CHARACTERIZATION AND VOLUMETRIC ESTIMATION OF BEDROCK BY ELECTRICAL PROSPECTING AT THE QUARRY OF FARATSIHO ON THE PK88 OF RNS43, MADAGASCAR

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Abstract

The quarry on the PK88 of RNS43 is located in the rural commune of Faravohitra. The massive granitoid migmatite rock forms the base of the trachytic eruption. The migmatite is relatively highly altered. Geophysical surveys were carried out to assess the volumetric evaluation of quarryable rocks at the identified quarry, with the results distinguishing three distinct rock characteristics: highly altered rock, altered rock and unaltered rock. The volumetric estimate found after data processing was 234,200 m^3.

Keywords : *Quarry, electrical prospecting, trachyte, unaltered rock, altered rock*

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1. Introduction

The construction and/or rehabilitation of a road project considers massive rock as a raw material, which requires a much more precise knowledge of the quality and morphology of the rock mass reserve.
This is the case for the road project linking Faratsiho and Ambohibary - Sambaina (RNS43), Madagascar.

The main objective of this study is to characterize the geological nature of the quarry, delimit the sound rock and estimate the volume of exploitable rock, using the electrical prospecting method, more specifically, the electrical imaging technique and the vertical electrical sounding technique.

2. Quarry location

The area belongs administratively to the Vakinankaratra Region, the Faratsiho District, the Faravohitra Rural Commune and the Amparihimanga Fokontany *(Figure 1).*

Access is possible using the RNS43 from Sambaina to Faratsiho, around 30km away. The RNS43 links Analavory and Sambaina, with PK0 at Analavory. From this point, the quarry is at PK88.

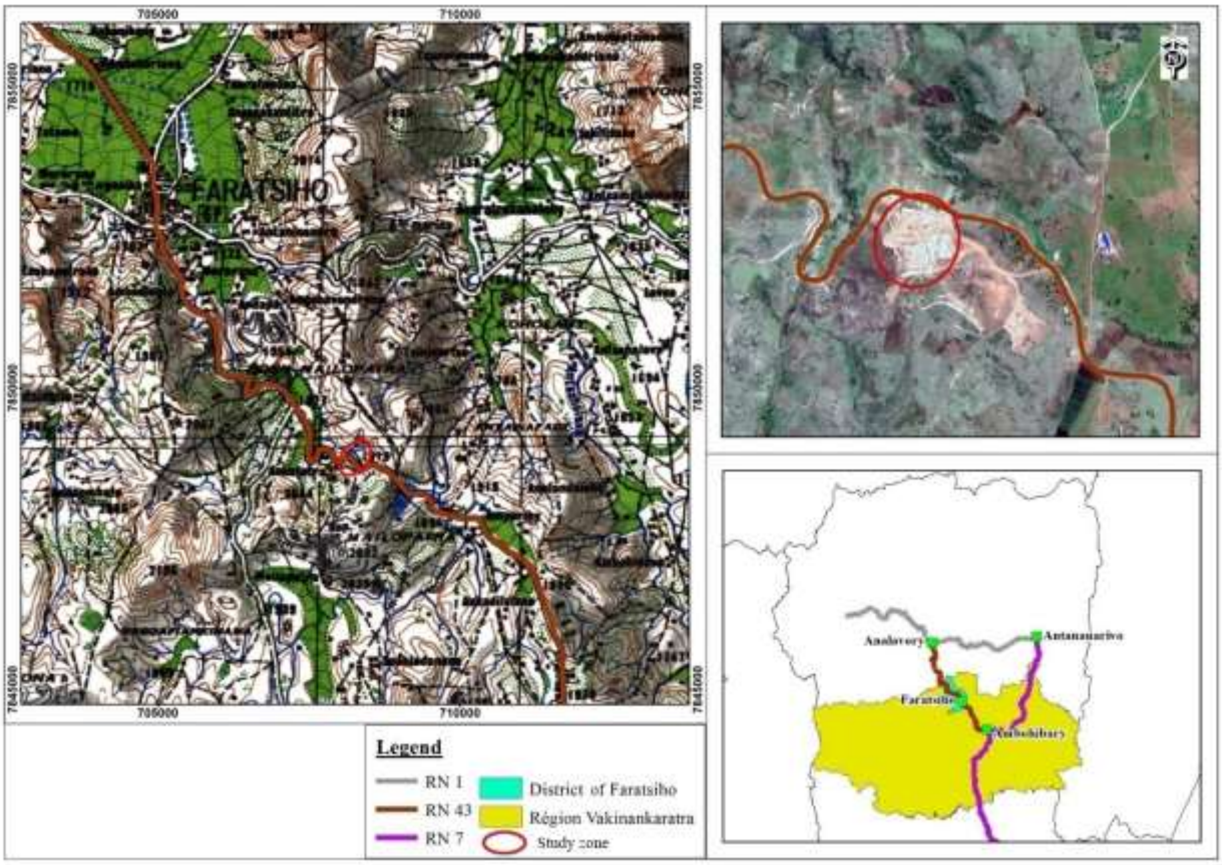

Figure 1. *Location of the quarry on PK88 of RNS43*

3. Geology of the area

The area is located in the Ankaratra volcanic region. It is part of the Antananarivo domain massif, which has been affected by recent volcanic eruption from Itasy to Betafo *(Bernard 2007).* In the Pliocene, extensional tectonics accelerated volcanic activity, building the imposing Ankaratra and Vakinankaratra massifs.

The quarry is located on an island of recent trachytic eruption. This is a late eruption, so the degree of alteration is still low and only affects the superficial part of the rock *(Figure 2)*.

The site is located in the south-eastern part of the Ankaratra volcanic massif. It is generally located in the contact zone between the migmatitic block and the Ankaratra volcanism.

4. Geological description of the quarry

Field observation reveals that the surrounding granitoid migmatite rock forms the base of the trachytic eruption. *The migmatite is relatively highly altered.*

Granitoid migmatite is unsuitable for use as paving rock, due to its coarse-grained nature. It is relatively friable. As a result, its distribution in the quarry is very random (Photo 1). *The upper part of the erupted rock is slag-like, affected by advanced weathering (Photo 2).* The rock has a network of perpendicular diaclases.

Based on the characteristics of the host rock, the geophysical survey's objective is to delimit the hard, sound trachytic rock that can be mined for bedrock. The photos below illustrate the quarry geology developed above. The first photo was taken on the quarry face open to current operations, while the second shows the outcropping part of the eruptive rock.

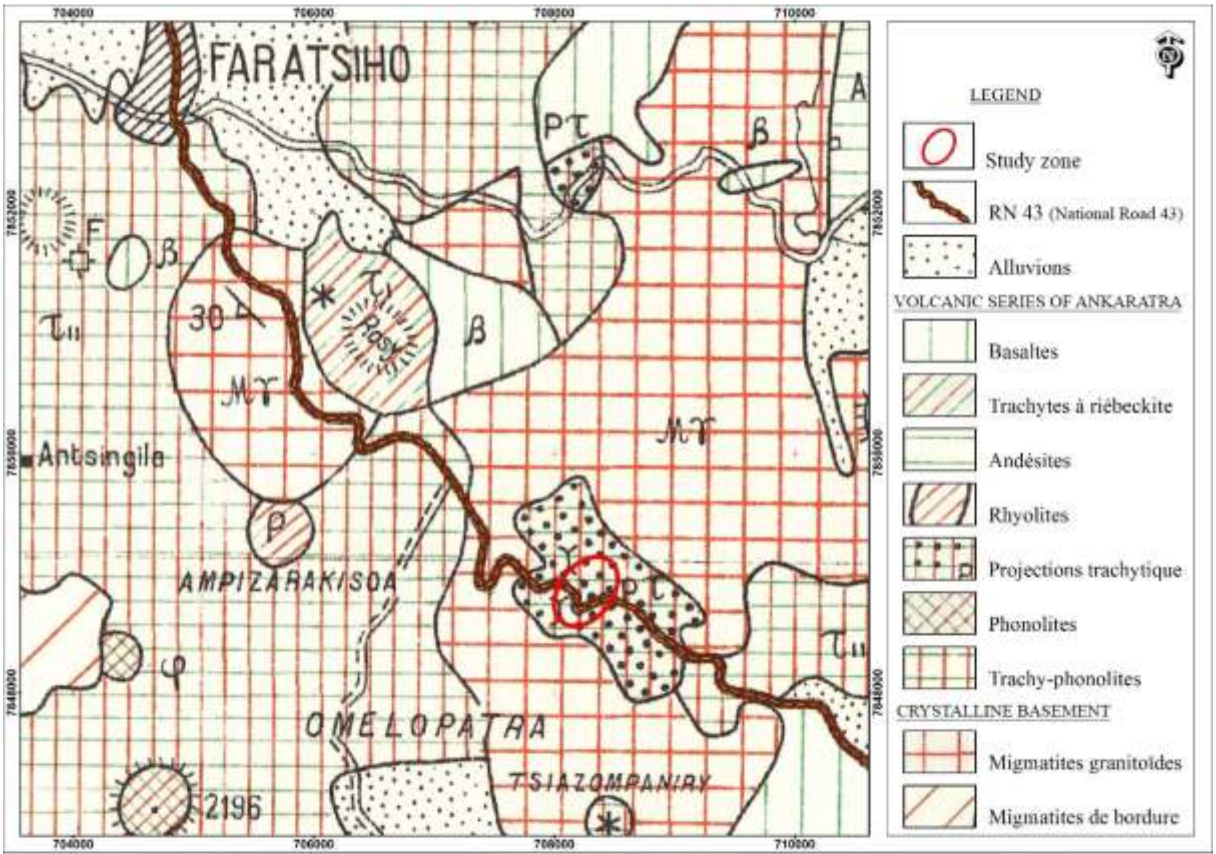

Figure 2- Geology of the Faratsiho area

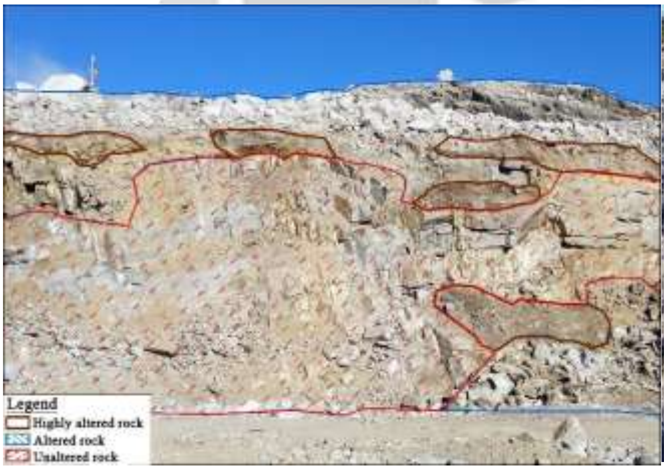

Photo 1- Cutting face of the quarry

Photo 2- Slag outcrop covering hard rock (with perpendicular diaclases)

5. Approach methodology

The electrical method, vertical electrical sounding techniques and the electrical panel were adopted **to delineate the various horizons forming the solid rock quarry.**

The cross-sections obtained using these techniques provide **an image of the electrical resistivity of the first twenty meters of the subsoil**. These sections will then be used for 2D modelling of the quarry and to provide further **information on the morphology of the underlying hard rock.**

6. Results and interpretation

6.1. Location of geophysical surveys

Nine Wenner-type vertical electrical boreholes and **two electrical panel profiles** were spread over the site. **They were laid out to cover the entire surveyed area and also to provide more information on the bedrock deposit** (Figure 3). The second panel, with an overall East-West direction, was installed to follow the eastern extension of the quarry (panel directions : PE1 : NE-SW ; PE2 : NW-SE).

The nine boreholes are grouped on two profiles to provide two geoelectric cross-sections and, above all, to follow **the quarry's alteration / sound rock / migmatite laterite horizons**. *Details of the results for each hole are appended to this report, but the results obtained after interpretation of the geoelectric cross-sections are given here.*

Figure 3 : Layout of geophysical work

6.2. SEV interpretation, profile I

The first profile passes over the four sounding points, SE8, SE9, SE1 and SE2, from north-west to south-east. Borehole SE8 was laid out opposite the current working face, on the terrace at the base of the working face.

The cross-section revealed two distinct horizons :

An interface separating the moderately resistant formation and the resistant formation with an electrical resistivity value of 3500 Ωm, representing the sound rock mined at the quarry. The thickness of the cover is around 10m at SE9 and SE1, with virtually no cover below SE8 and SE1.

A horizon separating the resistant formation and the alteration zone (altered migmatite) at the base of the trachyte effusion.

The cross-section shows that the thickness of the hard rock decreases towards the south. The rock disappears completely in the south of SE2.

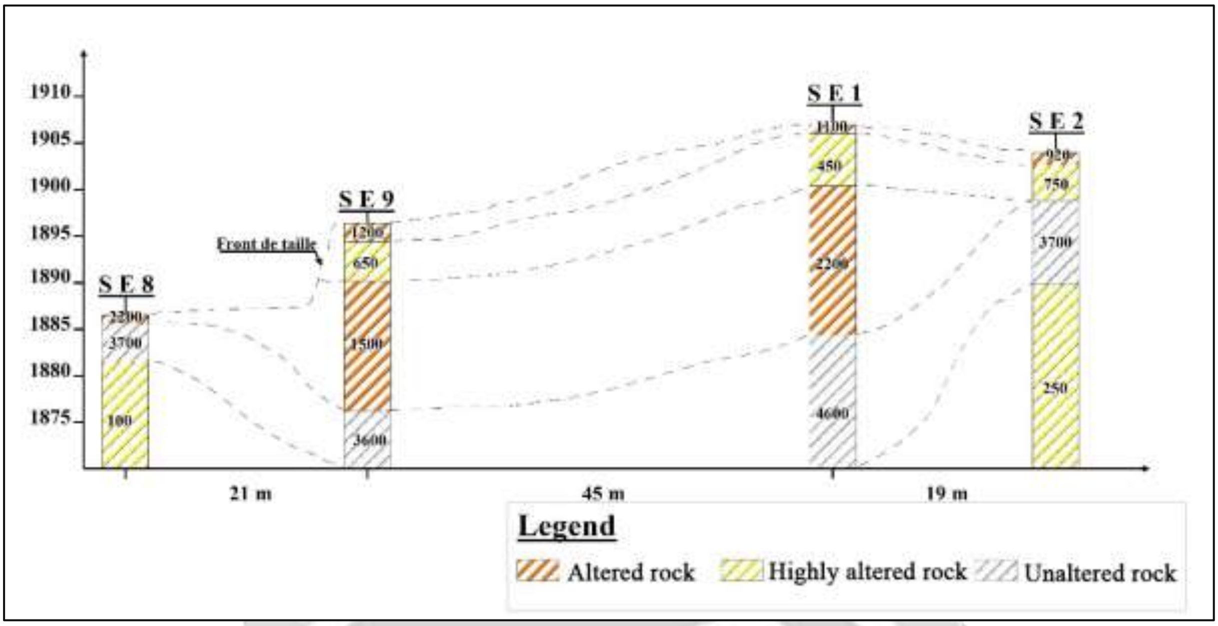

Figure 4 : Geoelectric cross-section, profile I

- Highly altered rock <700 Ωm, - Altered rock around 1300 Ωm, - Unaltered rock >3200 Ωm
5m depth : altered rock

6.3. SEV interpretation, profile II

The second profile is formed from the five boreholes, SE4, SE3, SE6, SE7 and SE5. The section revealed only the first horizon. This means that the base of the sound rock lies at a depth of over twenty meters on this level.

The thickness of the overburden is around 5m below boreholes SE4, SE3, SE7 and SE5. The rock is at a depth of 3m below point SE6.

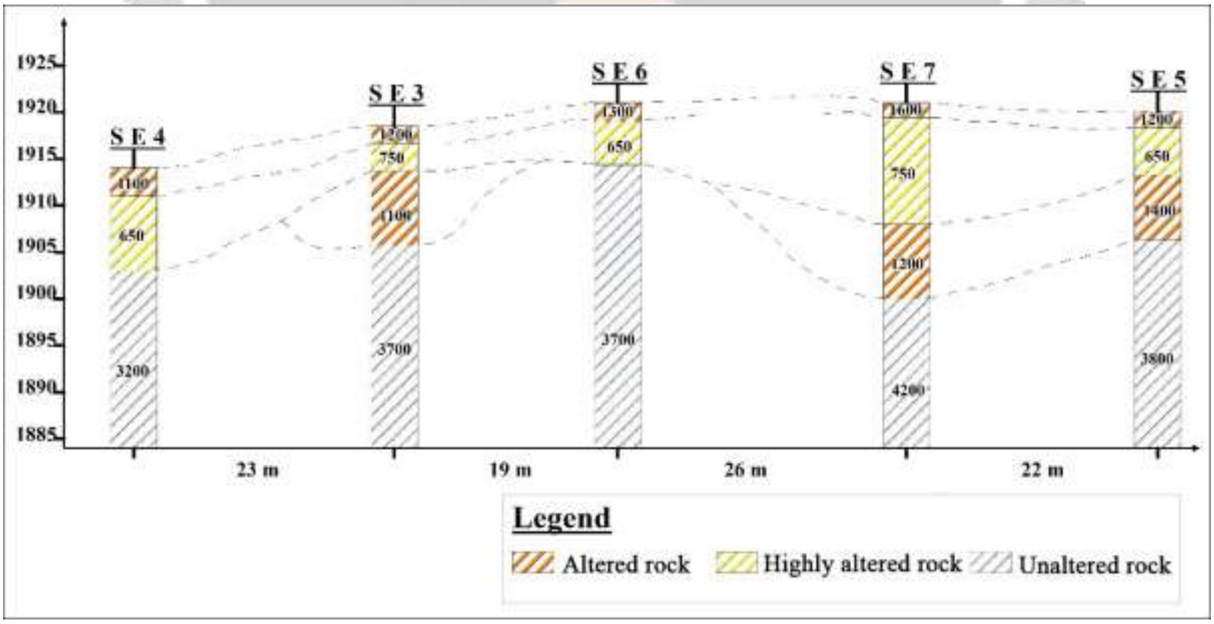

Figure 5 : Geoelectric cross-section, profil II

The cross-sections show that the thickness of the weathered cover and the sound rock vary from place to place. The thickness of the weathered formation is around 10m under profile I and around 5m under profile II. The thickness of the sound rock is limited at both ends of profile I, and the base of the rock is not reached by the length of line drawn under profile II.

6-4 Panel results and interpretation

The two panels were installed in two almost perpendicular directions, NE-SE and NW-SE (see Figure 6). An inter-electrode distance of 5m was adopted, reaching an investigation depth of 25m.

Panel 1

Panel 1 is located in the upper part of the quarry. It was laid out in a south-west-north-east direction. The center of the line is located geographically at X=708343m and Y=7848481m.

The line was laid out to provide information on the continuity of the rock along its direction of spread.

The horizons encountered during the interpretation of the borehole diagrams are confirmed by the electrical model derived from the data inversion.

The cross-section shows three different zones : the moderately resistant zone, essentially composed of weathered rock ; the resistant zone, composed of sound rock ; and the conductive zone, indicating the weathering of granitoid migmatite.

The resistant zone is around 55m wide and 15m thick.

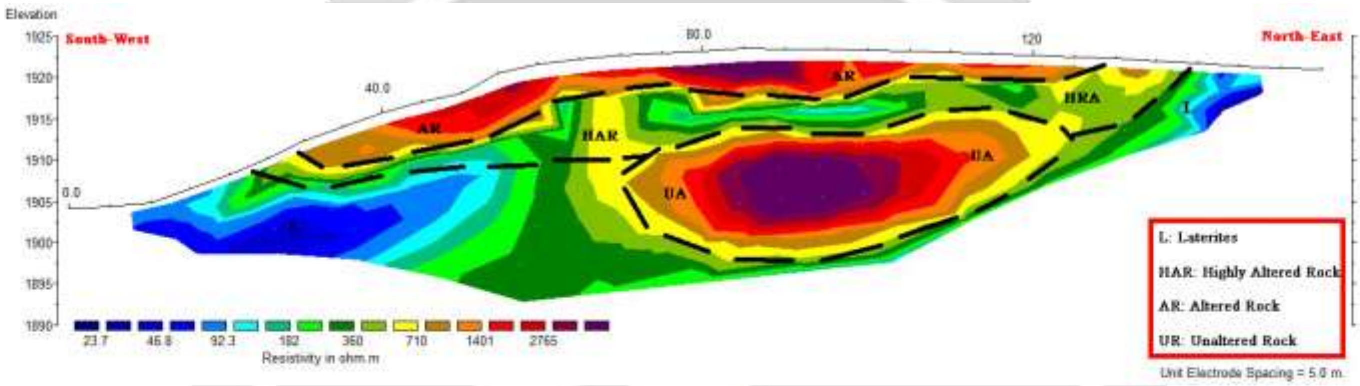

Figure 6 : Geoelectric cross-section, panel 1

Panel 2

The second profile was laid out perpendicular to the first. The center of the device is geographically located at X=708390m and Y=7848445m. It was installed to define the eastern extension of the deposit.

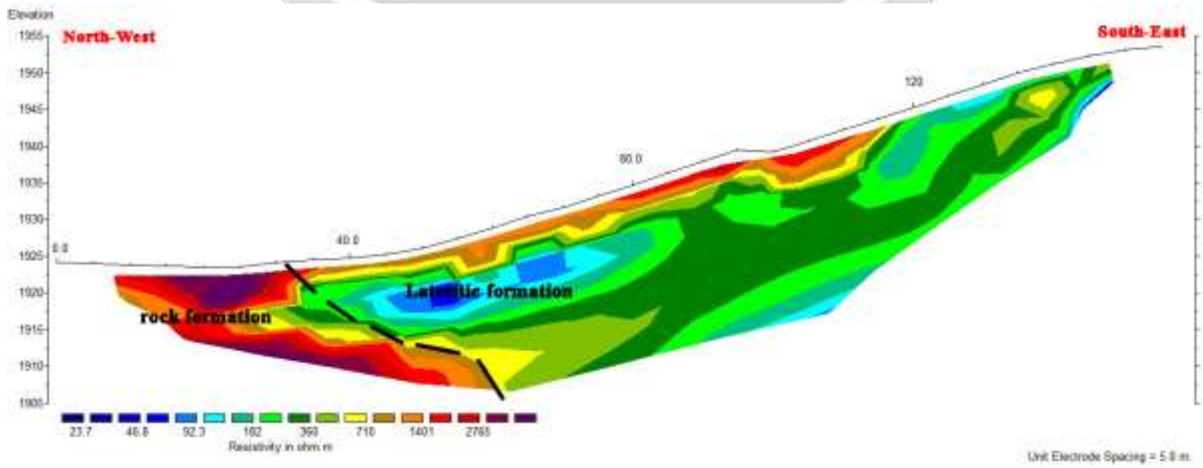

Figure 7 : Geoelectric cross-section, panel 2

The cross-section shows that the sound rock does not extend beyond the 60m abscissa of the spread line. The eastern extension of the rock is therefore limited.

7- Volumetric estimation

The volumetric estimation of the bedrock reserve is made by compiling information from exploration, topographical data and detailed electrical prospecting.

The geological exploration defined the nature of the rocks at the site and also identified the horizons that can be distinguished using geophysics. The topography of the site combined with the geophysical cross-sections enabled us to calculate the volume of mineable rock.

Cubic capacity calculations were performed using Covadis. The horizon separating the laterite cover and the sound rock was taken as the top of the deposit, taking into account the topography of the site, and the second horizon limiting the volcanic effusion and the migmatite was taken as the base of the deposit, taking into account the topography.

The calculation yielded the results shown in the following table for the zones

Table 1- Volumetric calculation

Rock type	Volume (m^3)
Altered cover	96,000
Healthy rock	**234,200**

The sound rock covers an area of 1.8 ha. Mining is carried out on two platforms. The map below illustrates the extent of the solid rock in the study area.

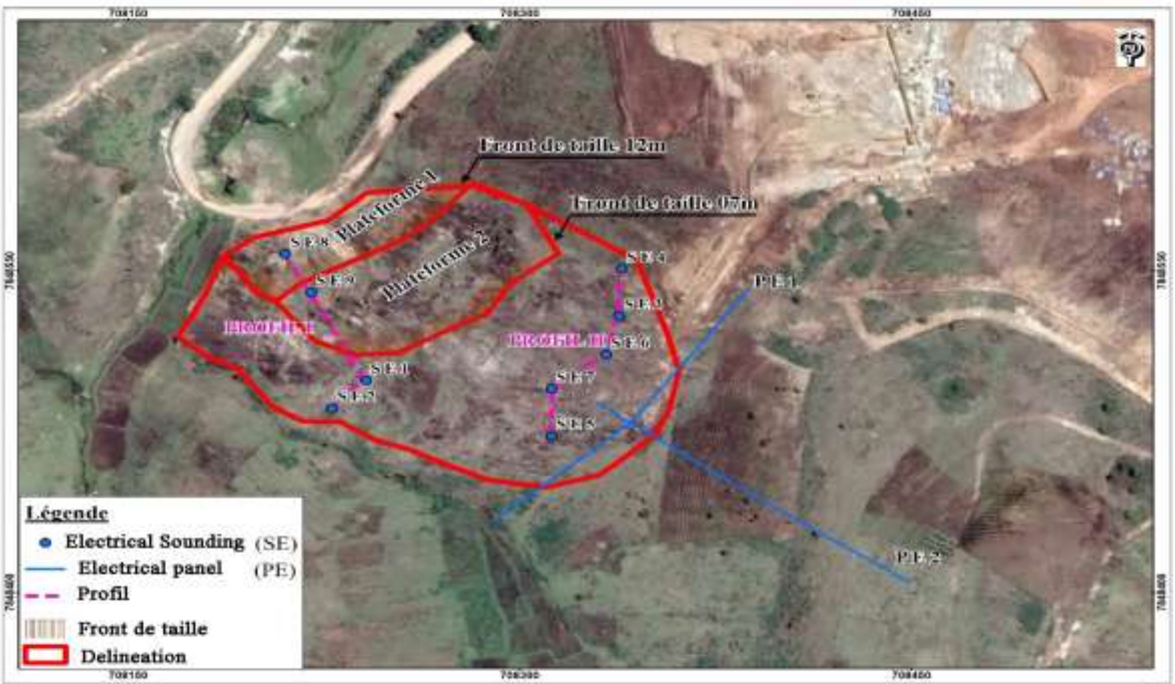

Figure 8 : Delineation of quarryable solid rock

8. Conclusion

Geological observation reveals that the surrounding granitoid migmatite rock forms the base of the trachytic eruption. The working face shows that the trachyte effusion is deposited on the altered granitoid migmatite formation, and the sound rock is covered with altered rock and slag.

Electrical exploration has enabled us to define the nature of the rocks at the site, and also to determine the horizons that can be distinguished using geophysics.

- Highly altered rock (< 700 Ωm)
- Altered rock (around 1300 Ωm)
- Unaltered rock (>3200 Ωm)

The calculation carried out by entering the various geological, lithological and topographical information gave a volume of mineable sound rock equal to 234,200 m3. The sterile cover is estimated at around 96,000 m3. The thickness of the cover is not uniform across the surface.

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