THE POTENTIAL OF GOLD MINE DEVELOPMENT PROJECT: A CASE STUDY OF CHIFUNDE DISTRICT IN MOZAMBIQUE

[1]SARA MABECUANE, [2]APISITNUMPRASANTHAI, [3]SUNTHORNPUMJAN

[1,2,3]Department of Mining and Petroleum Engineering, Faculty of Engineering Chulalongkorn University, Bangkok, Thailand
E-mail: [1]saraha.mabecuane@gmail.com, [2]apisit.nu@chula.ac.th, [3]sunpumjan@gmail.com

Abstract- The exploration carried out to date has confirmed several high-grade gold deposits and the high overall outlook of the project area. In addition, there is the potential for the presence of Fe Cu-Au-U-REE oxide deposits (Cu-Au type) and alkaline porphyry Cu-Au deposits associated with Mesoproterozoic granitoids within the limits of the project area and immediate surroundings. The orogenic event was accompanied by the generation of metamorphic and hydrothermal fluids containing Au (Ag and Cu) that infiltrated the shear network and impulse zone and resulted in the extensive formation of litho-structurally controlled gold deposits. In the mineralization map now updated, 200 sample points were plotted with the respective levels ranging from 0.001 g / t to 63 g / t. The inferred mineral resource is 178.2 tons, the reserve was calculated using the Triangular Method, based on data from the 5 holes drilled in the study area so far. Regarding the laboratory results, they indicate that most of the gold is extracted in the panned concentrate and panned middling portions which combined make up 0,8% of the total sample size. This gold will be processed in a beneficiation plant composed of mills, sieves, and deposit boxes, with an installed capacity of 20 tons / hour.

Keywords - Gold, Silver, Copper, Mineralization, Processing

I. INTRODUCTION

Alluvial and hard rock extraction from gold deposits in Mozambique has been carried out by local artisanal opportunists and neighboring countries, only a small number of companies are registered, which has led the Government of Mozambique to carry out research work to identify new areas occurrence of gold to have more control over existing resources. This paper with the title The Potential of Gold Mine Development Project, located in the district of Chifunde, in the province of Tete, in northwest Mozambique, approximately 220 km north of the capital of the province of Tete deals with geological work carried out in the study area, in order to describe the geological units, structures and occurrence of gold in the study area; produces an updated map of mineralization of the study area, estimate the resources of the existing deposit, and provide sustainable processing techniques based on the plan to mitigate the resulting environmental impacts.



Figure 1.1: Overview of the most prospective gold areas of Mozambique.

II. ANALYSIS METHOD

2.1 Geological Part:

During the project phase, fieldwork was carried out, which consisted of collecting samples of rocks and soils including river sediments for chemical analysis and subsequent data interpretation, the samples were collected on the A and B horizon, activities were carried out in confluence bar, drawn bar and point bar. Cabinet work involved geophysical interpretations and satellite images, to identify the type of structures that control the type of mining within the study area. Below the geological map of the study area.

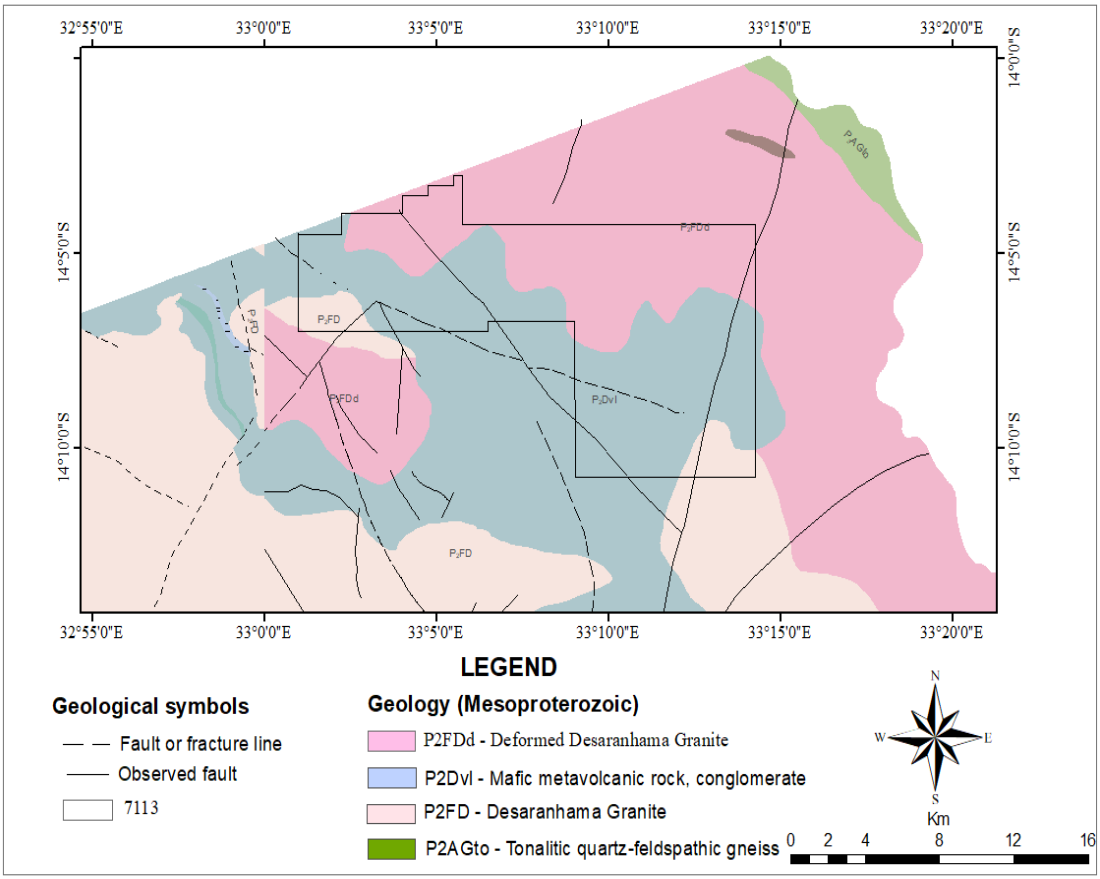

Figure 2.1: Geological map 1:250 000 scale of the area. Norconsult (2007) database.

According to Norconsult (2007), the area is comprised of Mesoproterozoic rocks including granitic gneiss of Desanharama, Amphibolitic schist, gneiss to actinolite; and Desanharam porphyritic gneiss identified in the map with symbols: P 2FDd, P2DVi, and P2FD, respectively.

2.2 Mining Part:

To calculate the reserve, the Triangular Method was used, which was made based on the 5 holes drilled so far, the area, volume, and reserve of the three triangles were calculated separately and finally the total reserve. The blocks were made using ARCGIS 10.7 the coordinates of the points were plotted to obtain the distances between them and then the points were joined using the triangular method. Regarding the mine plan, it is intended to use mechanized open sky mining technologies with various processing phases such as: deposition in the factory, washing, separation, screening, and casting.

2.3 Processing Part:

It is intended to install a processing plant in the mine that will consist of a mill, sieves, and deposit boxes. Initially the ore will be deposited in the plant's feeding mouth via dump trucks, the material will pass to the mill where a wet washing process will be started, the material that will leave the mill will have a dimension below 30cm, this material is submitted to a primary sieve that separates the material with a dimension greater than or equal to 5mm, material that goes to a conveyor belt that deposits the material outside the plant, the same material depending on the level of washing that is submitted or not to be deposited again on the plant a second time for more efficient washing.

The material that varies from 5mm to 2mm goes to the nugget trap. In this case, the material with a size less than or equal to 2mm will be sent to the deposition boxes where the gold itself is deposited in them, as it has a density in the order of 19.3 g / cm3 relatively higher than the density of the other constituents of the ore matrix that mostly has quartz which in turn has a density in the order of 2.65 g / cm3.

MINING PHASE 1 - FLOW DIAGRAM: 20T/H GOLD PROCESSING PLANT

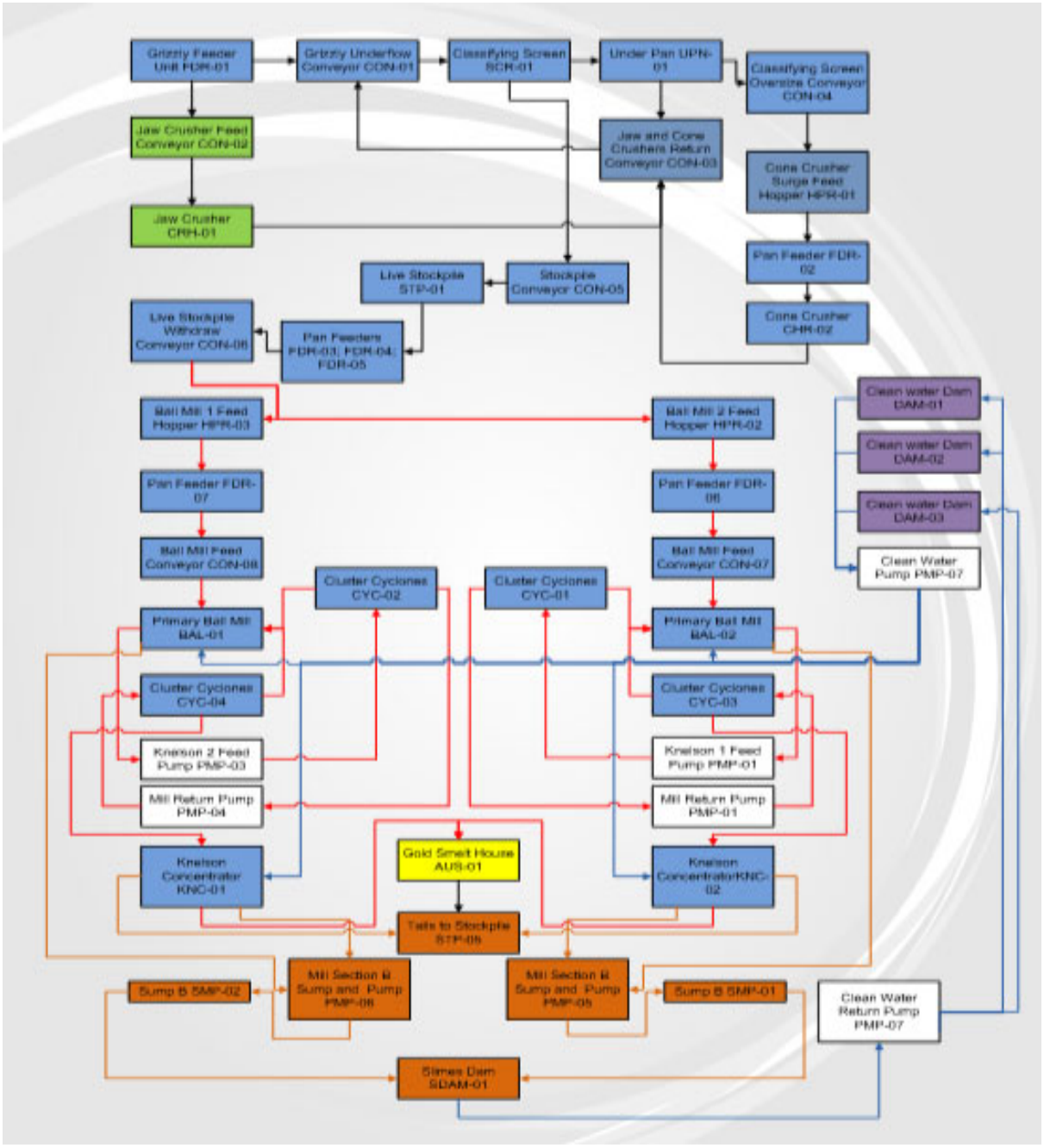

Figure 2.2Flow Diagram Processing Plant.

2.4 Economic Evaluation:

The project presents all favorable economic and financial indicators encouraging investors since the return on investment is assured.

On the other hand, it has positive externalities for society, given that in addition to creating direct and indirect employment, the project is committed to issues of social and environmental responsibility.

2.5 Social and Environmental Impact Assessment:

This Social and Environmental Impact Assessment contains environmental issues that should be given special attention by the proponent, as well as by the different affected and / or interested parties. This plan also presents the environmental monitoring program, the environmental components that should be monitored in relation to the activity, the management and implementation structure of the Socio-Environmental Impact Assessment and information on auditing, environmental assessment and management actions, training and environmental awareness, in accordance with the legislation in force.

III. RESULTS

There are two types of gold deposits in the area, one associated with the quartz veins inserted in the amphibolitic shales (primary deposit) and the other

associated with soil deposits and alluvial sediments (secondary deposit).
The quartz veins are housed in microfractures and macrostructures with spacing ranging from 5 to 50 cm within the amphibolic shales with various orientations {two confirmed orientations (NW-SE and SW-NE)} where the most common minerals in this rock are specialists, arsenopyrite with a ferrogenic matrix where gold is found. However, studies carried out show a high probability of occurrence of gold within the amphibole shale, since there is clear evidence that they have undergone high-grade metamorphism of the green shale, since there are occurrences of biotic gneiss grenades in the form of profiroblasts.

On the map below, figure 3.1 200 sample points were plotted within the study area with the respective levels, with levels ranging from 0.001 g / t to 63 g / t, and those greater than the green points were considered positive points. (green dots). 0.2 g / t and those less than 0.2 g / t were considered negative (red dots). The terms positivity and negativity were used to consider the limit of occurrence or indication of a deposit, or even if the deposit is small, medium, or large, according to the Mozambican deposit table. Both the laboratory results and the high-grade nature of the sampling are highly encouraging results, which makes the related EW structure an obvious priority target for future exploration, so the reserve was made through the Triangular Method figure 3.2 where the geological resource inferred is 178.2 tons, the result of the five holes drilled to date.

The results of initial production capacity will be around 15.16 MT. Maximum production will be around 75.8 MT, reached in the fifth year of production.With the price of 62,499,600.00dollar per ton, based on the price of 32,150 TO (troy ounce) corresponding to September 18, 2020, the sales revenue for the first year will be 947,493,936.00 dollars and reaching about 473,746,965 dollars in the five years of production.

In the Environmental Impact Assessment, measures were outlined to mitigate the environmental impacts arising from mining activities. The relevant components of this assessment are:

Air Pollution
Both the beneficiation plant and the flowchart of the process itself were designed to respect universally accepted environmental standards, in order to mitigate this impact.

Noise pollution
For workers involved in the job, they will be required to wear ear plugs permanently. The noise level is not expected to disturb the local fauna and flora. The noise to be emitted should be limited to standards acceptable for mining areas.The monitoring of the noise level must be concentrated in the noise generating places through the control of the noisy machines and equipment installed in these places, mainly the air compressors and motorized equipment, and the containment measures proposed in this document must be observed.

Solid Waste Management
The most important solid waste will be sterile. The extraction and transport can also generate solid waste consisting basically of aggregates that will be deposited along the roads, during the operation solid domestic waste will also be produced, consisting mainly of kitchen, hygiene and cleaning waste. and operation.These will regularly be collected selectively and deposited in appropriate places for recycling or final disposal in appropriate places.

Liquid waste management
Whether opening access roads or improving existing ones and carrying out excavations, there will be no significant production of liquid effluents, as there is no forecast for the use of liquids in the process, with the exception of water, which will be used to attenuate dust in the mill. as well as the water used for washing.

This will be channeled to the water treatment basin.Liquid waste, including effluents that may be associated with other sources and activities, is basically water for cleaning installations, vehicles or individual and collective hygiene, as well as slipping of black water, oils and lubricants used in the maintenance of machines.Black water must be transported by collectors suitable for temporary pits or latrines, while liquid hydrocarbon waste will be transported to a collector connected to a settling tank for pretreatment purposes, before being discharged into a drum.

The treatment aims to evaporate the water in order to reduce the volume of waste to be destroyed by incineration, as they will be in insignificant quantities.The quality of these effluents will be subject to periodic monitoring, involving independent entities, which will ensure compliance with environmental quality standards.

The recommended quality standards have been adopted for the management of significant impacts associated with the activity, including environmental quality and effluent emission standards (Decree nº 18/2004 of 2 June), where national permissible limits for liquid effluents fall. industrial waste, as well as wastewater and emission of industrial gaseous pollutants, and / or other accepted international standards.

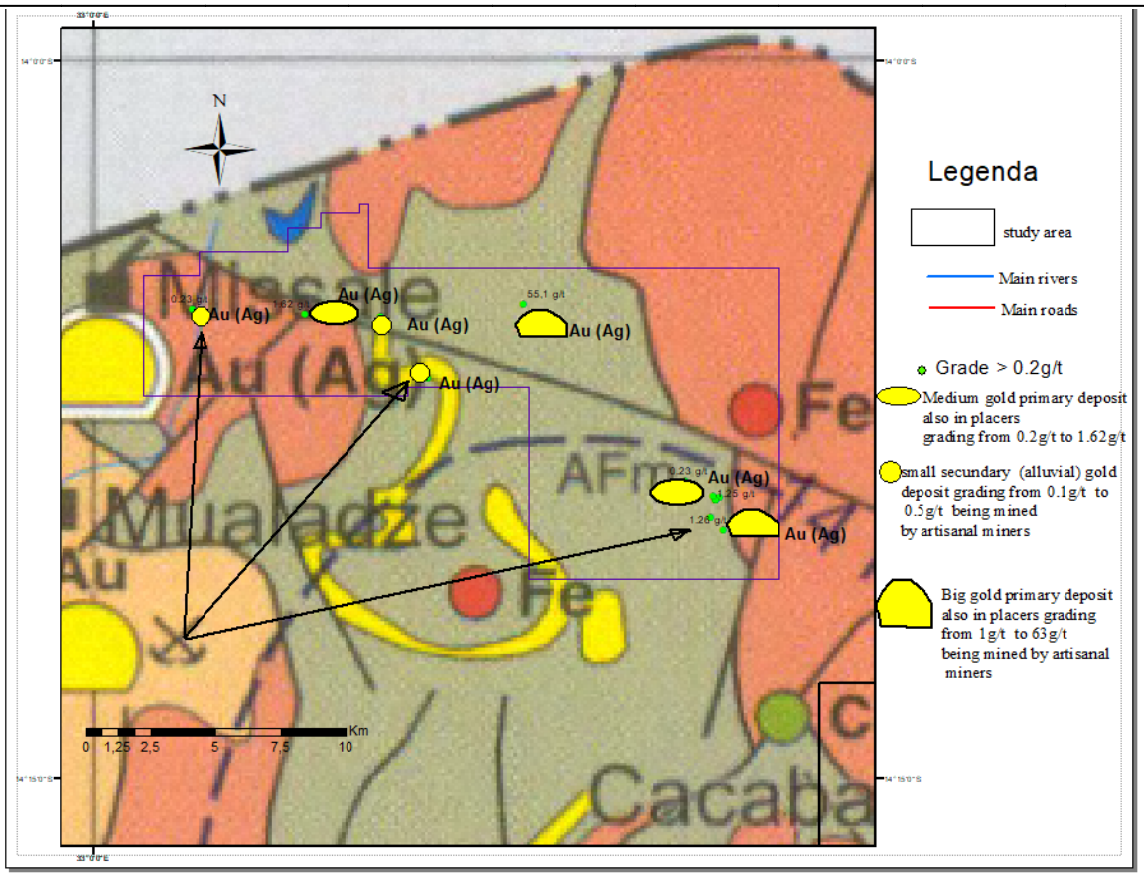

Figure 3.1: Mineralization map of the study area.

Summarized results from SGS laboratory,

Borehole ID	Explored Area	Composite ID	Au Head Grade (g/t)	Primary Concentrate (g/t)	Recovery (%)
CHDD001	Southern tip of Pit 1 Area, cross cutting N/S	CHD-01	0,03	0,79	25,90
		CHD-02	0,02	0,62	20,46
		CHD-03	0,03	0,82	26,32
		CHD-04	0,02	0,91	43,35
		CHD-05	0,02	0,55	19,36
		CHD-06	0,03	0,76	25,16
Average			**0,03**	**0,74**	**26,76**
CHDD002	Directly under Pit 1 Area, cross cutting N/S and E/W	CHD2-01	0,05	2,41	40,51
		CHD2-02	0,05	2,31	40,00
		CHD2-03	0,06	3,41	50,03
		CHD2-04	0,04	4,24	8,90
		CHD2-05	0,07	3,85	46,09
		CHD2-06	0,05	2,42	42,46
Average			**0,05**	**3,11**	**38,00**
CHDD003	South of Pit 1 Area, cross cutting E/W and N/S	CHD3-01	0,03	1,56	39,64
		CHD3-02	0,03	1,55	40,04
		CHD3-03	0,04	1,01	23,10
		CHD3-04	0,03	1,02	31,76
		CHD3-05	0,03	0,98	29,70
		CHD3-06	0,04	0,92	21,09
Average			**0,03**	**1,18**	**30,89**
Thrust Zone Bulk Samples	Northern Thrust Zone outcrop bulk samples	Thrust Comp 1	<0.5	<0.5	NR
		Thrust Comp 2	<0.5	<0.5	NR
		Thrust Comp 3	<0.5	<0.5	NR
		Thrust Comp 4	<0.5	<0.5	NR
		Thrust Comp 5	<0.5	<0.5	NR
		Thrust Comp 6	<0.5	<0.5	NR
Average			**<0,5**	**<0,5**	**NR**

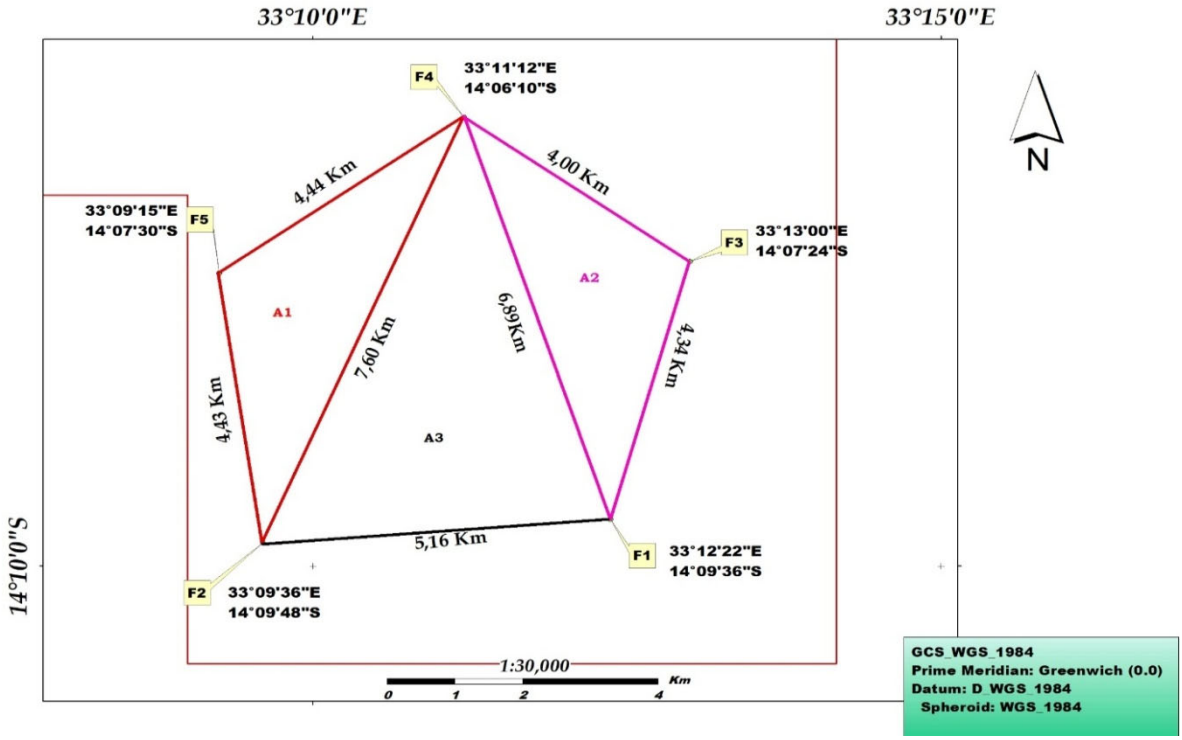

Fig 3.2 2D Bloc Model.



Figure 3.3 Example of an open pit exploration on benches

IV. CONCLUSION

According to the interpretations of geophysical maps and data collected in the soil, it can be concluded that the structures control mineralization within the study area. Through observations made on the ground, one can conclude and state categorically that within the study area there are two types of gold deposits (primary and secondary), but the company prioritizes primary deposits, where this occurs in the form of quarzitic veins between amphibolic shales;

For the secondary deposit, the data show that mineralization is richer in the lower zones (downstream). The updated mineralization map was superimposed on the existing mineralization map and it can be concluded that no deposits were discovered in the study area, this study being an asset in updating the map. It should also be noted that in the surrounding areas there are gold and iron deposits of medium and small scale already explored in the past, however the new discovered areas continue to be the target of mineralization by artisanal miners, removing

2 grams of gold per day a group of 2 people using rudimentary instruments.
The inclination / rest angle of the well must be 35 and 400, the bank width at least 3m and the face height at least 5m. The slope of the streets for trucks should not exceed 450.

RECOMMENDATIONS

Given the relatively poor conditions of the outcrop in the lower areas throughout the concession, systematic mapping should preferably be carried out in the river valleys.
The drilling program must be continued to delineate the attack and the dive continuations of the E / W attack extensional fault zones currently being explored by the artisans. A diamond drilling hole spacing of 100 m is recommended to establish an inferred mineral resource for the mining areas of well Chifunde 1 and 3.
Exploration throughout the concession area should focus primarily on identifying and delineating prominent subvertical and subvertical extending fault zones and E-diving, thrusting zones in W, as well as in the areas of intersection of these structures with marked N / S , subvertical shear zones.
A geotechnical test is recommended to better define the ideal parameters for the reserve calculation.

- Scanning electron microscope (SEM) studies should be performed to identify the distribution of refractory gold and other precious metals.
- Geochronological studies would be desirable to determine the absolute age of the parent rock, metamorphism, magmatism, deformation, hydrothermal fluid flow, alteration and mineralization of precious metals, which would help to restrict the tectono-metamorphic evolution of the area and allow lithium regional-structural correlations.
- Metallurgical testing work is highly recommended to be performed on the core of the drill and claw samples. In particular, the following tests must be performed:
  - Cyanidation tests to assess particle size, leaching time and the presence of substances or compounds that can delay cyanidation.
  - Foam flotation tests to recover free gold or gold associated with sulfide.
  - Gravity sedimentation tests, such as centrifugal concentration to recover free gold.

REFERENCE

[1] Graveyard Letter 1988. And Mineral Occurrence by the National Directorate of Geology and the Council for Geoscience of South Africa.
[2] Mineral Resources Management Capacity Building Project Republic of Mozambique, January 2007. Component 2: Geological Infrastructure Development Project Geological Mapping - Lot 1.
[3] GTK Consortium (2006). Map Explanation.
[4] Decree Law number: 21/2014. Approves the Social and Corporate Responsibility Policy for the Mineral Resources Extractive Industry.
[5] Law No. 20/2014 (August 18, 2014). Mine Law. Maputo.
[6] MIREM. 2015. Mining Law Regulations. Decree No. 31/2015 of December 31st. Maputo 2015.
[7] Ministry of State Administration and MÉTIER. 2005. Profile of Chifunde District - Tete Province. 2005 edition.
[8] https://www.norconsult.com/career/candidate-database/
[9] Davies, 2011 D. Davies Teaching science creatively, Routledge, London (2011).
[10] JUNG, Carlos Fernando. Research & Development Methodology: Applied to new technologies, products and processes. Rio de Janeiro: Axcel Books of Brazil, 2004.
[11] MARION, José Carlos; Dias, Reinaldo; TRALDI, Maria Cristina. Monograph for Administration, Accounting and Economics Courses. Sao Paulo: Atlas, 2002.
[12] MARTINS, Gilberto de Andrade; THEÓFHILO, Carlos Renato. Scientific Research Methodology for Applied Social Sciences. Sao Paulo: Atlas, 2009.
[13] MATHIAS, Washington Franco; WOILER, Samson. Projects Sao Paulo: Atlas, 1996.
[14] MOTTA, Regis da Rocha; Calôba, Guilherme Marques. Investment Analysis: Decision making in Industrial projects. Sao Paulo. Atlas. 2002
[15] SANTOS, Edno Oliveira de. Financial Administration of Small and Medium Enterprises. Sao Paulo: Atlas, 2001.
[16] FERREIRA, AurélioBuarque from Netherlands. New Aurélio Dictionary. 1st ed. Curitiba: Positive, 2004.
[17] https://www.ggte.unicamp.br/ocw/sites/ocw/files/cursos/TecnologicasTerra/GE901/apostilas/aula_10_classificacao_de_reservas_2011.pdf.
[18] https://www.academia.edu/11373871/3._ESTIMATIVA_DE_RESERVAS.

★★★