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# Assessing the Applicability of Geophysical Methods for Exploring Vein Type Mica Deposits – A Case Study in Matale District, Sri Lanka

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## Abstract

Mica, a group of silicate minerals characterized by their layered structure, is integral in various industries due to its insulating properties, heat resistance, and aesthetic appeal. Mica is commonly found as pegmatite and vein type deposits. However, vein type mica is extremely difficult to explore because of the complexity of their underlying geology and structural features. Atipola mica mine is one of the well-known mica mining sites in Matale district, Sri Lanka where the exploration of vein type mica deposits is difficult due to their complex geological formation. Therefore, this work attempts to assess the applicability of the Ground Penetrating Radar (GPR) geophysical methods for discovering new mica deposits. The field survey data collecting, and coverage plan were developed to investigate the most appropriate and pertinent area based on preliminary field observations. Since mica mining has emerged as a crucial economic activity in Sri Lanka, this study will also contribute to the investigation and advancement of vein-type mineral deposit exploration in Sri Lanka. Integrating GPR could make it possible to explain the subsurface structure in a non-destructive and appropriate way, which could help with informed mining methods and lead to the right decision regarding the accurate categories of the mineralogy deposit.

*Keywords: Vein type; Mica; Geophysical; Ground Penetration Radar; Atipola mine; underground mining*

## 1. Introduction

Mica is a unique class of silicate minerals which is distinguished by its layered structure, making it simple to separate into thin, flexible sheets [1]. Owing to their insulating qualities, heat resistance, and shimmering look, mica is used in the production of electronics, cosmetics, and building materials [2]. The four main kinds of mica are lepidolite, muscovite, biotite, and phlogopite. Muscovite and phlogopite are the commercially important types of mica [3]. Among the mica group minerals, phlogopite is commonly found in hydrothermally altered rocks [4].

Phlogopite is the most common type of mica in Sri Lanka [1] and is extensively spread in Uva, Sabaragamuwa, and Central provinces (Figure 1). The deposits are found along the contacts between these rocks and pegmatites, or as irregular aggregates or vein-like masses in pyroxenites [1]. Phlogopite mica was previously extracted from comparatively shallow depths in some provinces [5]. There has been small-scale mica mining in the Kandy district, specifically in Naula and Madugoda, as well as in Dutuwewa, which is close to Kebitigollewa in the North Central province, in recent years [1].

There is evidence to say that, about 150 years back, phlogopite mica in Mailapitiya area, was mined in a systematic way. But at present, mining activities are carried out haphazardly. That is because the miners do not have a clear understanding about the geological setting of veins [3]. Vein-type mica deposits found in North-Central Sri Lanka have been formed by the hydrothermal alteration of meta-ultrabasite. Major alteration products are phlogopite with minor tremolite, calcite and quartz [4].

To explore vein-type mica deposits, researchers have gone through geological mapping, geochemical surveys, and geophysical surveys. Phlogopite mica deposits in Rathnapura area and central part of the Sri Lanka, has been identified using only structural mapping and geochemical exploration methods [3], [6]. In addition, geochemical analyses and field and petrographic observations have been carried out in north-central Sri Lanka where mica deposits can be found [4].

In Sri Lanka, mica mining has been carried out without exploration by observing surface mica, followed by subsequent excavation. This method is costly and uses more resources. Therefore, the present study is studying the potential of using Ground Penetration Technique (GPR) to explore vein-type mica deposits. Under the surface, these vein-like deposits occur as fracture-filling structures [7], which makes geological mapping more challenging and presents significant challenges for resource estimators and mine planning. Because of the complex geological conditions and intricate underlying structures of the deposits, vein type mica deposits are challenging to explore. Phlogopite mica has long been extracted from the Atipola mining area in the Matale district of Sri Lanka, the deposits are mostly classified as hydrothermal or vein types which was the main reason for particularly selecting this area.

This study evaluates the applicability of GPR as a geophysical technique for the exploration of vein-type mica deposits to address the afore-mentioned issues. In addition to being non-invasive, GPR can provide precise insights into the geological structures that support these mineral deposits.

Commercial GPR technology has been viable since the early 1970s [8]. Wideband short pulses with high frequency electromagnetic waves are used in the GPR detection technique [9]. These waves' reflections aid in the detection of subterranean interfaces and hidden items. Locations of hidden objects or the makeup of subsurface media can be ascertained by analyzing the time-frequency and amplitude of reflected electromagnetic waves. GPR surveys have been carried out on a range of mineral deposits such as alluvial channels, nickel and bauxitic laterites, iron ore deposits, mineral sands, coal, and kimberlites [10]. But has not been widely used for vein mica deposits. For vein deposits, Identification of linear structures are essential since they are filled in fractures in subsurface [11].

Innovations in exploration methods, like GPR, can greatly improve the productivity and efficiency of mining operations in areas like the Matale district, where mica mining is a vital economic sector. A more precise classification of mineral deposits can be attained by incorporating GPR into the exploration process, which will ultimately be helpful with improved decision-making and sustainable resource management. This study advances the area of mineral exploration while utilizing in real-world applications for enhancing the sustainability and economic feasibility of the mica mining industry in Sri Lanka.

## 2. Materials and Methods

### 2.1 Study area

The Atipola mine in Matale District, Sri Lanka (Figure 2), located approximately at coordinates 7.50238100 N, 80.57420400 E, is known for its phlogopite mica deposits. The region's climate is tropical, characterized by a significant amount of rainfall throughout the year, with a pronounced wet season from October to January and a relatively drier period from June to September. The mica deposits in this area are primarily found in pegmatite veins within metamorphic rocks, where phlogopite mica is mined due to its desirable properties.

Mica veins generally strike between 290º and 335º and dip between 62º and 84º towards the southwest.

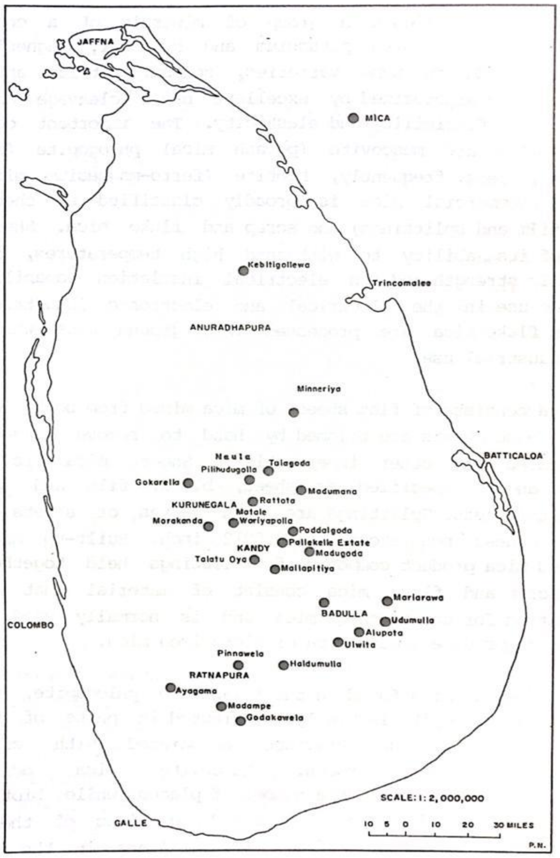


Figure 16 Mica occurrences in Sri Lanka.

## 2.2 Identification of the suitable paths

GPR tracks were selected after careful site inspections and consideration of the routes' accessibility (Figure 3). This method made sure that the routes selected were both conveniently accessible and ideally positioned to maximize data gathering, allowing for the efficient acquisition of data and the smooth running of the GPR equipment. To attain deeper penetration, a 60 MHz antenna frequency was selected, which enabled to acquire subsurface profiles up to 80 m depth. The purpose of using this frequency was to improve the understanding of the deeper geological structures connected to vein-type mica deposits.

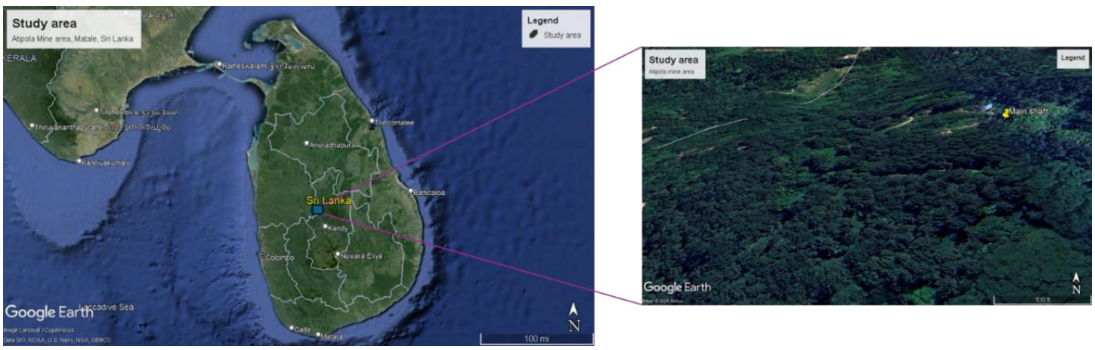


Figure 17 Atipola mine area, Matale, Sri Lanka.

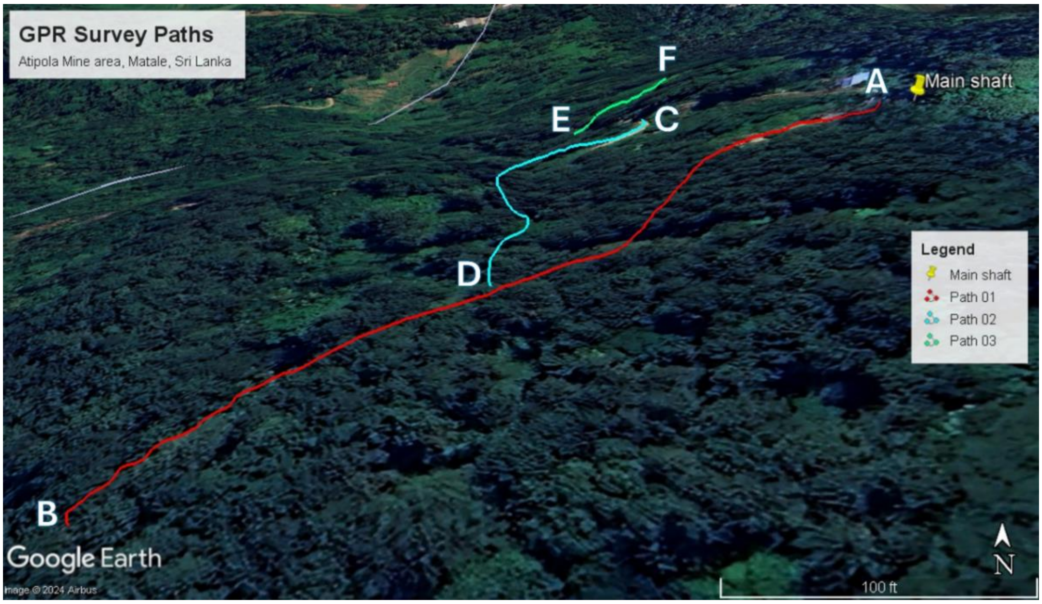


Figure 18 GPR data collected paths, Atipola mine area.

### 2.3 Data Interpretation using GPRSoft PRO software

The data from the GPR survey was interpreted using GPRSoft PRO (version 1.7). GPRSoft's workflow is easy to understand and operate. At the beginning, surface adjustment was carried out followed by selecting a reasonable frequency to locate the features. The "background removal" tool was then used to eliminate background noise. After applying the "gain" function, the image was ready for interpretation. Since vein type deposits formed as fracture filling structures [7], the main target of the survey was to identify fracture like features.

## 3. Results and Discussion

### 3.1 Results

The GPR profile from path 1 (A to B, Figure 3), was generated using a 60 MHz antenna and analyzed with GPRSoft PRO software. From the GPR profile, it is evident that the reflections within the 25-80 m depth range (Figure 4) exhibit a consistent pattern. These linear features could indicate that there are some fractures like features within the subsurface [12] but with poor resolution, however any other variations of the subsurface features were not identified.

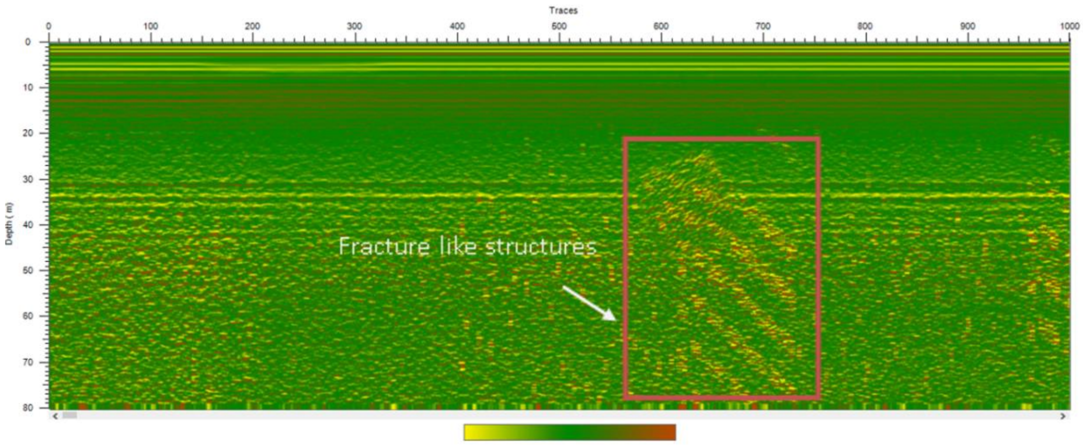


Figure 19 Identified fracture-like features within 25-80 m from GPR survey path 1 (60MHz).

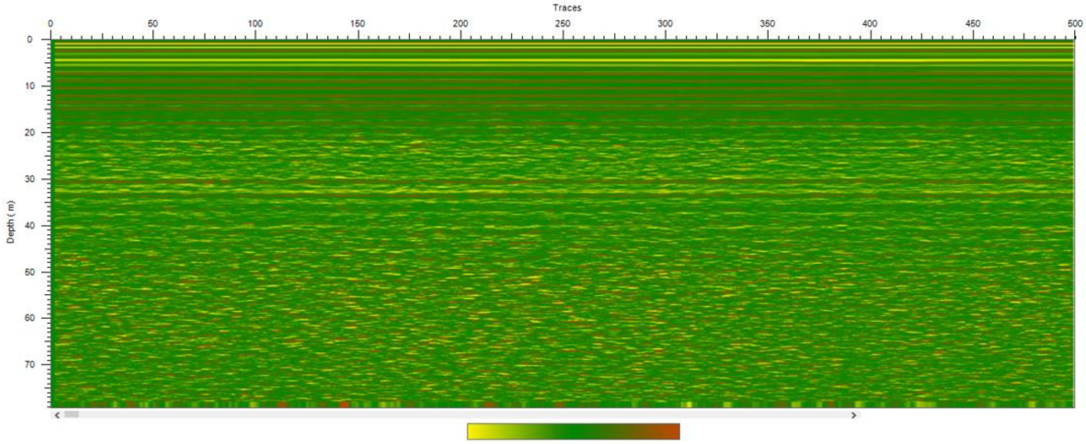


Figure 20 Profile from GPR survey path 2 (C to D, 60MHz).

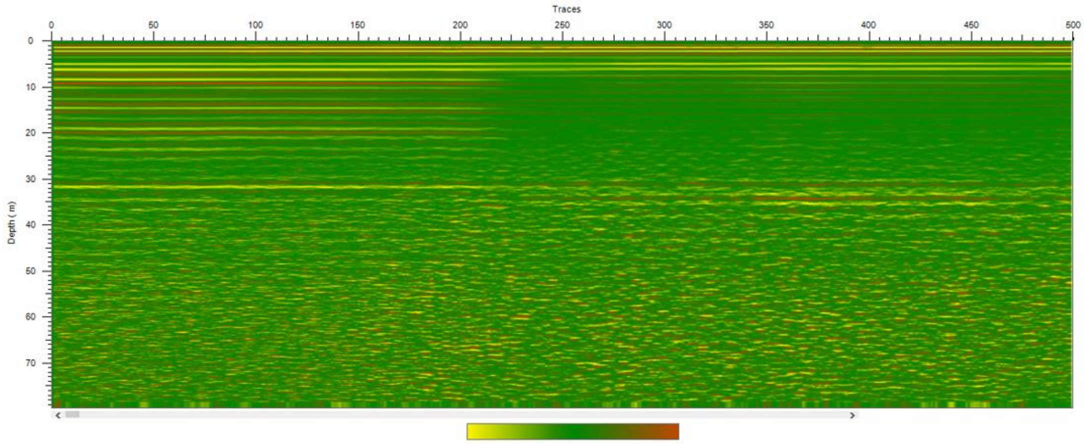


Figure 21 Profile from GPR survey path 3 (E to F, 60MHz).

However, there were no any notable variations identified in GPR profile 2 and profile 3 (Figure 5, Figure 6) due to poor resolution.

### 3.2 Discussion

Fractures often serve as pathways for hydrothermal fluids [13] which are essential in the formation of mica veins. Some fracture-like structures were seen between 25 and 80 m below the surface from profile 1 (Figure 4). But the actual dip of veins ranged between 62$^o$ and 84$^o$ towards the southwest, but fracture-like features suggest a dip variation of approximately at 45$^o$. Also, the profile does not indicate any other notable differences because of the low resolution. According to these observations, it can be concluded that the features shown do not indicate a mica deposit.

### 3.3 Conclusion and recommendations

Although the GPR technique enabled to discern certain fracture-like characteristics ranging from 25 to 80 m below the surface in profile 1 (Figure 4), the inadequate resolution hinders the capacity to identify additional noteworthy fluctuations in the profile. Furthermore, this constraint has increased the possibility of being these observed structures just noise created by the instrument. Based on the current findings, it is recommended not to use low frequency antenna (60MHz) for effective vein mica explorations. To increase the efficacy and dependability of this GPR method, more improving and validation using different approaches, such as drilling, are required.

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## References

[1] L. J. D. Fernando, "*Mineral resources of Sri Lanka*", 1986.
[2] W. T. M. Soiiallee, *Mica, Monazite and Lithium Minerals*. Available: https://pubs.usgs.gov/bul/0666x/report.pdf
[3] S. Hpsd, P. Wwsm, A. Amkb, and P. Hmr, "Phlogopite Mica Mineralization in the Central Part of Sri Lanka and Identify Suitable Areas for Mining," 2014.
[4] T. B. N. S. Madugalla, H. M. T. G. A. Pitawala, R. Naumann, and R. B. Trumbull, "Hydrothermal mica deposits in altered meta-ultrabasites from north-central Sri Lanka," *J Geochem Explor*, vol. 153, pp. 66–78, Jun. 2015, doi: 10.1016/j.gexplo.2015.03.002.
[5] C. Nupearachchi, K. Prematilaka, A. Attanayake, and G. Fernando, "Subsurface Geological and Hydrogeological Conditions of the Matale District, Sri Lanka: Inferred from Vertical Electrical Sounding Curves," *OUSL Journal*, vol. 6, no. 0, p. 91, Feb. 2010, doi: 10.4038/ouslj.v6i0.4116.
[6] S. Jrm, N. Nac, K. Awkn, A. Hwl, and A. Amkb, "Identifying Phlogopite Mica Mineralization in the Area around Rathnapura and Suggesting Suitable Mining Methods for Sustainable Exploitation," 2011.
[7] G. W. A. R. Fernando, A. Pitawala, and T. H. N. G. Amaraweera, "Emplacement and Evolution History of Pegmatites and Hydrothermal Deposits, Matale District, Sri Lanka," *International Journal of Geosciences*, vol. 02, no. 03, pp. 348–362, 2011, doi: 10.4236/ijg.2011.23037.
[8] A. Tarussov, M. Vandry, and A. De La Haza, "Condition assessment of concrete structures using a new analysis method: Ground-penetrating radar computer-assisted visual interpretation," *Constr Build Mater*, vol. 38, pp. 1246–1254, Jan. 2013, doi: 10.1016/J.CONBUILDMAT.2012.05.026.
[9] I. Catapano *et al.*, "Contactless Microwave Tomography via MIMO GPR," *IEEE Geoscience and Remote Sensing Letters*, vol. 20, 2023, doi: 10.1109/LGRS.2023.3257540.
[10] J. Francke, "A review of selected ground penetrating radar applications to mineral resource evaluations," *J Appl Geophy*, vol. 81, pp. 29–37, Jun. 2012, doi: 10.1016/J.JAPPGEO.2011.09.020.
[11] L. Tusa *et al.*, "Mineral mapping and vein detection in hyperspectral drill-core scans: Application to porphyry-type mineralization," *Minerals*, vol. 9, no. 2, Feb. 2019, doi: 10.3390/min9020122.
[12] R. Mendoza, B. Marinho, and J. Rey, "GPR and Magnetic Techniques to Locate Ancient Mining Galleries (Linares, Southeast Spain)," *International Journal of Geophysics*, vol. 2023, 2023, doi: 10.1155/2023/6633599.
[13] J. J. Wilkinson, "Fluid inclusions in hydrothermal ore deposits," 2001. [Online]. Available: www.elsevier.nlrlocaterlithos