

Nickel as A Strategic Mineral and Its Potential Resources in X-Field, North Konawe, Southeast Sulawesi, Indonesia

Dian Yesy Fatimah*¹, Juvens Yuda Her Krissanto¹, M. Nur Alif Pamunga², and Rio P. Nugroho¹

¹*Department of Geological Engineering, Faculty of Exploration and Production Technology, Universitas Pertamina*
²*PT. Sinar Jaya Sultra Utama*

Received: September 30, 2022 | Accepted: December 1, 2023 | Published online: March 31, 2024

ABSTRACT. Indonesia is the world's largest producer of Nickel laterite deposits. By the regulation of UU No. 3 2020, due to its utility as the main component of battery on electric vehicles (EV), nickel is a metal mineral that plays an important role in energy transition issues. It will drive the increasing demand for Nickel, and Indonesia needs a massive exploration and specific regulation, especially for this deposit. This research focuses on Ni's importance as a strategic mineral and potential resource in North Konawe, Southeast Sulawesi. The methods are based on field data analysis and reference studies. X-Field is located on Lasolo Island, North Konawe, Southeast Sulawesi. This area has potential resources of Ni-laterite deposit. The lithological condition consists of a massive ultramafic igneous rock complex. The serpentinization process has already enriched the host rock. The geochemical analysis shows various ranges of 0.87–2.43 % Ni content from different soil zones. To this day, the government regulation of Ni in a specific way as a critical mineral is still not present. The lack of data transparency (supply chain) and policy synchronization urgently need to be solved.

Keywords: Nickel · Strategic mineral · Sulawesi · Electric vehicle.

1 INTRODUCTION

Indonesia is the world leader in nickel production. According to the Ministry of Energy and Mineral Resources (ESDM), Nickel production in Indonesia reached 2.47 million tons in 2021. That value was mainly supplied by production from Sulawesi. The strange side of this fact is that as the main 'player' in nickel, Indonesia still does not have specific regulations to govern the practice of nickel production, processing, and selling. This condition potentially hinders the Indonesian government's realization of nickel-related strategic planning, such as pro-

ducing electric vehicle batteries and the defense industry.

This paper presents the result of an investigation of nickel characteristics from one of the producing mines as an example of what common nickel mines may contain besides just nickel. In addition, a brief explanation of the effect of nonspecific governing of nickel as a strategic mineral presents a picture of the potential implications.

2 GEOLOGICAL SETTING/SITE CHARACTERIZATION

Based on the physiography of Sulawesi (Van Leuween, 1994), Southeast Sulawesi consists of the Mandala Timur zone, an ophiolite belt influenced by Australian and Pacific plates. The area comprises Cretaceous-Miocene rocks

*Corresponding author: D.Y. FATIMAH, Department of Geological Engineering, Faculty of Exploration and Production Technology, Universitas Pertamina. Jl. Teuku Nyak Arief, Simprug, Kebayoran Lama, Jakarta 12220. E-mail: dian.fatimah@universitaspertamina.ac.id

(ultramafic-mafic igneous rock complex, limestone and flintstone). Based on the Geological Map of Indonesia Sheets Lulusua-Kendari (Rusmana *et al.* 1993) and Surono & Pangabea (2011), Southeast Sulawesi is composed of two rock complexes from the Carboniferous to Quaternary periods. These complexes are the Continental Fragment Complex and the Ultramafic Complex. This area is controlled by the Lawanopo and Matano strike-slip faults identified by the mountain complex's parallel lineament. The morphology of Southeast Sulawesi consists of mountain complexes dominantly in the northwest part of Southeast Sulawesi and hills and karst in the northern part. The Ni-bearing mineralization occurred in an ultramafic rock complex controlled by the laterite process. Based on Sufriadin *et al.* (2009), the serpentinization degree affects mineralogy, soil thickness, and the laterite profile's color. According to Waluyo (2013), the soil deposit of conglomerate ultramafic bedrock is thicker than compact ultramafic rock. It can be concluded that the differences in bedrock characteristics influence the thickness of soil deposits.

3 METHODOLOGY

The materials in this research include regional and local geologic maps and rock samples. The samples are taken by grab sampling each lateritic zone (limonite, saprolite, and bedrock zone) and logging. The analysis conducted in this study was field mapping to determine the distribution of rocks, geological structure petrography to identify mineral compositions, and X-ray fluorescence to get the value of Ni and other elements (Fe, Si, Mg) content.

4 RESULTS AND DISCUSSION

The morphology of the research area (Figure 1) formed as a structural hill (S3) is related to the Lasolo and Matano strike-slip fault, while the surrounding area is identified as a denudational hill (D2). This research's geological study area was focused only on 2 blocks (Block 1 and Block 2). The parent rocks of both blocks were defined as peridotite with a greenish-black color, holocrystalline, and predominantly olivine with clino- and orthopyroxene (Figure 2). The structure at the research location is believed to be a product of larger

major faults, namely the Lasolo, Matano, and Lawanopo Strike-Slip Faults (PT. SJSU Exploration Team, 2018). The main stress direction is west-east, transporting the ultramafic rock bodies from the east (Surono & Pangabea, 2011). This stress regime is also responsible for forming these three faults in a northwest-southeast direction. Minerals, including quartz and garnierite, have largely filled fractures at the research site. Laterite soil profiles at Blocks 1 and 2 have different characteristics.

Firstly, block 1 has a reddish brown soil horizon, while Block 2 has a yellowish brown soil horizon (Figure 3). Both consist of clay to coarse sand grain size. Secondly, the soil horizon of Block 1 is composed of topsoil, limonite, saprolite, rocky saprolite, and bedrock. The result of XRF in the soil horizon of Block 1: limonite zone 1.47 % Ni; 21.14 % Fe; 0.046 % Co; 0.416 % MnO; 20.84 % SiO₂; 2.57 % MgO; 3.71 % Al₂O₃, Saprolite zone 2.43 % Ni; 20.05 % Fe; 0.016 % Co; 0.15 % MnO; 27.54 % SiO₂; 9.95 % MgO; 3.25 % Al₂O₃, and bedrock zone shows 1.01 % Ni; 8.94 % Fe; 0.131 % Co; 1.114 % MnO; 39.04 % SiO₂; 32.3 % MgO; 1.25 % Al₂O₃. While in soil horizon of Block 2: limonite zone 1.34 % Ni; 20.2 % Fe; 0.064 % Co; 0.579 % MnO; 30.03 % SiO₂; 3.55 % MgO; 3.72 % Al₂O₃, saprolite zone 1.75 % Ni; 16.37 % Fe; 0.051 % Co; 0.389 % MnO; 33.81 % SiO₂; 14.54 % MgO; 2.44 % Al₂O₃, and bedrock zone 0.87 % Ni; 6.48 % Fe; 0.022 % Co; 0.16 % MnO; 42.56 % SiO₂; 34.75 % MgO; 1.24 % Al₂O₃. Different levels of weathering intensity might cause a difference in the chemical content of the samples. Block 1 (Figure 4) is relatively more intensely weathered than block 2. In Block 2, the saprolite is dominantly rocky (Figure 5).

In comparison, the deposit model of Ni-laterite in Madang and Central Serakaman, Sebuku Island, South Kalimantan (Figure 6) (Aribowo *et al.*, 2018) dominantly consists of serpentinized-dunite and harzburgite units, and another unit like gabbro, silicified gabbro, basalt, and tuff unit. The laterite profile characterized by (1) red limonite zone which composed dominantly hematite and goethite mineral (41.3–48.7 % Fe; 0.2–0.6 % Mg; 0.9–2.5 % Si; 4.0–8.4 % Al and 0.3–0.7 % Ni), (2) yellow limonite zone which composed by dominantly goethite and manganese mineral associated with clay, quartz, serpentine and minor

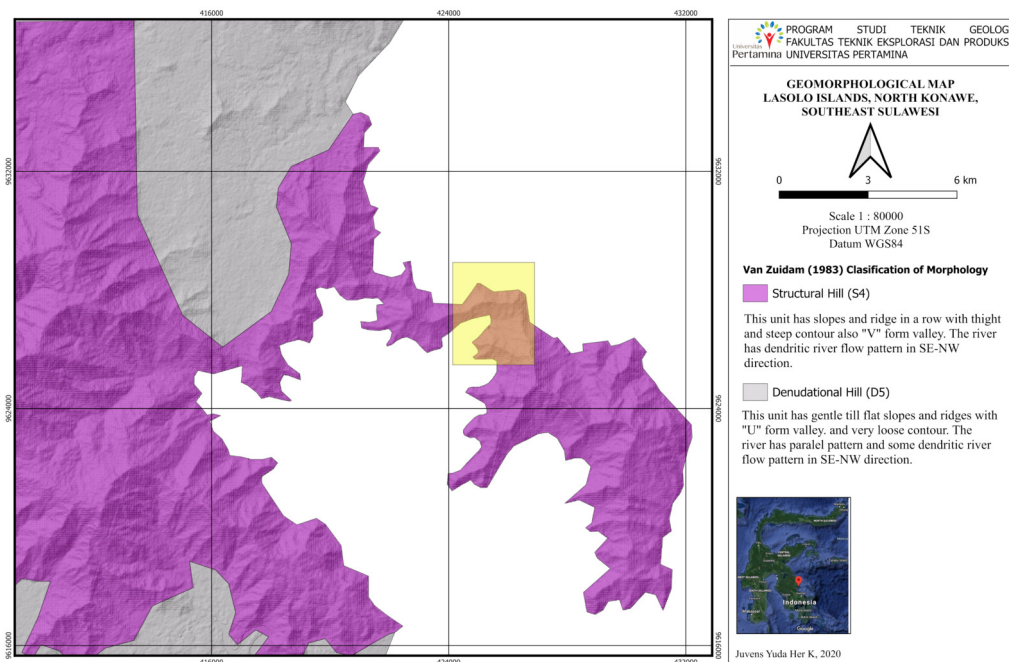


FIGURE 1. Geomorphology Unit Map of a research area shows the distribution of denudational and structural hills. The yellow highlight box above focuses on the study area.

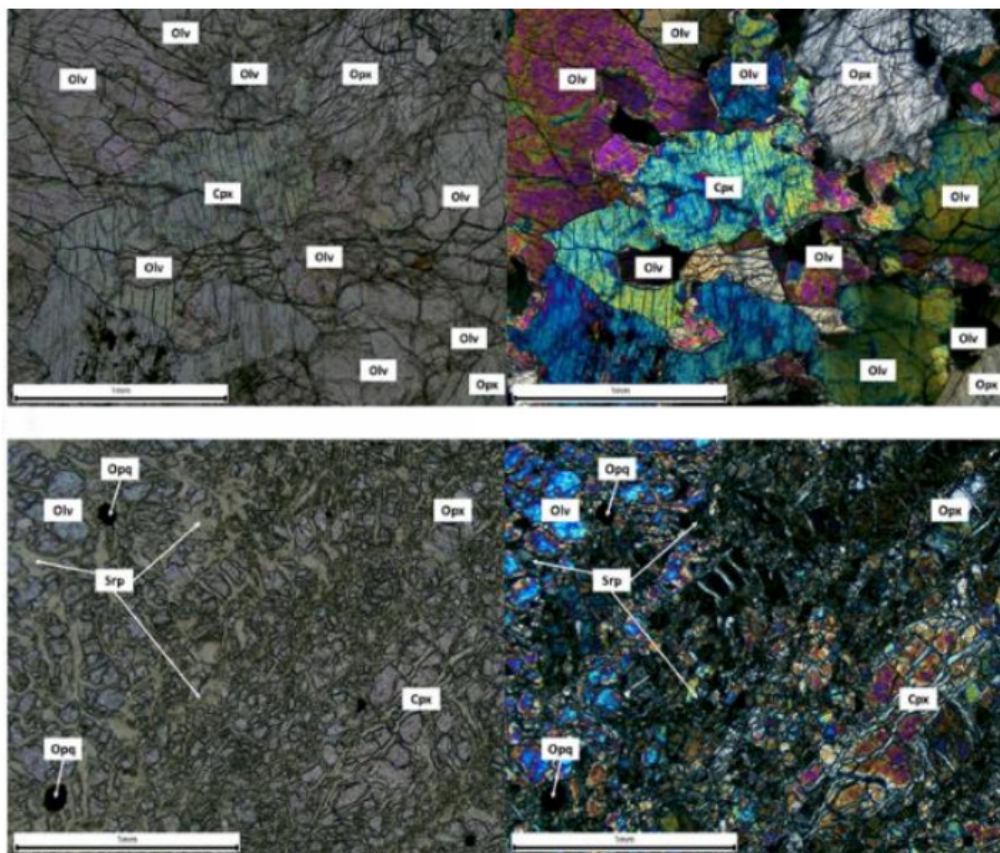


FIGURE 2. photomicrograph of sample from Block 1 (A) and Block 2 (B). Abbreviation: Oliv (Olivine), Cpx (Clinopyroxene), Opx (Orthopyroxene), Srp (Serpentine).

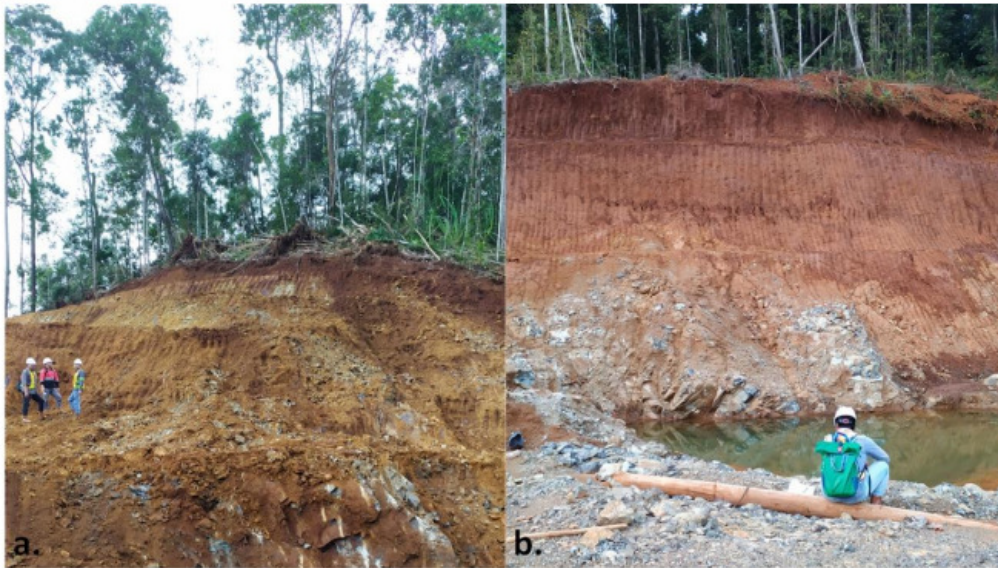


FIGURE 3. Appearance of Block 2(a) and Block 1(b) soil horizon.

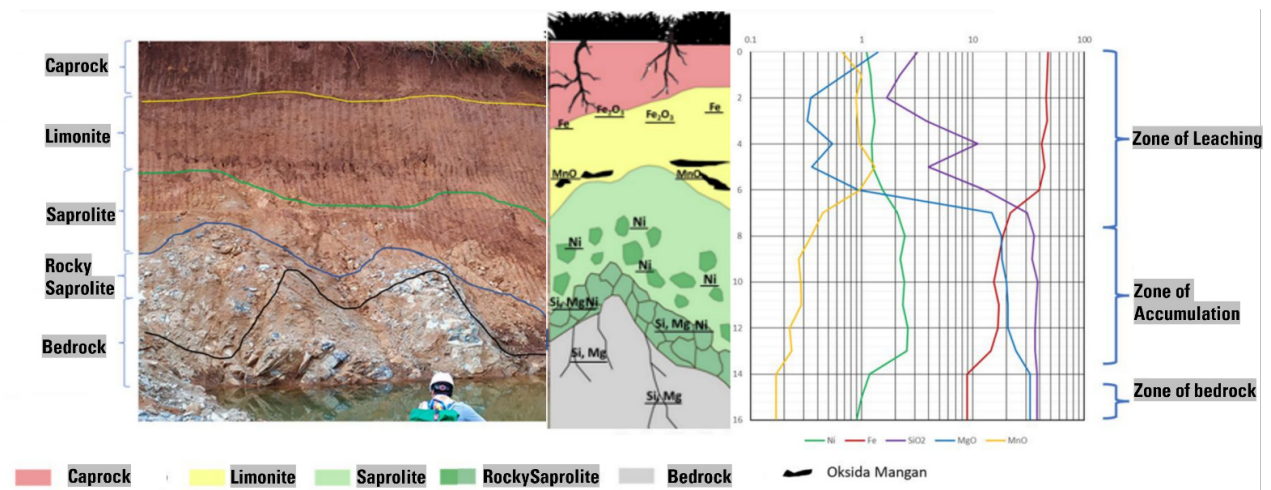


FIGURE 4. The conceptual model of Block 1 and its element distribution.

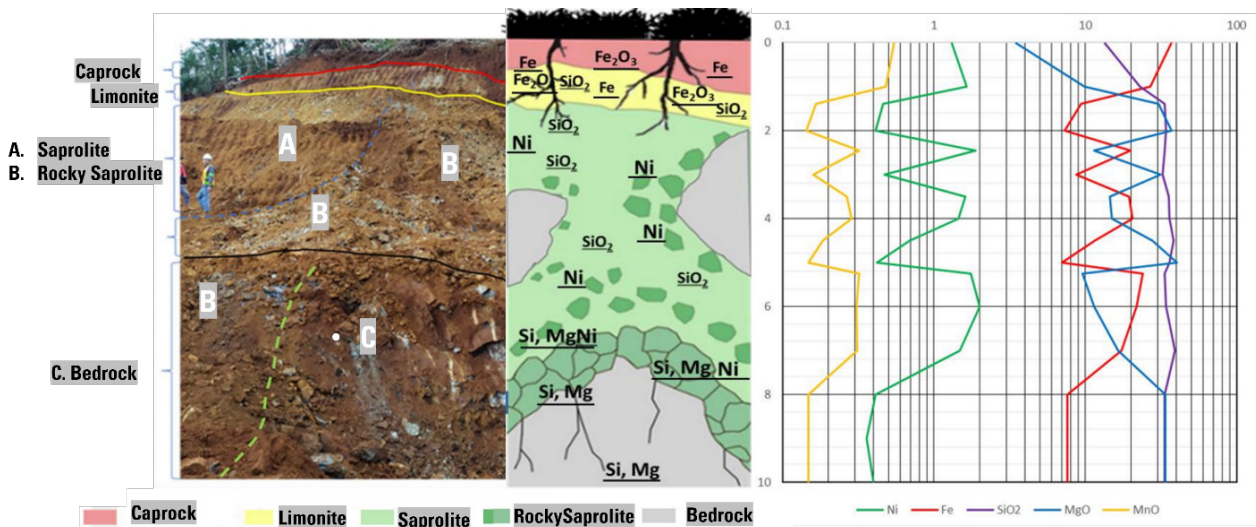


FIGURE 5. The conceptual model of Block 2 and its element distribution.

carbonate mineral (38.7–50 % Fe; 0.2–0.7 % Mg; 1.0–4.7 % Si; 2.5–8.1 % Al and 0.7–0.9 % Ni), (3) green-yellow Saprolith zone, composed by dominantly serpentine, olivine, goetite, clay mineral, and minor quartz mineral (10–21 % Fe; 1.5–14.7 % Mg; 2.9–17.8 % Si; 1–7.6 % Al and 1.0–2.2 % Ni), (4) bedrock zone, composed by serpentinized dunite and serpentinized harzburgite (3.9–8.3 % Fe; 19.6–29.6 % Mg; 16.9–20.7 % Si; 0–0.7 % Al and 0.2–0.4 % Ni). It shows a slight difference in the nickel content pattern in the saprolite zone compared to Blocks 1 and 2, which have almost twice the content. It might result from the bedrock type, which exhibits more complete oceanic crust rocks than those at Blocks 1 and 2.

From the previous results, both blocks exhibit a considerable amount of Ni in the saprolite and limonite zones. As these blocks are only two among many other operating blocks in Sulawesi, there might be blocks with higher Ni content in both zones and other associated potentially economic elements such as Co. With the absence of specific regulations governing the extraction, processing, and selling of Ni with its potential economic elements, there might be potential benefit loss due to the static value of the commodity. For example, the absence of a policy regulating nickel ore sales without considering cobalt content might impact the planned strategic industrial sector (e.g., defense and electric vehicle batteries). The Indonesian government needs to put extra effort into determining and specifying the ruling for strategic minerals, in this case, Ni and its associated elements, to achieve targeted performance in strategic industry realization.

5 CONCLUSION

Due to the geological condition mentioned above, X-Field in Konawe, Sulawesi, is one area in Indonesia that potentially produces Ni-deposit with grades ranging from 0.87–2.43 %

Ni content in various soil horizons. Hence, Indonesia has the potential to achieve self-sufficiency in resource supply and to dominate the global market. Indonesia needs to encourage massive and further exploration and synchronize the regulations to get an ideal design industry to mitigate the potential loss.

Acknowledgements We are thankful to PT. Sinar Jaya Sultra Utama for permission and support in the collection of the field as well as geochemical data.

REFERENCES

- Aribowo, Y., Syahputra, Y., Widiarso, D.A., 2018, Characteristic of Lateritic Nickel Mineralization in Mid Part of Madang and Serakaman Areas, Sebuk Island, South Kalimantan, *MATEC Web of Conferences* 159, 01038, IJCAET & ISAMPE. <https://doi.org/10.1051/mateconf/201815901038>
- Elias M. (2002). Nickel Laterite Deposits – Geological Overview, Resources, And Exploitation. In: *Giant Ore Deposits: Characteristics, Genesis, and Exploration*, eds DR Cooke and J Pongratz. CODES Special Publication 4 (pp 205-220), Centre for Ore Deposit Research, University of Tasmania
- Brand, N.W., Butt, C.R.M. And Elias, M. (1998). Nickel laterites: classification and features. *AGSO Journal of Australian Geology & Geophysics*, 17(4): pp. 81-88
- Golightly, J. P. (1981). Nickeliferous Laterite Deposits. *Economic Geology 75th Anniversary Volume*, h. 710-735.
- Lewis, J. F., Draper, G., Fernández, J. P., Espaillet, J., & Jiménez, J. (2006). Ophiolite-related ultramafic rocks (serpentinites) in the Caribbean region: a review of their occurrence, composition, origin, emplacement, and Ni-laterite soil formation. *Geologica Acta*, 4(1-2), 237-264
- Sufriadin, S., Idrus, A., Pramumijoyo, S., Warmada, I. W., & Imai, A. (2011). Study on mineralogy and chemistry of the saprolitic nickel ores from Soroako, Sulawesi, Indonesia: Implication for the lateritic ore processing. *Journal of Applied Geology*, 3(1).
- Tim Eksplorasi PT. SJSU. (2018). Exploration Report. Kendari: PT. Sinar Jaya Sultra Utama.

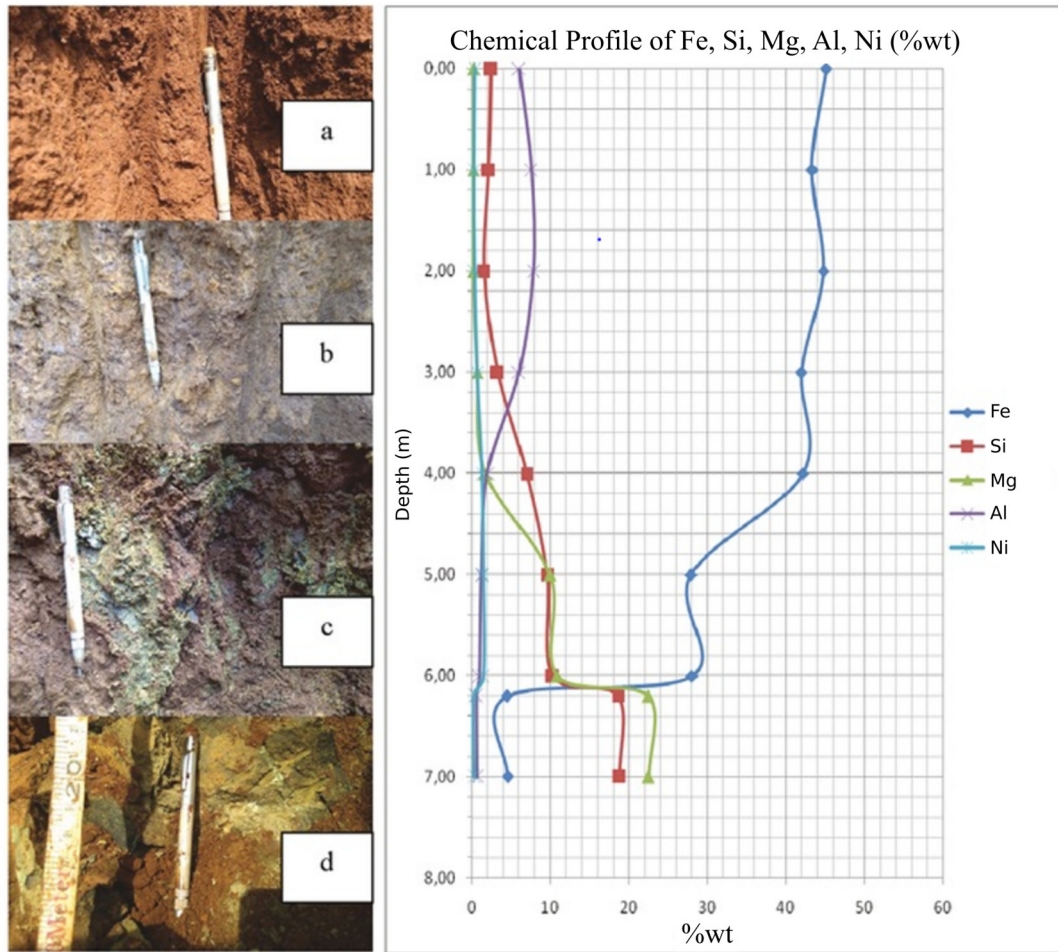


FIGURE 6. The laterite and chemical profile of Mangan and Serakaman Ni-Laterit deposit by Aribowo *et al.* (2018).