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Valorization of phlogopite ore by geochemical analysis and interpolation with Aster satellite images (case of Ampandrandava - South of Madagascar)

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Abstract

Phlogopite is one of the oldest industrial minerals exploited in southern Madagascar. From Ihosy to Fort Dauphin, there are several types of farmers who live from the artisanal exploitation of phlogopite with various underground mica mines abandoned before 1940. Currently, it is exploited almost everywhere in the south of Madagascar. This irrational exploitation, without specific characterization makes this mineral cheap, likewise destroys the environment and leads to waste of the deposit. Ampandrandava is one of those former semi-mechanized underground mines still in operation, and is the only underground mine on the island. With a depth of at least 100m, this mine is characterized by its different minerals and unique phlogopite. In order to develop this mineral and to include this mine among the mining heritage in Madagascar, it is important to characterize its products and value the mine and the existing minerals in the town. The analysis of the samples and the interpretation of the geochemical data of this mineral associated with analyzes of ASTER satellite images will allow us to know its mineral specification as well as the value of the mine. The results of this process will show a correlation to the distribution of this mineral in the study area. The interpolation with the relevant lithological information and the mineralization indices shows a homogeneity of the results obtained. However, these results provide a new layer of information that can be used for the detection of favorable lineaments for a new exploitation.

1. Introduction

The Ampandrandava mine is the only oldest underground mica mine in Madagascar. It is one of the legends of geological and mining works in Madagascar known by its minerals and its mica deposit with an underground exploitation going down to -181m with multiple mica deposits in the surroundings.

This work aims at the geochemical characterization of the various minerals of phlogopite in the mine of Ampandrandava and its surroundings in order to their valorization.

Analyses and interpretation of geochemical data and satellite imagery have been used for mineral specificity and mineral resource development in the district.

Satellite image data are widely used in various aspects in the field of geoscience. The use and exploitation of ASTER images in the exploitation of a mineral takes an important place. Deposits can be identified through the detection of rocks hydrothermally by their spectral signatures. The use of remote sensing data, more specifically ASTER images in the field of geological mapping.

2. Localization

Ampandrandava is located 12Km from Beraketa in the Anosy region, district of Amboasary Sud.

3. Method

The methodological approach used in this work consisted of field work, sampling, laboratory work and finally the analysis of satellite images.

3.1. Works geological

The study area is mainly formed by leptynites, pyroxene gneisses. We also find pyroxenite with diopsidi and phlogopite. Pyroxene is the parent rock carrying phlogopite mineralization in the region.

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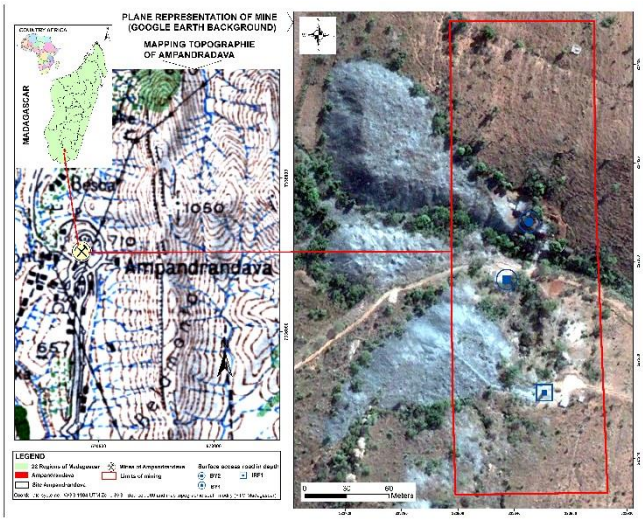


Figure 1. Localization map Ampandrandava

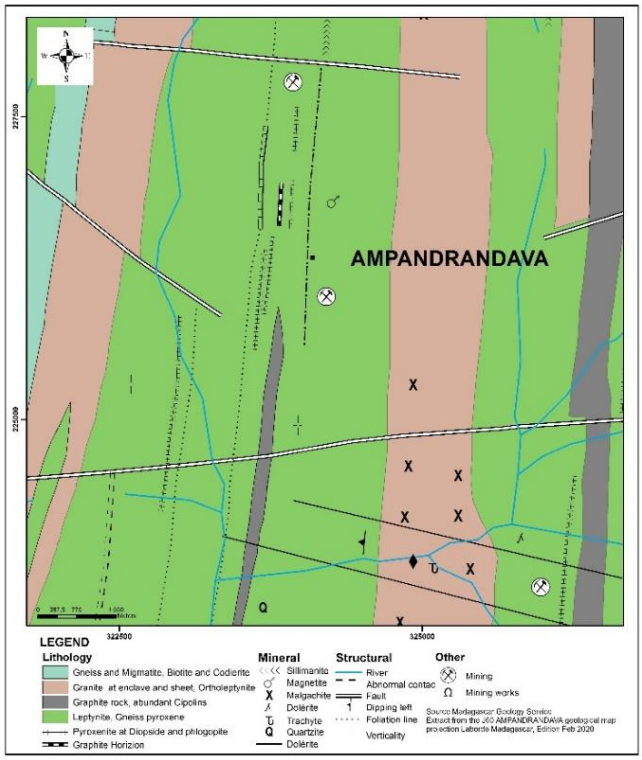


Figure 2. Geological map of Ampandradava

Figure 3 shows the cross section different levels of the mine going from +15 m to -181m above sea level.

3.2. Geochemical analysis

Some phlogopite samples from the Ampandrandava underground mine were analyzed by direct excitation X-ray spectrometry. X-ray fluorescence spectrometry (FX, or XRF for X-ray fluorescence) is a non-destructive technique used to quantify the elemental composition of solid and liquid samples for elemental analysis. This method is a quantitative analysis of the chemical elements present in the mineral.

3.3. Mapping and processing

The data used are ASTERS (L1T) satellite images. The analysis of ASTER data aims to describe the lithology, based on the relationship between the absorption or spectral emittance and the mineral composition of the rock units studied. The composition of the different bands contains a large volume of information, including geological, topographical and roughness information. In the present work, the main image processing techniques performed are: mineral index, spectral analysis and classification.

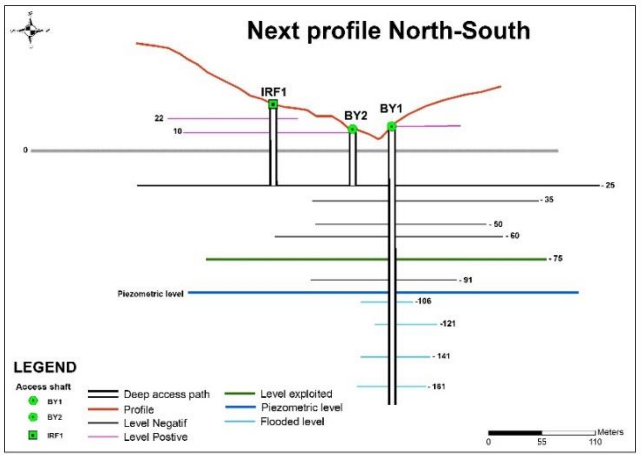


Figure 3. Cross section (North South)

4. Results

4.1. Level -75 structural map

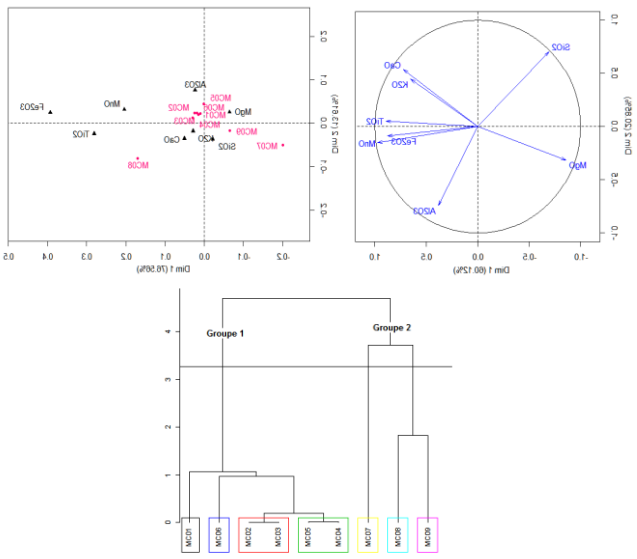
In the NS pyroxenite banks we find eruptive rocks (phlogopite vein associated with anhydrite, calcite, pyrite, diopsidites and pegmatite).

According to the structural exploitation map of level -75, from East to West we have eight layers carrying named mineralization: Alpha, Baltazar, Bravo, Charly, Delta, Echo, foxtrot and Golf.

4.2. Geochemical analyzes

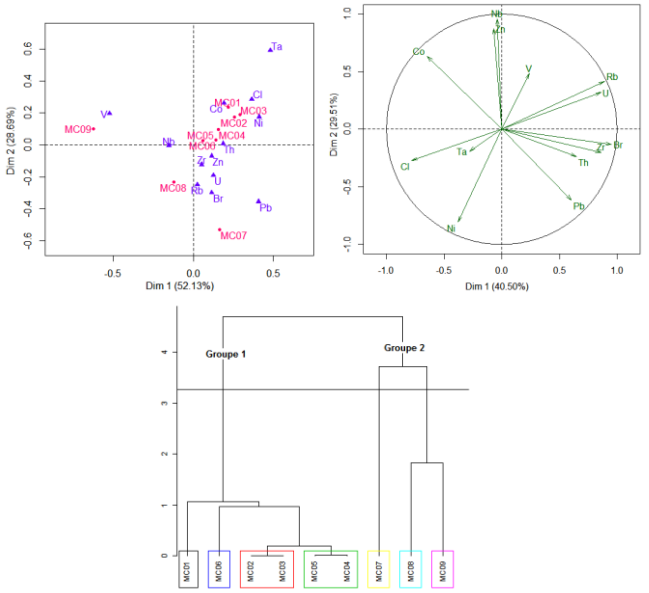
The XRF geochemical analysis made it possible to know the distribution of the chemical elements on some phlogopite samples of the level -75.

Oxide variation



- the Ampandrandava phlogopites are highly rich in [SiO_2> 35%, Al_2O_3> 10% and MgO> 25%] a with an abundance of [CaO> 10% and K2O> 10%] b, they are of aluminous-magnesian type;
- high probability of talc in the phlogopite mineral due to the abundance of MgO.

Variation of minor ro trace elements



- four elements of this classification are present in this mineral, the majority of which is lithophilic;
- presence of trace element: U and Th in this mineral of phlogopite.

4.3. Isotainer map of the chemical elements in level -75

The distribution of some chemical elements are present in the isotene map.

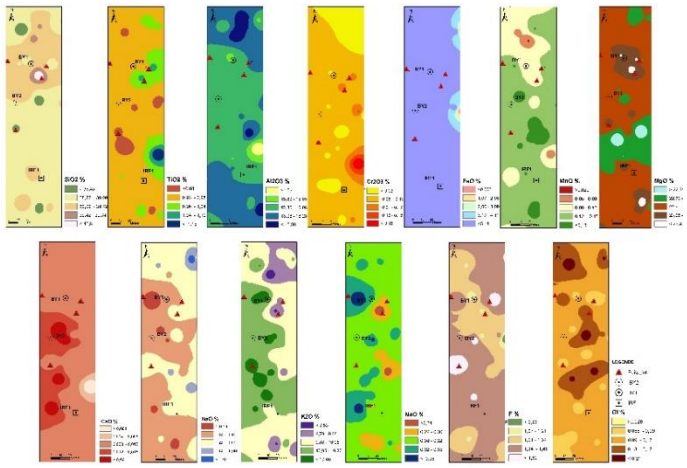


Figure 5. Isotainer map of the chemical elements in level -75

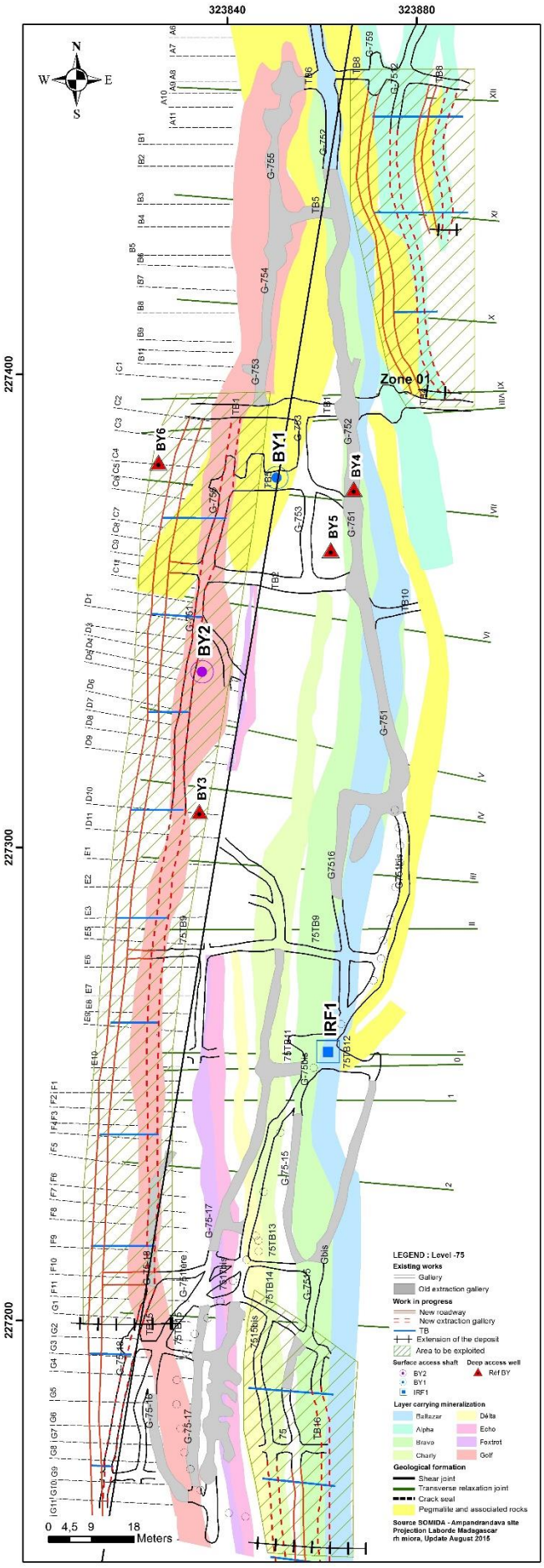


Figure 4. Cross section (North South)

Geochemical analysis of the -75 level phlogopite samples shows that the Ampandrandava phlogopites are rich in SiO_2, Al_2O_3, MgO and K_2O including SiO_2> 35%, Al_2O_3> 15%, MgO> 20%.

This phlogopite is of the magnesium aluminous type with a high resistivity at a temperature + 500 ° C. This resistivity is due to several factors including: depth exploitation, high intensity metamorphism zone.

4.4. Aster image processing

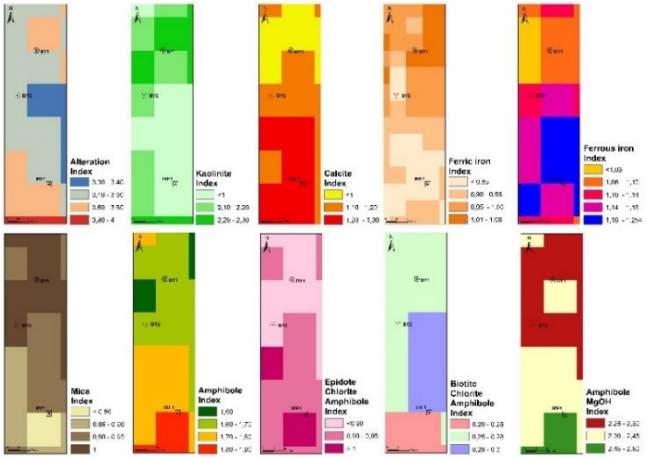


Figure 6. Maps produced form Aster data

The distribution of minerals and chemical elements in these analyzes of the aster images gives us an idea of the outcrops on the surface. This variance is due to the absorption spectrum including 0.48µm <Fe3+ <0.80µm, 0.40µm <Fe^{2+}<0.55µm.

Hydrothermal alteration minerals containing Al(OH) radicals, alunite, muscovite and kaolinite have a strong absorption spectrum, don't 2.14µm-2.28µm.

The ratios between bands 4, 5,6 and 7 of VNIR and SWIR provide the mineral distribution associated with the parent rock carrying mineralization.

5. Discussion

Drilling in certain levels of the mine is important for the confirmation and extension of the deposit. The geochemical analysis which allowed us to make the distribution of the chemical elements in the -75 levels will be advantageous accompanied by dreams.

The correlation between processed aster image and geochemical analysis is complex given the depth of investigation. However, it allows us to understand the variation of minerals on the surface and on an investigation depth or outcrop (dike, fault, foliation).

The Ampandrandava phlogopite deposit is not thick, but in-depth investigation remains the main mining problem.

6. Conclusion

The Ampandrandava mine is the only functional underground mine in Madagascar today. It is unique for its phlogopite which is the most demanded on the international market with its various minerals: anhydrite, apatite, calcite, pyrite, gypsum, diopside, pegmatite etc. Many deposits are mined artisanally in the south because of the high demand for phlogopite. The Ampandrandava mine production is the most solicited because of its geochemical and physical properties. The analysis of the Aster data allowed us to make a classification of the minerals and to make a lithology mapping of a given region. With the combination of the bands as well as the ratios, the analyses and the corrections brought to the satellite images, it describes us important geological information.

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