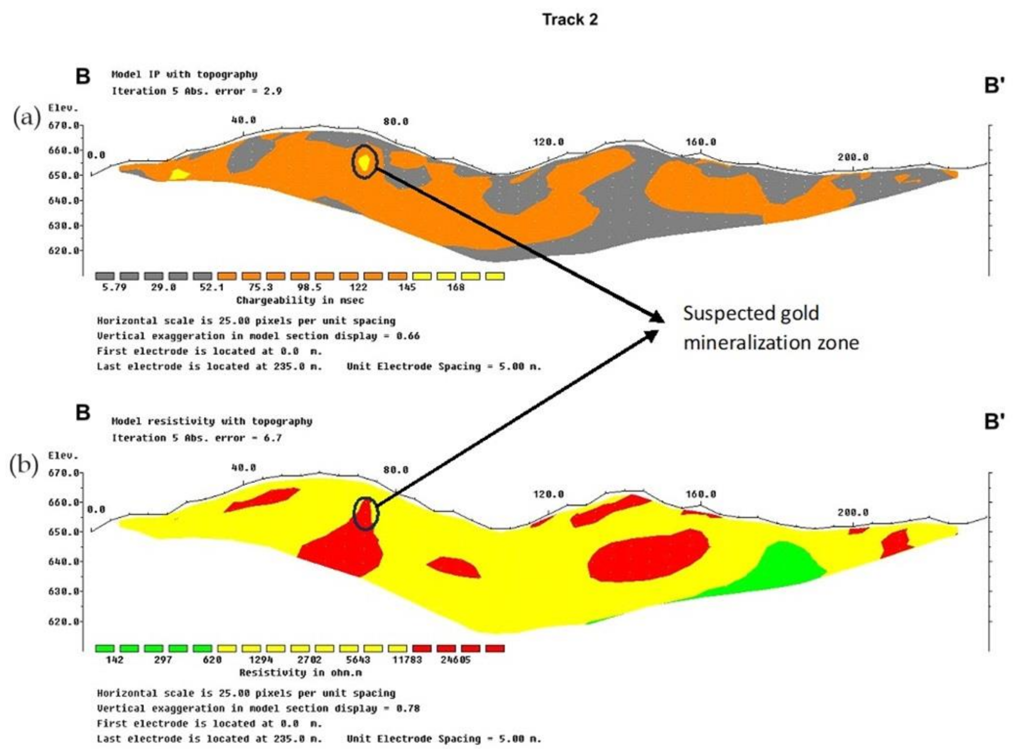

Figure 5. 2D profiles (a) Chargeability and (b) resistivity on track 2

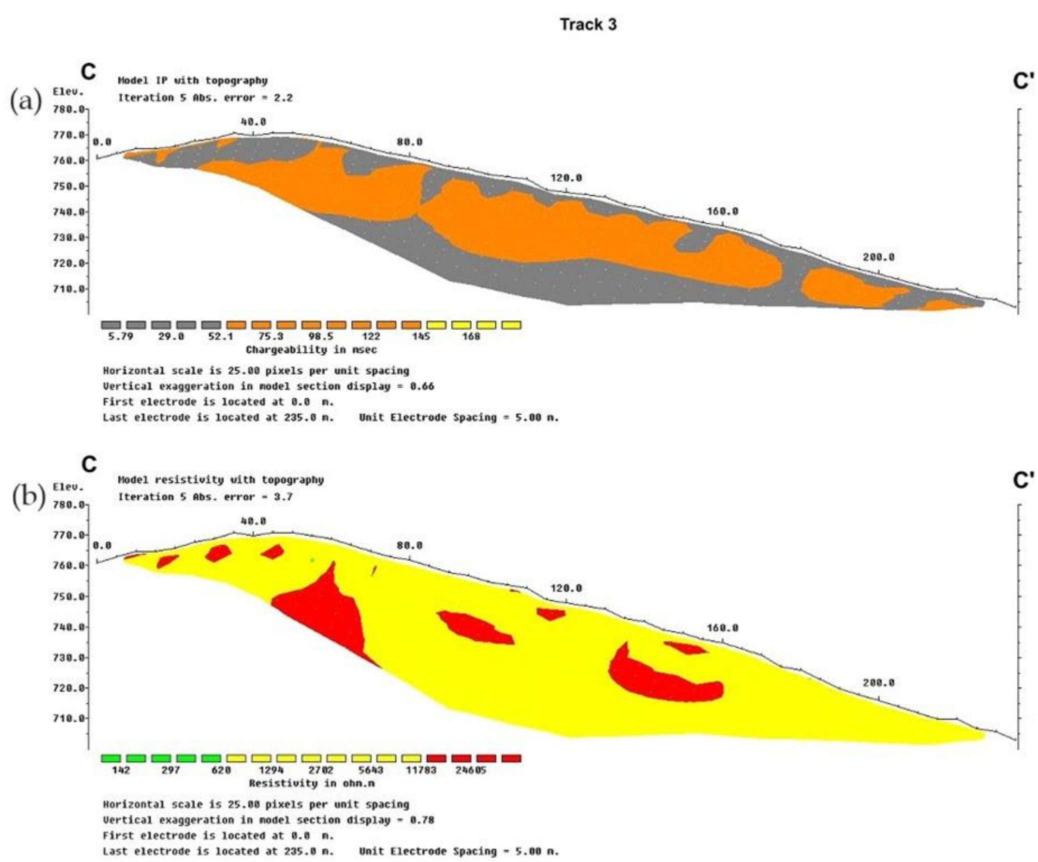

Figure 6. 2D profiles (a) Chargeability and (b) resistivity on track 3

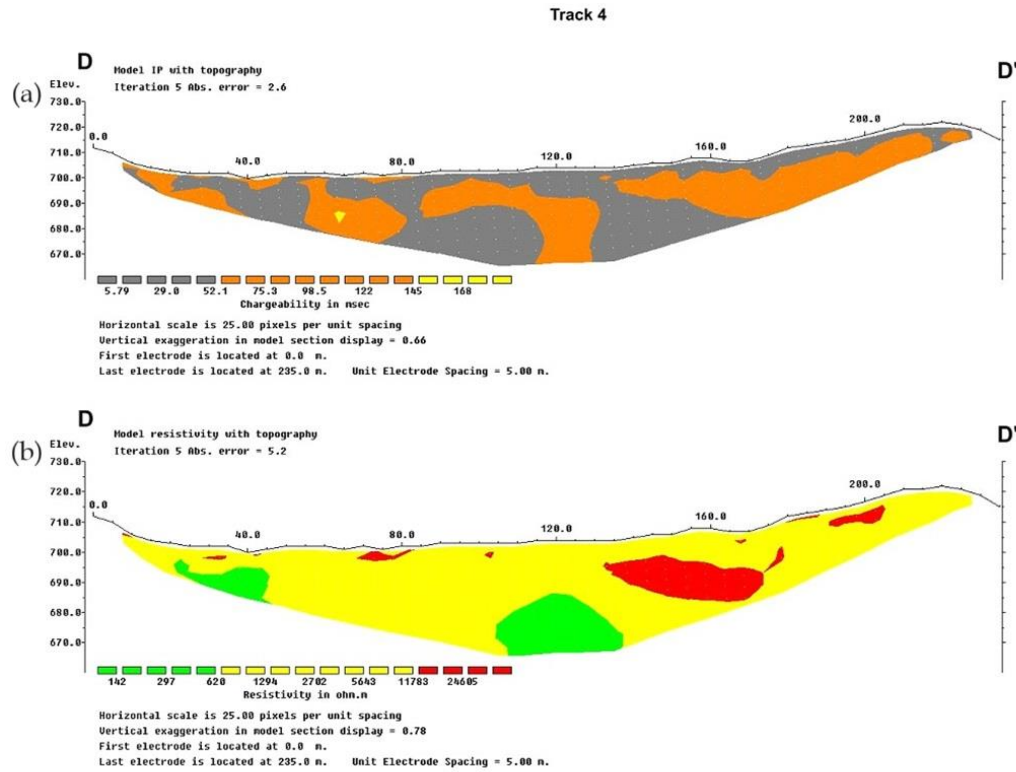

Figure 7. 2D profiles (a) Chargeability and (b) resistivity on track 4

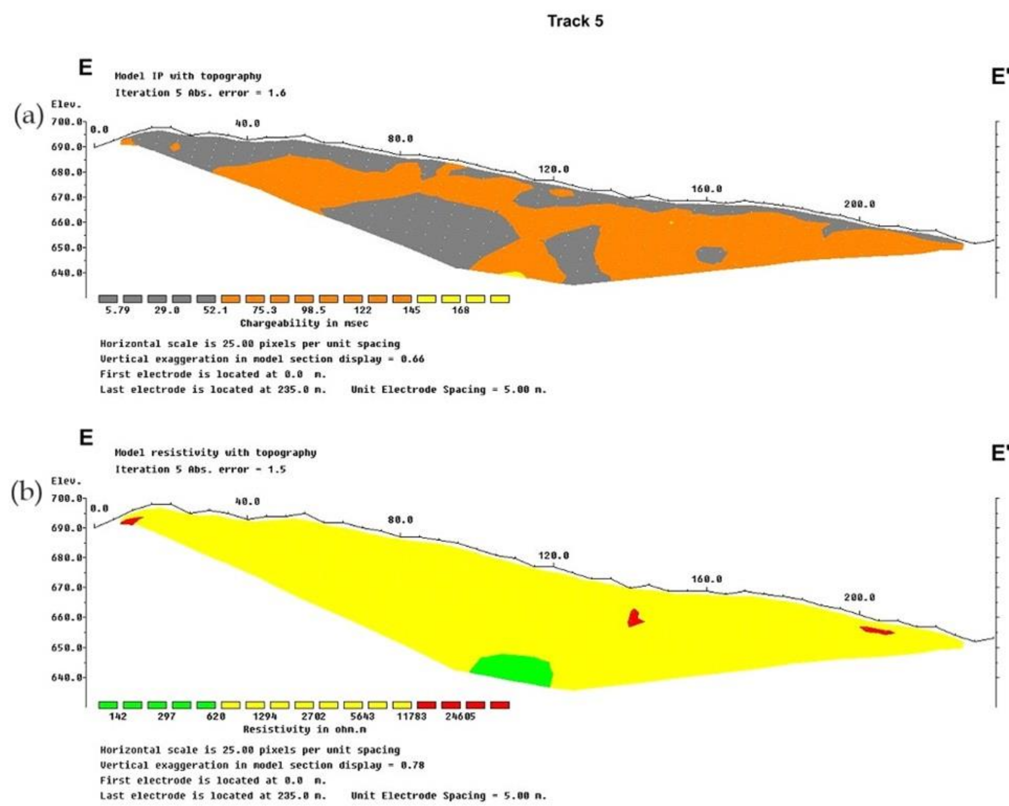

Figure 8. 2D profiles (a) Chargeability and (b) resistivity on track 5

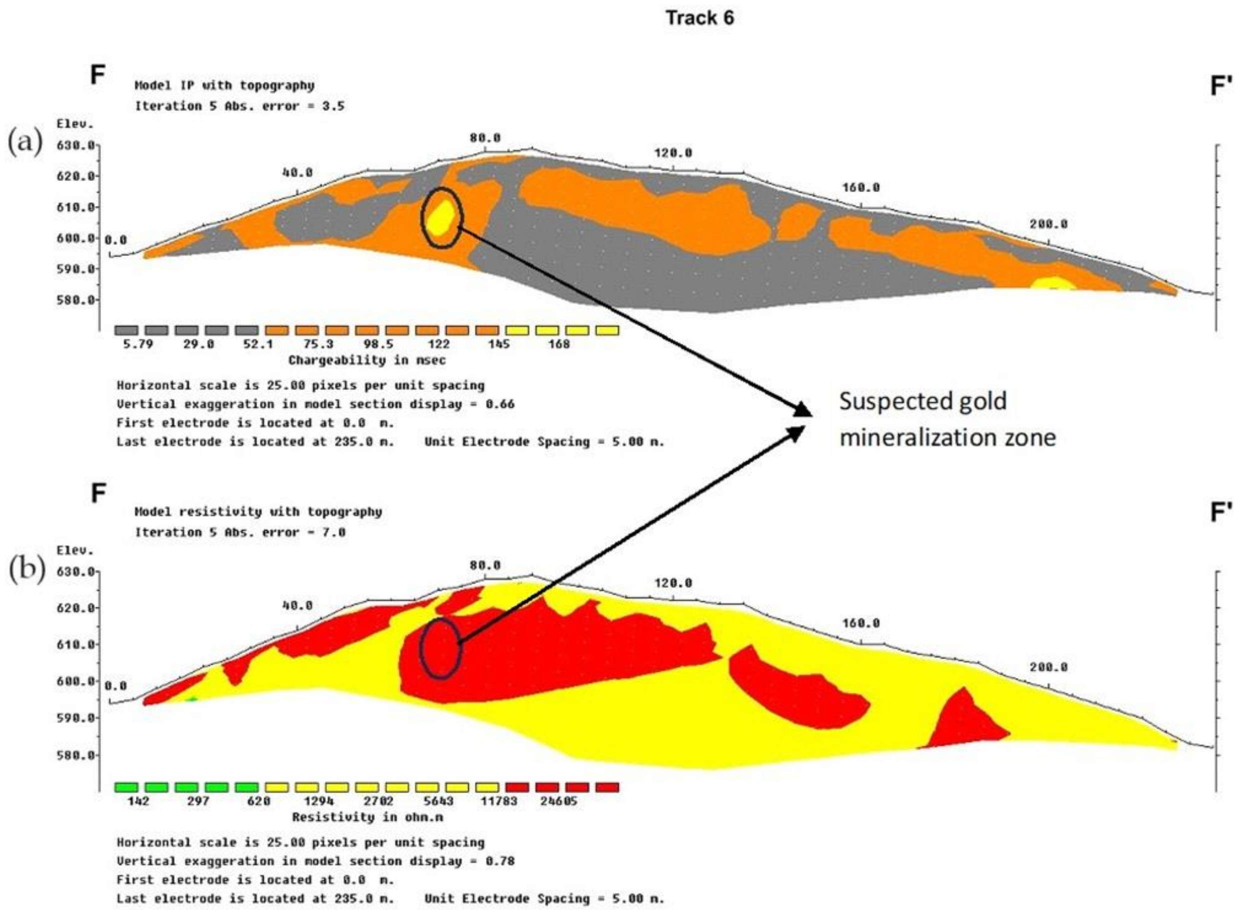

Figure 9. 2D profiles (a) Chargeability and (b) resistivity on track 6

The gold mineralization zone is located on tracks 2 and track 6. On track 2 the gold mineralization zone is located at a distance of 70-75 m from point B with an elevation between 650 - 660 m. On track 6, the gold mineralization zone is located at a distance of 65-75 m from point F with an elevation between 600 - 613 m. Based on the combination of chargeability, resistivity, and geological data of the research location, gold deposits are in phyllite rocks that have undergone alteration, namely philic, argillic, and silicified rock. Filite is generally dark gray to metallic and derived from mica. Weathered phyllite rocks are gray-black. The phyllite rock shows an irregular layered texture interspersed with mica. This rock contains mica, quartz, and chlorite minerals based on its mineral composition.

The quartz vein outcrops containing gold mineral cut phyllite around the study area are shown in Figure 10. The quartz veins around the study area are milky white with massive and comb textures. Based on these characteristics, it can be interpreted that the surface of the mapping area is in the upper boiling zone of the Buchanan epithermal model. The presence of quartz veins and mineralized zones at the study site characterizes the presence of gold minerals. This corroborates the results of geoelectric measurements at the study site.

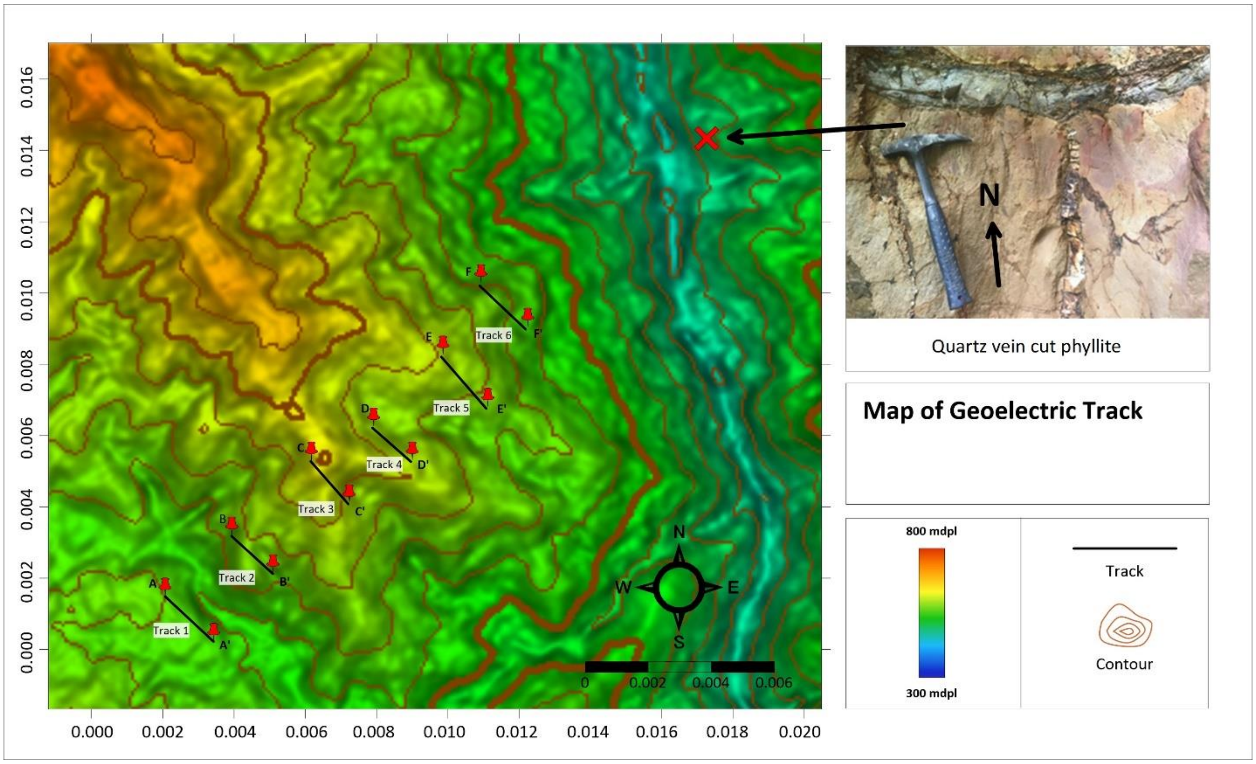

Figure 10. Filite outcrops around the research site

Conclusion

The 2D chargeability and resistivity profile results indicate that the suspected gold mineralization zone is located on tracks 2 and 6. On track 2, the gold mineralization zone is located at a distance of 70-75 m from point B, with an elevation between 650 - 660 m. On track 6, the gold mineralization zone is located at a distance of 65-75 m from point F with an elevation between 600 - 613 m. The gold deposits are found in phyllite rocks that have undergone alteration, namely philic, argillic, and silicified rock. The quartz vein outcrops containing gold minerals that cut through the phyllites around the study area confirm the results of the 2D resistivity and chargeability profiles. To support the study's results, a geochemical survey of each element's part per million (ppm) content can be conducted.

Acknowledgment

The researcher would like to thank the National Research and Innovation Agency (BRIN) and UIN Sunan Kalijaga Yogyakarta for providing the opportunity for this research.

References

[1] Y. M. Said, B. Adhitya, A. D. Siregar, H. W. Utama, M. Ritonga, and E. Kurniantoro, "Busur Magmatik Granit Tantan-Nagan Sebagai Potensi REE Di Jambi," *KURVATEK*, vol. 4, no. 2, pp. 79–85, 2019, doi: 10.33579/krvtk.v4i2.1569.

[2] F. Firmansyah and A. Budiman, "Pendugaan Mineralisasi Emas Menggunakan Metode Magnetik di Nagari Lubuk Gadang Kecamatan Sangir, Solok Selatan, Sumatera Barat," *J. Fis. Unand*, vol. 8, no. 1, pp. 77–83, 2019, doi: 10.25077/jfu.8.1.77-83.2019.

[3] L. O. M. Y. Amsah and E. P. Umar, "Identifikasi Zona Mineralisasi Emas Menggunakan Metode Resistivitas dan Induksi Polarisasi (IP) di Desa Lintidu Kab Buol," *J. GEOCELEBES*, vol. 4, no. 2, pp. 144–149, Oct. 2020, doi: 10.20956/geocelebes.v4i2.11126.

[4] M. I. A. Natsir, J. Safani, and E. Anshari, "Interpretasi Sebaran Zona Mineralisasi Emas Berdasarkan Metode Polarisasi Terinduksi Di Daerah 'Y' Gunung Pongkor Jawa Barat," *JRGI*, vol. 1, no. 2, pp. 24–35, 2019.

[5] S. Indarto *et al.*, "Batuan Pembawa Emas Pada Mineralisasi Sulfida Berdasarkan Data Petrografi Dan Kimia Daerah Cihonje, Gumelar, Banyumas, Jawa Tengah," *J. Ris. Geol. dan Pertamb.*, vol. 24, no. 2, pp. 115–130, 2014, doi: 10.14203/risetgeotam2014.v24.88.

[6] N. D. Suryaningsih, R. Efendi, and S. Kasim, "Identifikasi Zona Mineralisasi Emas Dengan Menggunakan Metode Geomagnet DI Kecamatan Sausu Kabupaten Parigi Moutong," *J. Gravitasi Fis.*, vol. 16, no. 2, pp. 49–53, 2017.

[7] U. A. Al-abshor, S. S. Larasati, and O. D. Puspita, "Identifikasi Alterasi Dan Mineralisasi Emas Menggunakan Data Geologi Dan Geofisika Di Daerah Gunung Gupit, Kabupaten Magelang, Jawa Tengah," in *Prosiding TAU SNAR-TEK 2019 Seminar Nasional Rekayasa dan Teknologi*, 2019, pp. 135–141.

[8] M. R. Widara and A. Rauf, "Perbandingan Hasil Logam Emas Pada Pengolahan Bijih Emas Dengan Metode Sianida (Heap Leaching) Berdasarkan Perbedaan Ukuran Butir Umpan," in *Prosiding Seminar Nasional XII "Rekayasa Teknologi Industri dan Informasi,"* 2017, pp. 30–35.

[9] F. Y. Chaidir, O. D. Puspita, and G. Rumahorbo, "Identifikasi Keberadaan Endapan Emas Berdasarkan Analisa Data Geomagnetik Dan Induced Polarization Pada Daerah Randukuning, Selogiri, Wonogiri, Jawa Tengah," *J. Tek. Geol. J. Ilmu Pengetah. dan Teknol.*, vol. 4, no. 2, pp. 16–22, 2021, doi: 10.30872/jtgeo.v4i2.5438.

[10] S. Aminah, "Uji Mineragrafi Batuan Bijih Emas dari Banyuwangi, Jawa Timur," *J. Teknol. Sumberd. Miner.*, vol. 1, no. 1, pp. 25–30, 2020, doi: 10.19184/jeneral.v1i1.21561.

[11] M. R. Yusefi, M. K. Hafizi, and B. Salari, "Gold Exploration Using Induced Polarization and Resistivity Methods in Meyduk-Latala area," in *79th EAGE Conference and Exhibition 2017*, 2017, pp. 2–4. doi: 10.3997/2214-4609.201701546.

[12] C. A. Moreira, K. Borssatto, L. M. Ilha, S. F. dos Santos, and F. T. G. Rosa, "Geosciences in Gold Deposit Through DC Resistivity and Induced Polarization methods," *REM - Int. Eng. J.*, vol. 69, no. 3, pp. 293–299, 2016.

[13] C. A. Rivananta and R. Khumayroh, "Analisis Data Induced Polarization Dalam Menduga Zona Mineralisasi Logam Daerah Godean, Kabupaten Sleman DIY," *Al-Fiziya J. Mater. Sci. Geophys. Instrum. Theor. Phys.*, vol. 3, no. 2, pp. 78–83, 2020, doi: 10.15408/fiziya.v3i2.18159.

[14] M. S. Bodjawati, D. M. Heditama, and Y. A. Muttaqin, "Identifikasi Zona Mineralisasi Bijih Besi Menggunakan Metode Polarisasi Terinduksi di Daerah Ulusuliti dan Tanjung Lima Kapas, Solok Selatan, Sumatra Barat," *Bul. Sumber Daya Geol.*, vol. 15, no. 3, pp. 140–154, 2020, doi: 10.47599/bsdg.v15i3.307.

[15] Y. D. Persada, I. Ilham, H. D. Amaninida, P. Ariyanto, and S. T. Gustono, "Pendugaan Awal Deposit Emas Wilayah Poboya, Palu Dengan Metode Inversi HVSR," *JGE (Jurnal*

Geofis. Eksplorasi), vol. 7, no. 1, pp. 30–40, 2021, doi: 10.23960/jge.v7i1.122.

[16] E. Cornelius, M. Muhardi, R. Perdhana, M. Muliadi, and Z. Zulfian, "Identifikasi Zona Mineralisasi Emas di Desa Bhakti Mulya Kabupaten Bengkayang Menggunakan Metode Polarisasi Terimbas (Induced Polarization)," *Wahana Fis.*, vol. 7, no. 2, pp. 127–137, 2022, doi: 10.17509/wafi.v7i2.51259.

[17] B. Septadi, F. Naufaldi, F. Andradit, A. Widodo, and A. Ismanto, "Pemetaan Zona Bijih Emas Epitermal Sulfidasi Rendah Menggunakan Metode Resistivitas 2D dan Polarisasi Terinduksi," *J. Geosaintek*, vol. 4, no. 1, pp. 19–22, 2018.

[18] Y. Yatini, I. Suyanto, and D. Puspaningrum, "Application of Polarization Method (IP) to Delineate the Gold Mineralization Zones in Cihonje Areas, Banyumas Regency, Province of Central Java," in *IOP Conference Series: Materials Science and Engineering*, 2019, pp. 1–9. doi: 10.1088/1757-899X/546/7/072013.

[19] Y. Yatini, M. F. Zakaria, S. Suharwanto, and R. Putri, "Deteksi Zona Mineralisasi Emas Di Gunung Gupit, Magelang Menggunakan Metode Induced Polarization," *J. Geosci. Eng. Energy*, vol. 5, no. 1, pp. 33–43, 2024.

[20] A. H. P. Yuniarto, "Aplikasi Time Domain Induced Polarization dalam Eksplorasi Emas di Blok 'CPY' Gunung Pongkor Kabupaten Bogor," *J. Geosaintek*, vol. 6, no. 3, pp. 117–126, 2020, doi: 10.12962/j25023659.v6i3.6867.

[21] M. H. Arifin, J. S. Kayode, M. K. Izwan, H. A. H. Zaid, and H. Hussin, "Data for the potential gold mineralization mapping with the applications of Electrical Resistivity Imaging and Induced Polarization geophysical surveys," *Data Br.*, vol. 22, pp. 830–835, 2019, doi: 10.1016/j.dib.2018.12.086.

[22] N. M. Nasruddin, A. V. Saputra, M. D. Nafisah, and S. Sehah, "Identifikasi Lapisan Pembawa Mineral Emas dengan Metode Resistivitas dan Induksi Polarisasi di Desa Paningkaban Kecamatan Gumelar Kabupaten Banyumas Jawa Tengah," *J. Fis. Flux J. Ilm. Fis. FMIPA Univ. Lambung Mangkurat*, vol. 17, no. 1, pp. 20–29, Feb. 2020, doi: 10.20527/flux.v17i1.6602.

[23] T. Seizarsyah, A. P. Setiahadiwibowo, F. Maskuri, and S. Sutarto, "Identification of Alteration-Mineralization in Skarn Deposit System based on Time-Domain Induced Polarization Method Approach in Kasihan Area, Pacitan, East Java," *J. Geocelebes*, vol. 6, no. 1, pp. 56–63, 2022, doi: 10.20956/geocelebes.v6i1.17558.

[24] M. Zhdanov, M. Endo, L. Cox, and D. Sunwall, "Effective-medium inversion of induced polarization data for mineral exploration and mineral discrimination: Case study for the copper deposit in Mongolia," *Minerals*, vol. 8, no. 2, pp. 1–22, 2018, doi: 10.3390/min8020068.

[25] W. Lowrie, *Fundamentals of Geophysics*, 2nd ed. Cambridge University Press, 2007.