AUXICO RESOURCES

WORK'S AND EXPLOITATION PROGRAM FOR THE LEGALIZATION OF THE MINING TITTLE LFH-14431X

TITLE HOLDER:
CLIMACO SILVESTRE UNDA BARRIOS

LOCALIZATION:
VEREDA CASUARITO, PUERTO CARREÑO-VICHADA

MINERAL:
MINERALES DE ESTAÑO, ORO, TANTALIO, VANALIO Y SUS CONCENTRADOS

AUGUST, 2021

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1. INTRODUCTION

In accordance with the provisions of the Ministry of Mines and Energy, the Works and Works Program (PTO) corresponds to the supply of the technical, logistical, economic and commercial basis for the investment and development of a mining project. That said, the program of works and Works here present is carried out for the legalization of the Mining title LFH-14431X for the extraction of Coltán-type minerals (Columbite-Tantalite) and tin, located in the Casuarito village, in the municipality of Puerto Carreño. -Vichada.

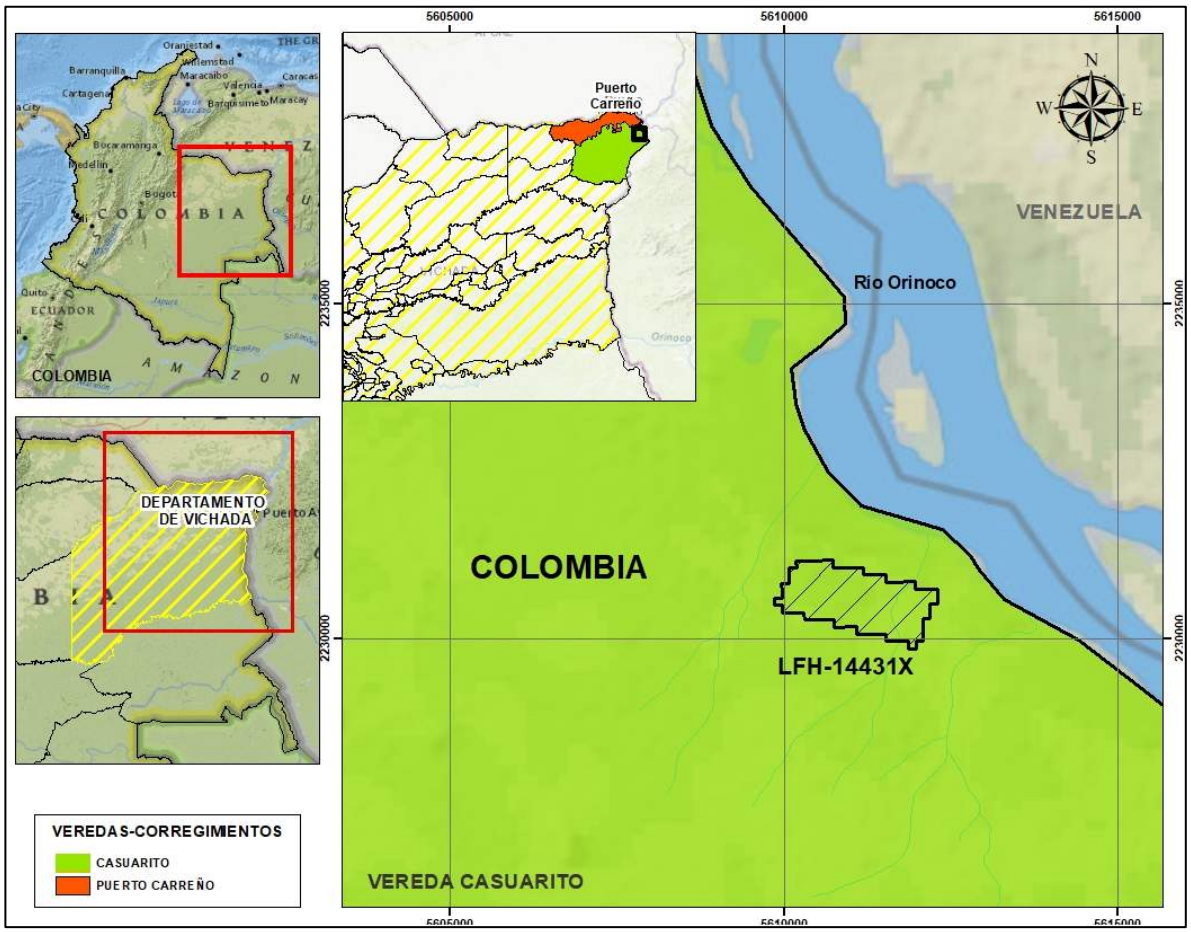
According to the terms of reference, the PTO summarizes the market analysis carried out towards the minerals focus of the exploitation, the planning and design of the same, the benefit and transformation of the obtained minerals, the study of transport infrastructure, the evaluation financial project and the promotion of minerals. Similarly, the PTO specifically defines the exploitation time through a schedule of this phase, and the phases to be developed once said time is over, corresponding to the closure and abandonment phase.

This study was developed under the stipulations of the Terms of Reference created and adopted by the Ministry of Mines and Energy, making the pertinent adjustment according to the specific conditions and characteristics of the area of this project.

2. GENERAL LOCATION OF THE PROJECT

The reference project is located on the eastern margin of the country, near the border with the Orinoco River. The area is distributed across the rural area of the Vichada department, northeast of the Casuarito village.

Figura 1. Location of the zone of interest

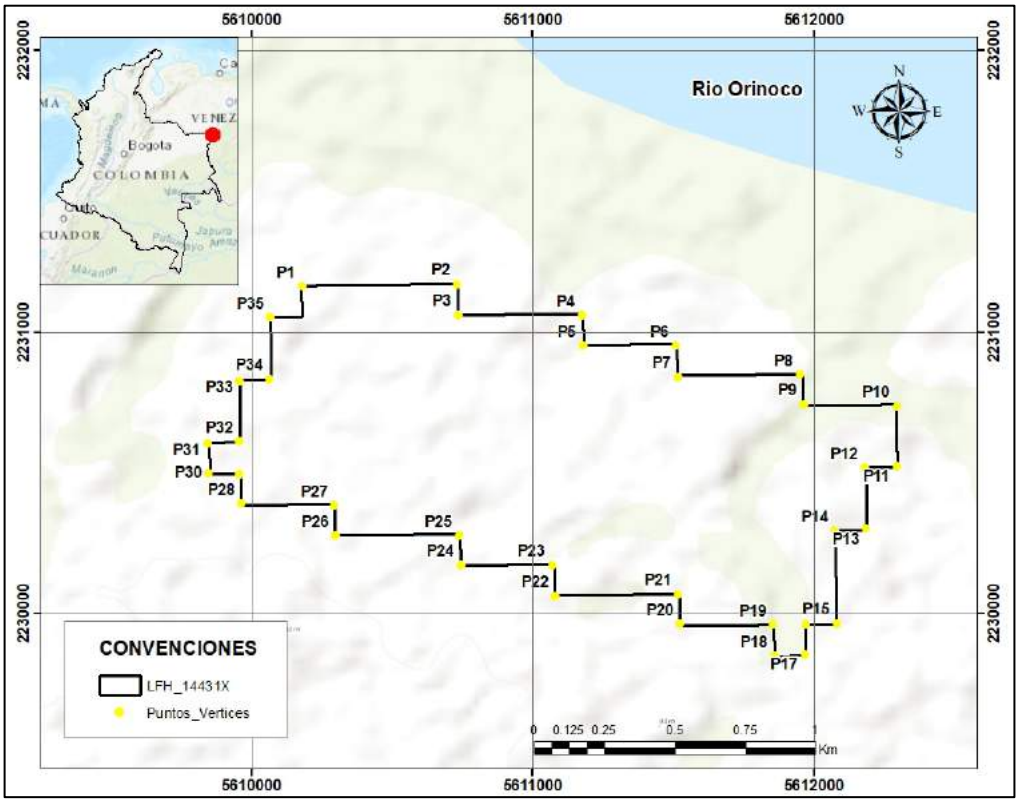


Source: Autors

3. POLYGON WITH LICENSE No. LFH-14431X

The LFH-14431X Mining legalization contract covers an area of 189,796 hectares, distributed in a single area, whose Arcifinio point corresponds to the mouth of the San José channel, located in the Casuarito village, in the municipality of Puerto Carreño - Vichada. , as illustrated in Figure 2. Next, the alignment defined by points and coordinates for said area is described and a diagram of it is shown.

Figura 2. Polygon for the legalizacion of the mining title LFH-14431X



Source: Autors

Equally, the coordinates are then recorded in the single origin for Colombia CTM-12.

Tabla 1. Coordinates that make up the vertices of the polygon FLH-14431X

NAME	EST	NORTH
P1	5610182	2231164
P2	5610735	2231172
P3	5610737	2231062
P4	5611178	2231060
P5	5611180	2230954
P6	5611512	2230954
P7	5611519	2230842
P8	5611953	2230851
P9	5611964	2230745
P10	5612295	2230739
P11	5612295	2230523
P12	5612182	2230521
P13	5612187	2230303
P14	5612077	2230296
P15	5612081	2229968
P16	5611971	2229963
P17	5611969	2229855
P18	5611861	2229853

NAME	EST	NORTH
P19	5611857	2229963
P20	5611526	2229965
P21	5611519	2230071
P22	5611081	2230064
P23	5611070	2230174
P24	5610746	2230174
P25	5610739	2230280
P26	5610301	2230280
P27	5610297	2230385
P28	5609966	2230392
P29	5609959	2230495
P30	5609849	2230500
P31	5609845	2230605
P32	5609959	2230612
P33	5609959	2230828
P34	5610067	2230835
P35	5610069	2231053

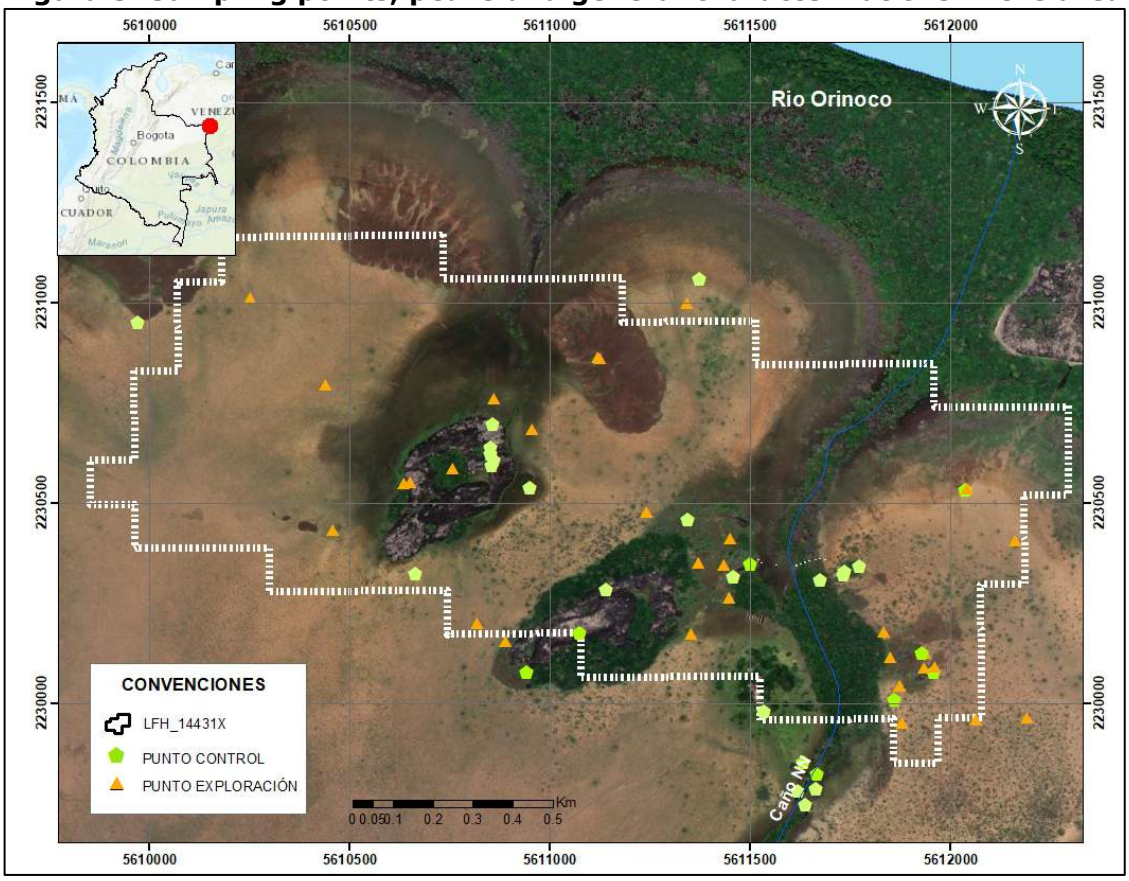
Source: Autors

3.1 DESCRIPTION OF THE OF EXPLORATION ACTIVITIES

3.1.1 General geological survey

The geological reconnaissance of the area was developed in different field phases, in which the objective was to establish the geological characteristics of the rocks and likewise, of the deposits of recent materials that are evidenced in the area. Therefore, prior to the visits, different points of interest were defined and once in the field, apiques, description of profiles, characterization of hand samples, taking structural data, general characterizations of the rocks and finally, samplings for laboratory tests.

Figura 3. Sampling points, peaks and general characterizations in the área



Source: Autors

3.1.2 Definition and location of apiques

The development of the apiques and trenches was defined by targeting the areas near the inselbergs present in the area, locating the orientation of these hills and of the quartz veins that are cutting the hills. Once the apiques near these hills had been made, and showing the distribution and orientation of the materials in depth, we continued with the realization of more apiques. Similarly, the trenches that have been previously made in the area were used to characterize the material. As a result of this process, a total of 24 apiques and trenches of varying depth and measurements were obtained, ranging from depths from 1.20 meters to 7-8 meters. The variation of the depths was mainly due to the fact that the apiques were made in winter times, where the rains are constant, leading to the filling of the holes, for which it was not possible to continue with their development. However, and as established in chapter 4.2, in parallel with the start of exploitation activities, and once the rainy seasons end, the exploration processes will continue, following the schedule and the phases referenced in this document.

Photography 1. Apiques and trenches made in the area of interest

Source: Autors

3.1.3 Sample and chemical analysis

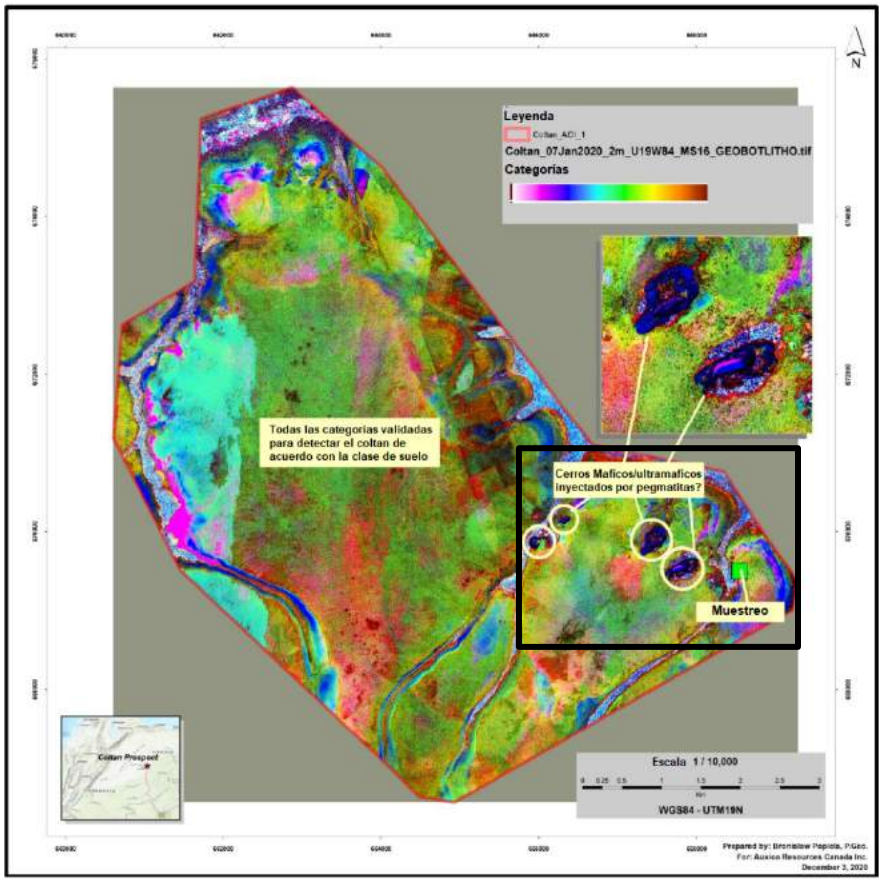
Sampling was carried out for chemical analysis based on a proposal established by the Japosat company, which was related to outcropping rocks in hills and soils. This proposal was defined from satellite and multispectral analyzes carried out in the area of the polygon and its surroundings. For the above, a pre-processing was carried out using the Geomática 2016 software (PCI Geomatics), and its results were analyzed as mentioned below:

3.1.3.1 GeoBotLitho Program

This technology corresponds to realizing the target of a mineral through multi-spectral geobotany, which is produced through the calculation of different

vegetation indices, where characteristics such as chlorophyll content, plant pigmentation, water content, among others are observed. Once this process has been carried out, the GeoBotLitho image is generated, which defines geochemical changes within the vegetation-soil-rock.

Figura 4. Data of the GeoBothLitho program

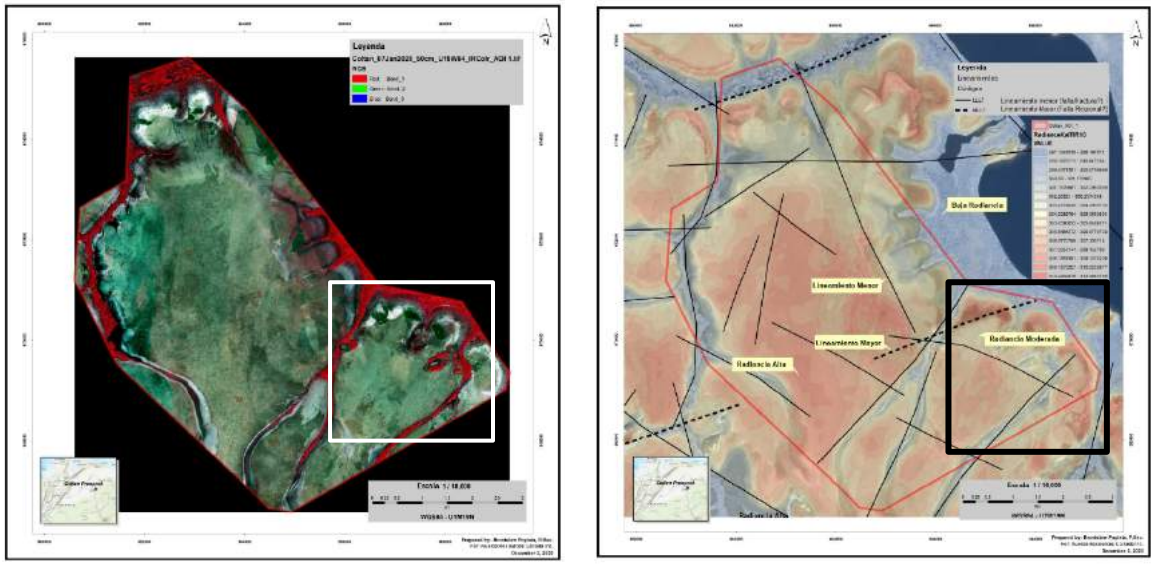


Source: Autors

3.1.3.2 Image "False Infrared Color" 50cms and "Thermal Infrared 30m.

For the processing of these images, the Pleiades 1,2 and 4 bands were used, in conjunction with the Landsat bands 10 and 11, producing images of infra-red composition with a detailed scale, reaching 50cms, and a radiance image, which reaches 30 meters.

Figure 5. Results for False Infrared Color and Thermal Infrared



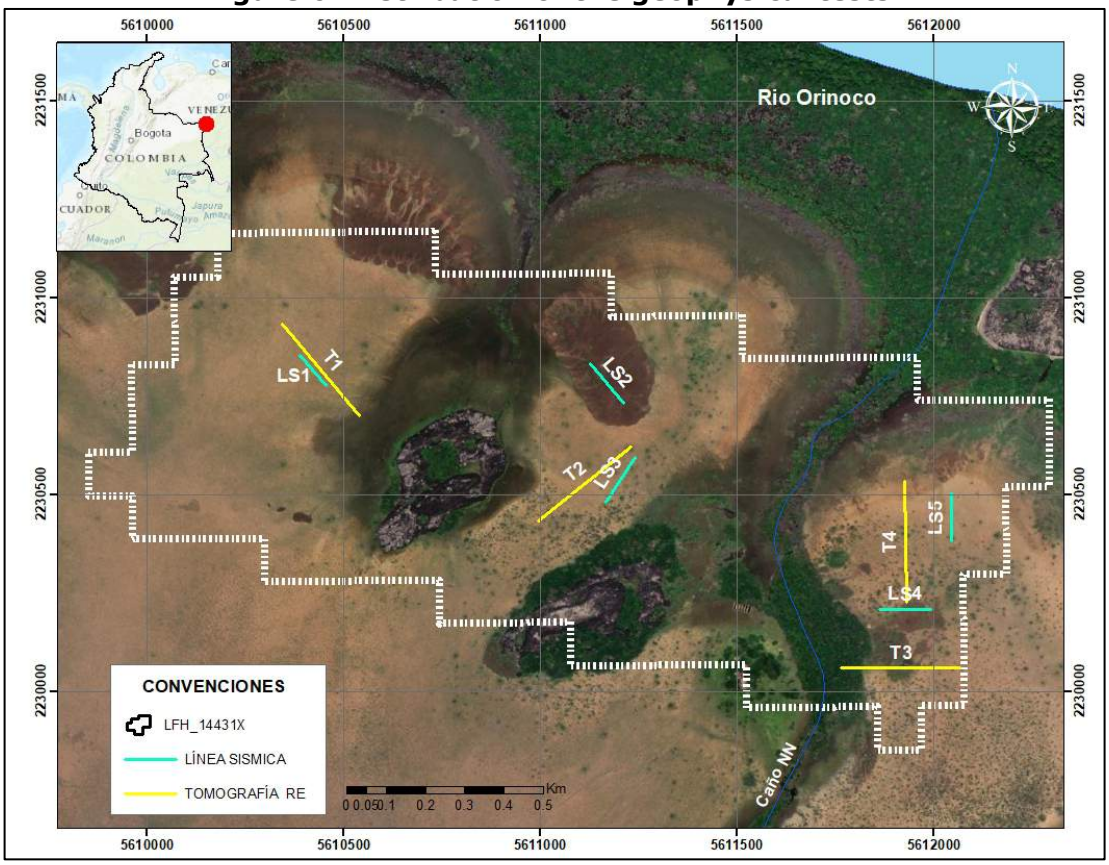
Source: Autors

Based on these analyzes, a total of 39 samples located within the polygon of interest were taken, where by means of the images previously shown some type of spectrometric anomaly was determined. The rock sampling was carried out taking between 400 and 600 gr at the points of interest, and for the sediments, holes between 15 and 25 cm deep were made, taking between 350 and 600 grams of the extracted material; in the same way, in the points or areas close to veins that were evident on the surface, material was taken from them and from the box rock.

3.1.4 Geophisical studies

Geophysical studies are part of indirect subsoil investigations, which are used as applied techniques to support mining, civil engineering, geotechnical activities, among others, in order to determine basement depths or contact between geological units, define the characterization of the soil profile, degree of mineral competition, etc. For the area of interest, in order to delve into the issue of the distribution of the materials present, 9 geophysical lines were developed, which included 5 refraction seismic tests and 4 electrical resistivity tomography tests, distributed as shown next:

Figure 6. Distribution of the geophysical tests.

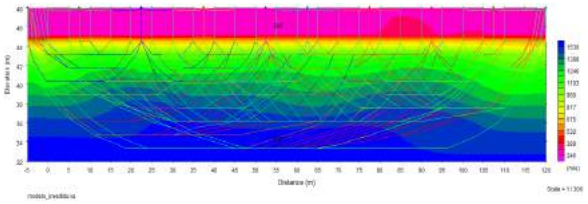


Source: Autors

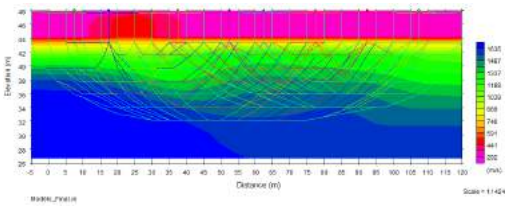
As a result of the processing of the tests carried out, it was possible to establish continuity and depth of materials, resistivity values, and groundwater levels.

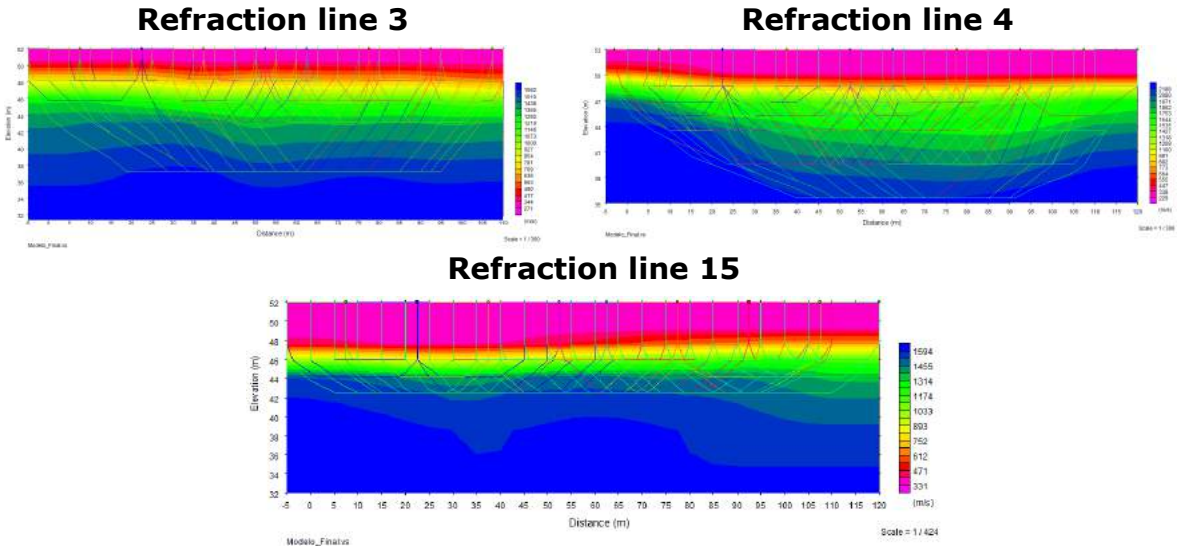
Figure 7. Results obtained in seismic refraction tests

Refraction line 1



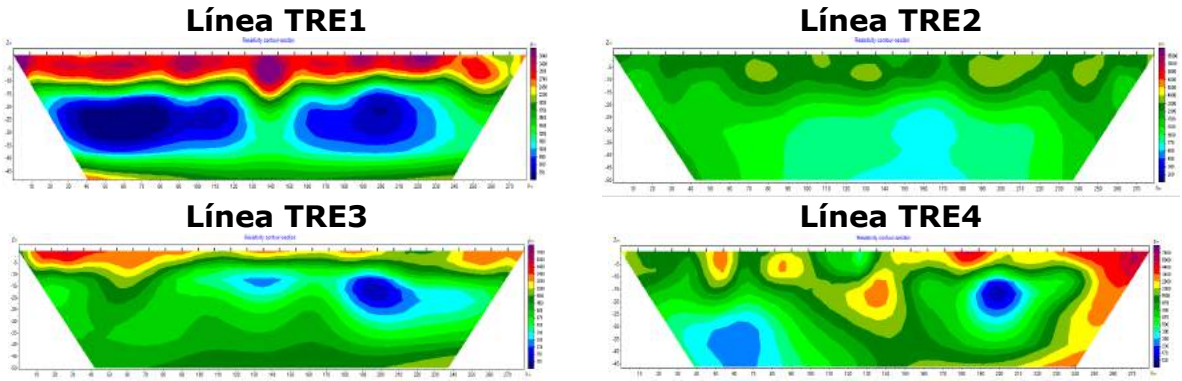
Refraction line 2





Source: Autors

Figure 8. Results obtained in Electrical Resistivity Tomography tests



Source: Autors

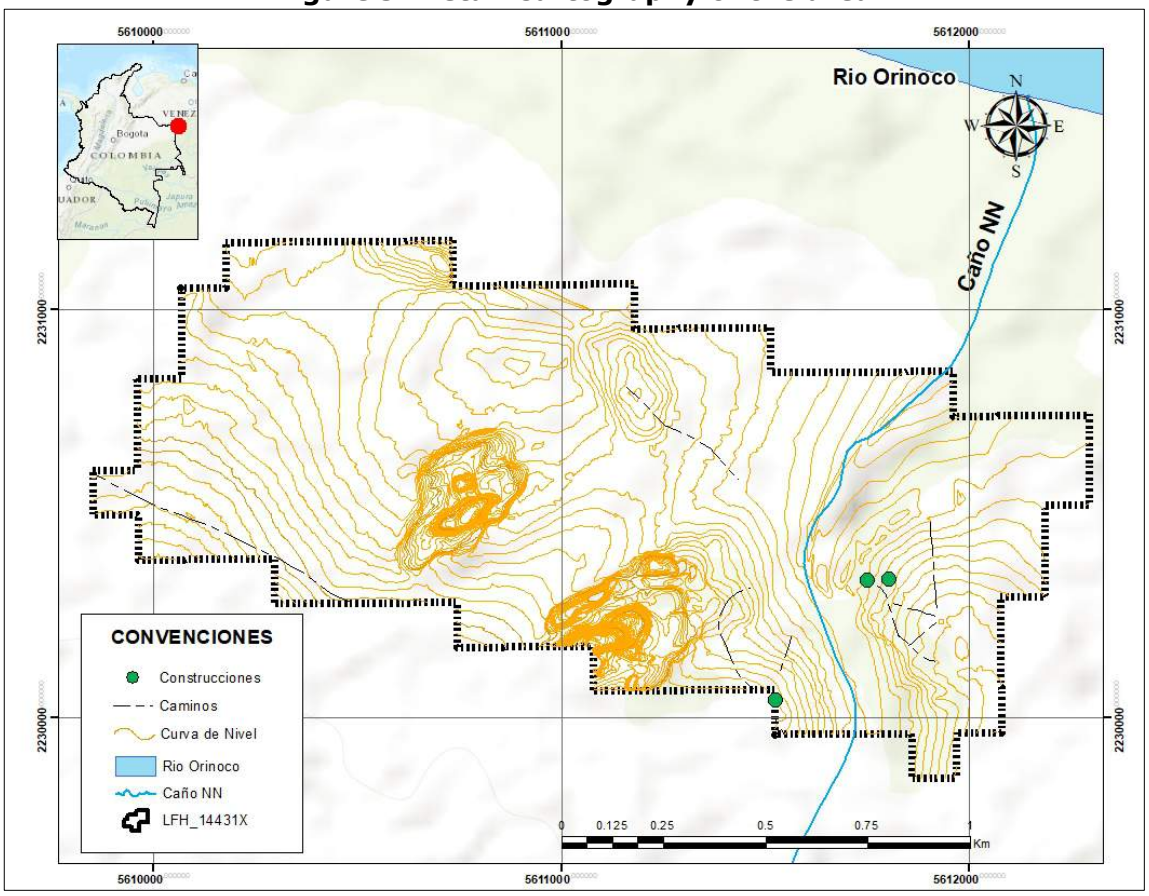
3.1.5 Identification of potencial areas for explotation

Once the samplings, geophysical tests and laboratory results had been obtained, the identification of the potential areas of exploitation in the area began. Thus, based on the characteristics of the mining title, it was possible to identify the presence of minerals such as tin, tantalum, and concentrates in various proportions, distributed throughout the polygon that comprises the title LFH-14431X, so that in the Following chapters will show the delimitation of the exploitation area and the phases to follow for this process.

3.1 DETAILED TOPOGRAPHY AND CARTOGRAPHY OF THE AREA

The base cartography presented in the project area is detailed below, where for the mining title there are detailed contour curves, separated every 10 meters, with a minimum height of 10 meters above sea level and a maximum height of 48 meters above sea level. In the same way, there is the channel of the Caño NN, which crosses the polygon in the SW-NE direction, the location of 3 buildings corresponding to camps (2) and houses (1), and finally, there is the location of roads that have been generated within the title for the staff pass.

Figure 9. Detail Cartography of the area



Source: Autors

3.2 DELIMITATION AND CHARACTERISTICS OF THE AREA OF EXPLOTATION

The exploitation area was defined based on the geological, hydrogeological, geomorphological, hydraulic and coverage of the land's characteristics of the

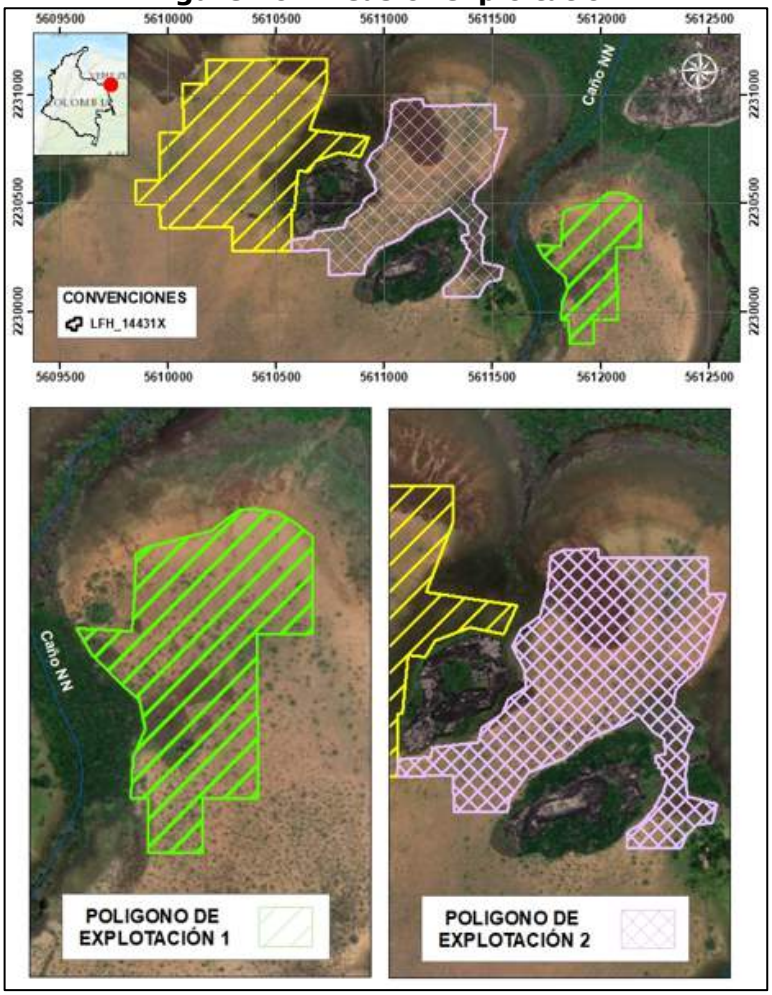
area of interest. For this delimitation, the team initially started from the flood line that is generated by the Orinoco River in winter, which intervenes in approximately 19% of the area of the mining title. Once the flood limits of the river had been established and, in the same way, of the water current that flows along the polygon, the results of field work were verified, where it was projected that the objective areas for exploitation correspond to those that are made up of deposits of materials that expose areas of low slopes, for which the areas of the hills or inselbergs were excluded from said delimitation. Similarly, the delimitation had as reference the gallery and riparian vegetation that is located in the surroundings of the inselbergs, the NN channel and the Orinoco river flood zone. Finally, the last item to take into account for the delimitation of the exploitation areas corresponded to the water table that was evidenced in the area during the apiques and trenches carried out, as well as from the results of the electrical resistivity tomography. Therefore, the mining title was divided into 3 polygons, corresponding to the exploitation polygon 1 and 2, and a last exploration and exploitation polygon 3.

The exploitation of polygons 1 and 2 correspond to the areas where the greatest exploration and collection of information was carried out from trenches and apiques, therefore, they correspond to the areas projected as the beginning of the project's exploitation. As will be described in this document, the exploitation method used will correspond to the discovered exploitation method, which will allow the extraction of the materials that are located in the surroundings of the inselbergs. These materials correspond mainly to gravelly materials with a high iron content, gravelly sands, silty sands, and some silty-clayey lenses, which generally contain the minerals that are the object of the project. The explotation polygon 1 covers a total of 18 hectares, and the explotation polygon 2 covers a total of 40.15 hectares.

During the rainy season, these areas have a water table located at an average depth of 6 meters, and it is estimated that in dry times the water table is located at a depth greater than 10 meters, therefore, it is projected to work at depths less than 10 meters during winter times, in order to avoid the water table. In the same way, as will be discussed in the chapter on the Closure and Abandonment Plan, the restructuring of the land will be carried out in parallel with the exploitation, so that once the material has been extracted and the benefit that will be developed in the area has been made, the remaining they

will be deposited back into the exploited areas, so that during the winter and with the increase in the water table, there will be no effect on its characteristics.

Figure 10. Areas of exploitation



Source: Autors

The coordinates of each of the vertices associated with the exploitation polygons are shown below.

Tabla 2. Coordinates of the vertices for the exploitation polygon 1

VERTEX	EST	NORTH	POLIG_EXPL	VERTEX	EST	NORTH	POLIG_EXPL
67	5611858	2229851	Phase 1	76	5611979	2230506	Phase 1
68	5611969	2229852	Phase 1	77	5611826	2230458	Phase 1
69	5611968	2229963	Phase 1	78	5611820	2230302	Phase 1
70	5612079	2229964	Phase 1	79	5611708	2230306	Phase 1
71	5612076	2230297	Phase 1	80	5611740	2230251	Phase 1

VERTEX	EST	NORTH	POLIG_EXPL	VERTEX	EST	NORTH	POLIG_EXPL
72	5612187	2230298	Phase 1	81	5611838	2230161	Phase 1
73	5612185	2230496	Phase 1	82	5611850	2230103	Phase 1
74	5612116	2230545	Phase 1	83	5611821	2229962	Phase 1
75	5612036	2230550	Phase 1	84	5611857	2229962	Phase 1

Source: Authors

Tabla 3. Coordinates of the vertices for the exploitation of the polygon # 2

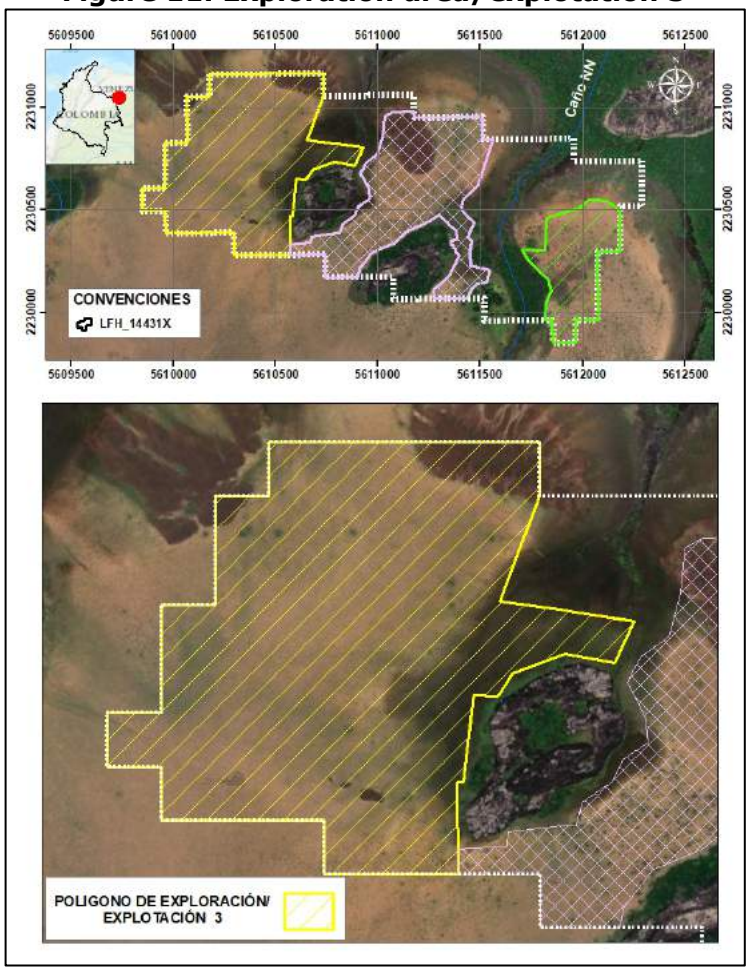
VERTEX	EST	NORTH	POLIG_EXPL	VERTEX	EST	NORTH	POLIG_EXPL
8	5610742	2230284	Phase 2	30	5611474	2230441	Phase 2
9	5610743	2230173	Phase 2	31	5611410	2230503	Phase 2
10	5610908	2230174	Phase 2	32	5611420	2230554	Phase 2
11	5610914	2230216	Phase 2	33	5611493	2230621	Phase 2
12	5610973	2230295	Phase 2	34	5611569	2230847	Phase 2
13	5611080	2230341	Phase 2	35	5611514	2230847	Phase 2
14	5611146	2230397	Phase 2	36	5611513	2230958	Phase 2
15	5611302	2230479	Phase 2	37	5611180	2230954	Phase 2
16	5611386	2230402	Phase 2	38	5611180	2230983	Phase 2
17	5611389	2230356	Phase 2	39	5611069	2230978	Phase 2
18	5611360	2230331	Phase 2	40	5611034	2230957	Phase 2
19	5611395	2230269	Phase 2	41	5611002	2230775	Phase 2
20	5611356	2230188	Phase 2	42	5610945	2230734	Phase 2
21	5611314	2230142	Phase 2	43	5610919	2230681	Phase 2
22	5611274	2230114	Phase 2	44	5610961	2230557	Phase 2
23	5611274	2230067	Phase 2	45	5610909	2230522	Phase 2
24	5611438	2230069	Phase 2	46	5610889	2230475	Phase 2
25	5611459	2230114	Phase 2	47	5610826	2230433	Phase 2
26	5611535	2230147	Phase 2	48	5610817	2230387	Phase 2
27	5611563	2230199	Phase 2	49	5610675	2230369	Phase 2
28	5611458	2230229	Phase 2	50	5610674	2230341	Phase 2
29	5611459	2230349	Phase 2	51	5610572	2230334	Phase 2

Source: Autors

As for the third polygon, this area corresponds to 55.6 hectares and presents a much lower degree of exploration, which consisted of carrying out some apiques and electrical resistivity tomography lines, in conjunction with seismic refraction tests. That said, during the exploitation works in polygons 1 and 2, day of exploration will be carried out in this area, so it is estimated that once the first two polygons are exploited, the work in the third zone will be carried out. From the tests carried out, it was possible to conclude that the area is composed in the first meter by sands of medium to fine size grains, and superficially, close to

the inselbergs you can see the gravel material with a high iron content that is observed in polygons 1 and 2. As for this area, the water table is located at much shallower depths, reaching a depth of between 1.5 to 2 meters, which is why, once the exploration phase contemplated for this area has been completed and exploitation has begun, the latter will be carried out in summer, avoiding damage to the water table, as will be handled in the other two areas.

Figure 11. Exploration area/explotation 3



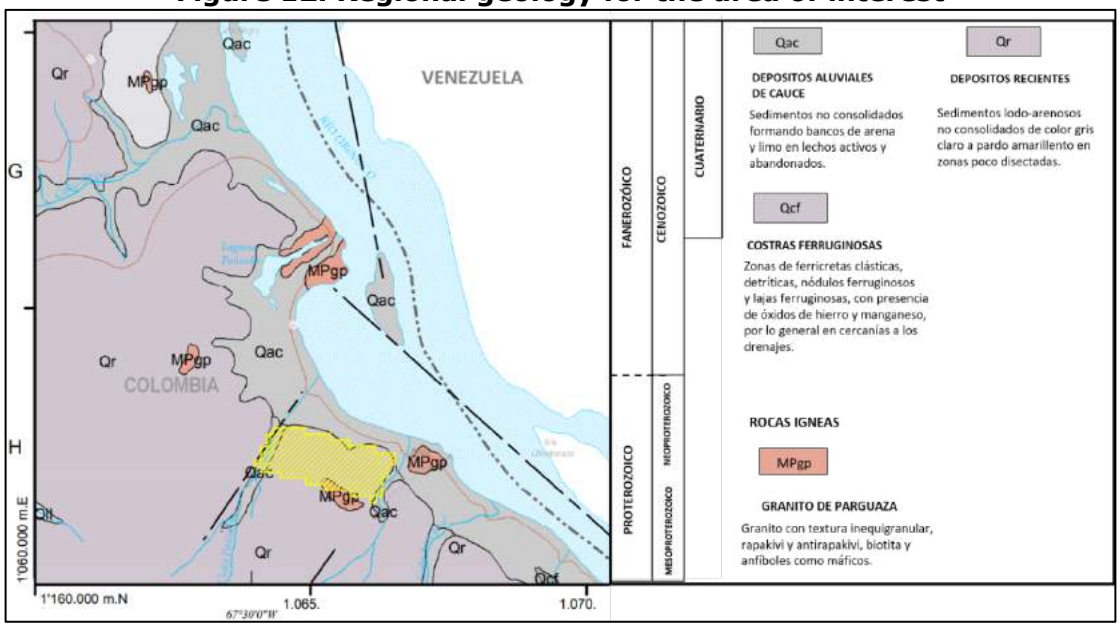
Source: Autors

4. GEOLOGICAL CHARACTERIZATION OF THE AREA

The geological characterization of the area includes all the information related to the rocks and structures present in the area, which are part of the oldest terrain of the Colombian territory, made up of rocks of Pre-Cambrian age, belonging to the Amazon Craton located NE of South America, and specifically, to the Guiana Shield. Likewise, this characterization focuses on local information, which describes what is related to the areas of interest for exploitation, the geology of the deposit, the physical and chemical characteristics of the minerals to be exploited, the characteristics of location and calculation of reserves.

4.1 REGIONAL GEOLOGY

Figure 12. Regional geology for the area of interest



Source: Colombian Geological Survey, 2009

4.1.1. Stratigraphy

The area of interest is located on plate 162Bis of the Colombian Geological Service, where it describes an area made up of Precambrian rocks, together with deposits of recent materials. These rocks make up what is known as the Guyanas Shield, while the recent deposits are made up of materials that have been transported by the Orinoco River, by the different channels present in the area and by wind action.

The litho-stratigraphic units present are described below.

4.1.1.1 Granito de Parguaza (MPgp)

This unit is made up of volcanic and intrusive granitic igneous rocks with a high content of potassium feldspar such as granodiorites, monzogranites and their varieties (Pinto Y González, 1989 in SGC, 2009). The Parguaza granite is found outcropping along the western bank of the Orinoco River and forms isolated domes with steep slopes, known as island hills or "Inselbergs". Texturally, the rocks are classified as the term Rapakivi, described as rounded phenocrysts, composed of potassium feldspar, surrounded by sodium feldspars (SGC, 2009).

The outcropping rocks of the Parguaza granite present associations of fine to medium-grained granite dikes, phaneritic, composed of quartz, feldspar and mafic to a lesser extent, reaching up to 2 meters wide. Similarly, there are areas with pegmatite quartz-feldspathic dikes and quartz dikes, as well as small irregular bodies defined as enclaves..

Photograph 2. Parguaza granite cut by quartz veins and with Rapakivi texture

Fuente: Autores

4.1.1.2 Ferruginous Crusts (Qcf)

This unit corresponds to quaternary age sediments, deposited in an undulating peneplain shape, which are found near dendritic to subdendritic drainage

networks and in some sectors in the lower parts of the areas where the Parguaza Granite is located. These deposits correspond to masses with high concentrations of iron (limonite, hematite and goethite type), welded, very hard, with granular porous texture (SGC, 2009).

Photo 3. Ferruginous crusts

Fuente: Autores

In the area of interest, the ferruginous crusts are located around the hills formed by the Parguaza granite, and are sectorally covered by recent sandy deposits.

4.1.1.3 Recent Deposits (Qr)

As their name suggests, these deposits are of very recent ages and cover a large part of the area of interest. According to the SGC, the unit is made up of muddy-sandy sediments of undetermined thickness and age; They correspond to deposits from continental fluvial environments, covering the tertiary deposits and the Precambrian rocks present. Due to its characteristics, this unit is mostly covered by pastures and in some other areas, by wind sands (SGC, 2009).

For the area of interest, these recent deposits appear as orange-yellowish colored sands, made up of quartz grains, of fine to medium size, rounded, slightly damp due to the presence of the water table, without considerable plasticity to the touch. The thickness of these materials is estimated at a total of 2 meters for the central and western zone of the area, and a thickness of approximately 1 meter for the eastern zone.

Photograph 4. Sands that make up the recent deposits in the area

Fuente: Autores

4.1.1.4 Riverbed Alluvial Deposits (Qac)

This unit is made up of unconsolidated sediments, which have been deposited by the channels of the Meta, Orinoco, Dagua and Bita Rivers, with the Orinoco River deposits being the most important, leaving sandbanks located in the active beds, on the banks of rivers and locally terraces. The composition of these materials varies according to the dynamics of each one of the channels, being mainly siliceous sand of very fine grain, of good selection, rounded, with a low content of silty material (SGC, 2009). According to the distribution of these materials in the area, this unit is not located within the project area.

4.1.2. Structural Geology

Structural geology describes the analysis performed on geological structures that may exist in the area, such as lineaments, faults, and folds.

According to the tectonic configuration of the Colombian territory, and specifically the nature of the Guiana Shield, in the area there are different local

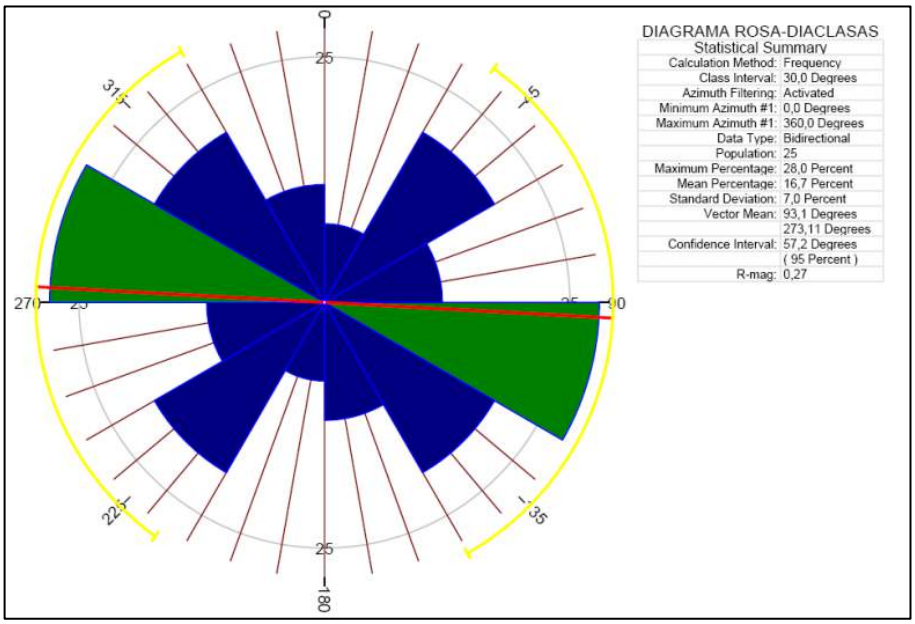
faults that according to different authors such as Galvis et. al (1979), de Boorder (1980) and Bruneton et. al (1983) in SGC (2009), which are abruptly modifying the Orinoco River channel.

The geostructural characterization of the area has been based mainly on the analysis of satellite images and aerial photographs, where, above all, guidelines have been observed, based on changes in drainage channels and their orientation.

In this way, the SGC identified 3 groups of main fractures present in the granite bodies of the area, which are characterized by presenting a main trend of joints in the E-W, NE-SW and NW-SE direction.

Next, the preferences of the joints identified in the area of interest and its surroundings are summarized in a rose diagram, according to the information collected by the professionals of the SGC.

Figura 12. Rose diagram showing the main preference for cleats in and around the area of interest



Source: Colombian GeologicalSurvey, 2009

4.2 GEOLOGY OF THE DEPOSIT

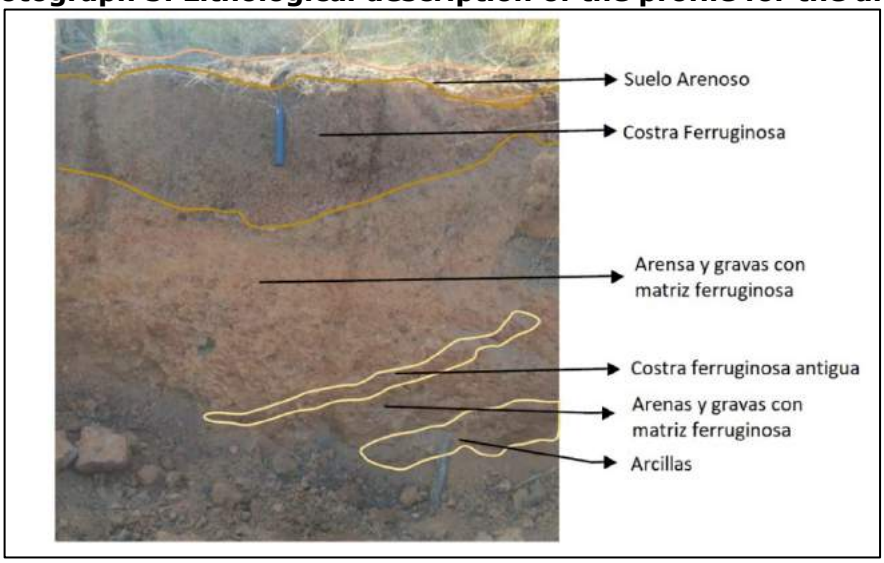
The unit of interest for exploitation is represented by a succession of recent sediments that are discordantly overlying the igneous basement of the area, formed mainly by the rocks of the Parguaza Granite. According to the results obtained during samplings in the area, the mineralization of interest appears

above all in the recent sediments in deposits of the alluvial and eluvial pleasure type, located around the igneous bodies, which it is inferred may be the origin of the mineralization. In order to know the distribution of the deposit and its thickness, apiques and trenches were made where the lithology of the sediments was established, and samples of these deposits were also obtained to be analyzed in the laboratory, as described in the chapter 4.2.3

4.2.1. Lithological characterization of the deposit

For the lithological characterization of the deposit, a total of 18 apiques with depths between 1.6 and 2.2 meters were developed. Once the apiques were made, the lithological profiles were described, and in general it could be observed that the first centimeters are composed of sandy soil, followed by a layer of what is known as ferruginous crusts (approximately 40 cm); then there is a layer of approximately 60 cm, which is made up of sandy and gravelly materials embedded in a ferruginous matrix; in this same layer at the bottom you could evidence the presence of some areas with ferruginous crusts and smaller areas with clayey lenses.

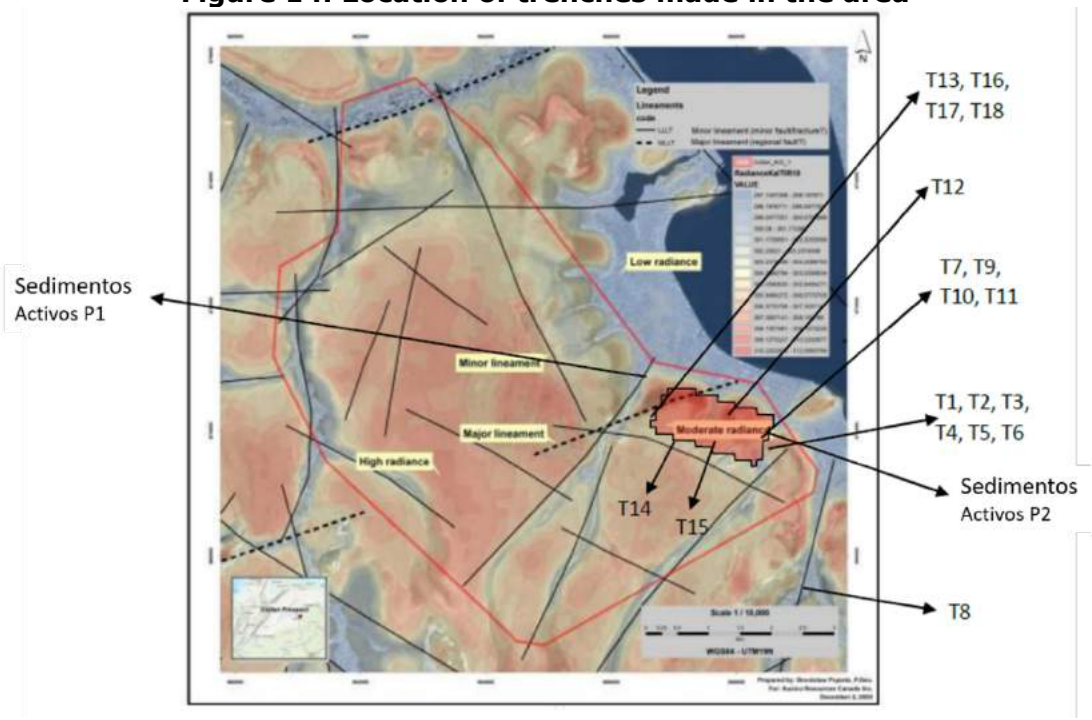
Photograph 5. Lithological description of the profile for the area



Fuente: Autores

Next, the location of each of the trenches made and a photographic record of some of them are listed.

Figure 14. Location of trenches made in the area



Fuente: Autores

Photograph 6. Trenches made in the area




Source: Autors

Table 4. Location and sampling of sediments in trenches

SAMPLING OF THE TRENCHES AND APIQUES MADE IN THE AREA OF LFH-14431X				
TRENCH ID	**SAMPLE ID**	**COORDINATES**		**DEPTH (m)**
		EAST	**NORTH**	
T1	CCET01R	5611903	2230167	1.6
T2	CCET02R	5611912	2230168	1.7
T3	CCET03R	5611917	2230149	1.8
T4	CCET04R	5611878	2230170	2

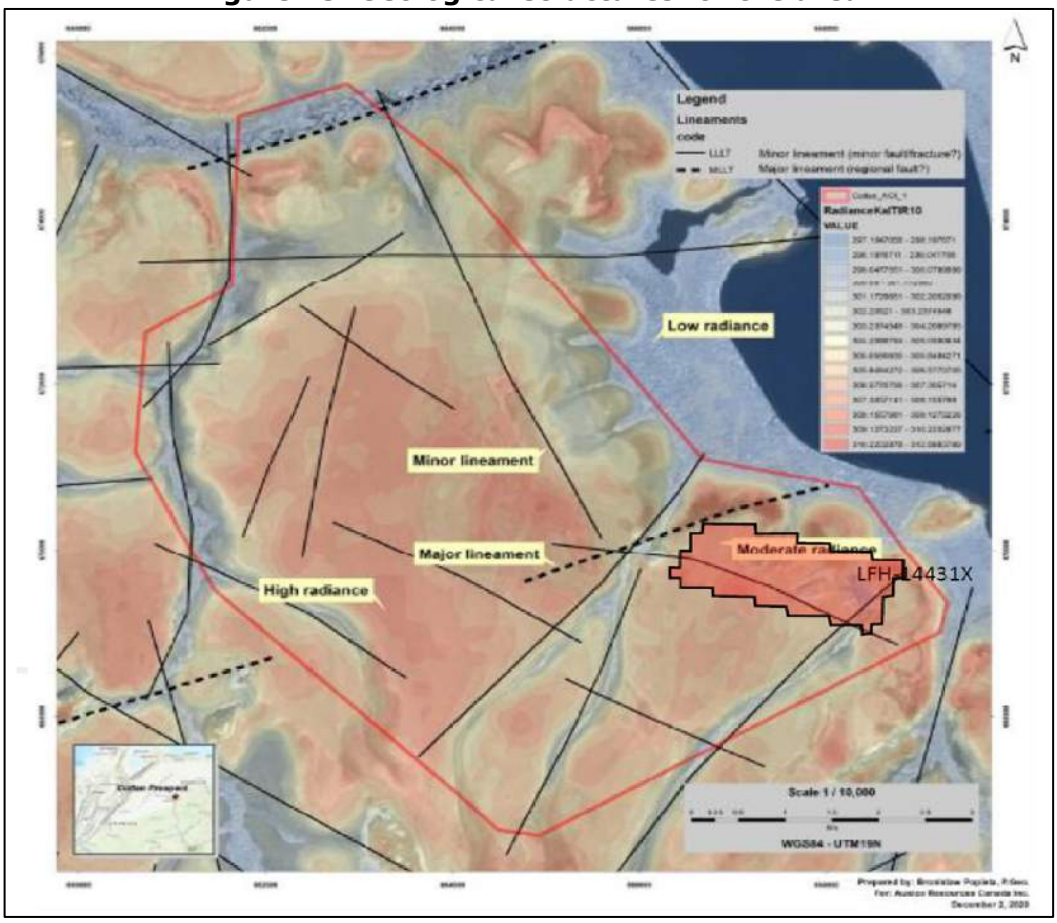
SAMPLING OF THE TRENCHES AND APIQUES MADE IN THE AREA OF LFH-14431X				
TRENCH ID	**SAMPLE ID**	**COORDINATES**		**DEPTH (m)**
		EAST	**NORTH**	
T5	CCET05R	5611837	2230168	2
T6	CCET06R	5611832	2230202	2.1
T7	CCET07R	5611514	2230415	0.3
T8	CCET08R	5604680	2230298	0.25
T9	CCET09R	5611559	2230496	2
T10	CCET010R	5611598	2230566	2
T11	CCET011R	5611638	2230638	2
T12	CCET012R	5611168	2230821	6
T13	CCET013R	5609575	2230503	2
T14	CCET014R	5610156	2230349	2.1
T15	CCET015R	5610830	2230199	2.2
P1	CCEB01	5609810	2231693	Active sediments
P2	CCEB02	5611880	2230769	Active sediments
T16	CCET016R	5609617	2230908	2
T17	CCET017R	5609773	2231014	2
T18	CCET018R	5609912	2231120	2

Source: Autors

4.2.2. Structural Geology of the Deposit

The structural geology of the area was based mainly on the analysis of satellite images, taking into account that in the area there are very few areas where there are rocky outcrops to be able to show data on fractures, folds, geological faults, among others. Based on the analysis carried out, a variety of lineaments could be identified, which were defined by changes in the direction of drainage, the alignment of the igneous bodies and the contrast in radiation images. Therefore, four patterns were established that were verified in the field with vein and fracture data, which correspond to: N20E, N15W, N65E and N50W. Locally, in the area of polygon LFH-14431X, lineaments in direction N45E-N65E are recognized.

Figure 15. Geological structures for the area



Source: Autors

Similarly, for the area of the polygon, it was possible to take some data from fractures that were located on one of the hills formed by the Granite of Parguaza, as well as the direction of the quartz veins that cut this material was confirmed.

Tabla 4. Fracture data in the Parguaza Granite

FRACTURE	DATA
1	180/84
2	182/81
3	12/32
4	10/35
5	178/69
6	177/75
7	315/42
8	308/31

Source: Autors

Quartz veins in the Parguaza Granite

Source: Autors

From the identified quartz veins it can be established that in general they have a SW-NE orientation, going from orientations of 245 ° to 260 °, and with thicknesses of between 2 and 10 centimeters.

4.2.1 Physical and chemical characteristics of minerals

During the field phase, the sampling of apiques and strips was carried out, analyzing the materials in a macroscopic way where the presence of granite samples, pegmatites, quartz veins and some iron crusts could be evidenced; Once this analysis was carried out, the laboratory work was carried out, with the aim of knowing the percentages of minerals and elements in each of the samples.

Photograph 7. Samples analyzed in the area

Fuente: Autores

The laboratory tests were carried out using XRF (X-ray Fluorescence) analysis, which is a non-destructive analytical technique used to determine the composition of elements in a mineral. The results of 10 specimens analyzed are summarized below:

Table 6. Results of samplings in the exploitation area

SAMPLE	TiO2	Nb2O5	Fe2O3	Ta2O5	SiO2	SnO2
Auxico 1	42.85%	25.44%	13.32%	8.28%	3.30%	0.58%
Auxico 4	0.83%	53 PPM	8.82%	-	63.49%	-
Auxico 5	0.48%	40 PPM	47.56%	-	45.50%	-
Auxico 8	0.64%	0.26%	83.80%	0.21%	6.71%	4.29%
Auxico 11	2.78%	0.81%	17.60%	0.66%	39.72%	1.49%
Auxico 13	0.27%	0.03%	68.02%	0.04%	27.04%	0.13%
Auxico 16	0.12%	-	0.90%	-	94%	-
Auxico 18	0.07%	0.33%	5.62%	0.33%	5.85%	0.57%
Auxico 21	0.03%	18 PPM	0.09%	-	99.30%	-
Auxico 23	18.91%	3.24%	9.71%	9.29%	6.71%	47.20%

Source: Autors

The XRF analysis indicates that the minerals of interest are in the form of oxides obtained through gravel samples. As will be explained later, the recovery of these minerals will not take place at the mine. The benefit in situ will only be the classification and washing of the gravelly sand material, in order to release these gravels, referred to in the document as "Concentrates".

Taking into account the chemical analyzes carried out on a sample of 500 grams of concentrate, a stoichiometric analysis is carried out to find the molecular

weight of the mineral (element) within the compound (mineral oxide). That said, the relationship between the concentrate and the mineral is as follows:

-500 gr of gravel (concentrate): 14.22 gr of Ta
-500 gr of gravel (concentrate): 14.67 gr of Sn
-500 gr of gravel (concentrate): 11.29 gr of Nb
-500 gr of gravel (concentrate): 0.33 gr of V
-500 gr of gravel (concentrate): 2.35 gr of Zr

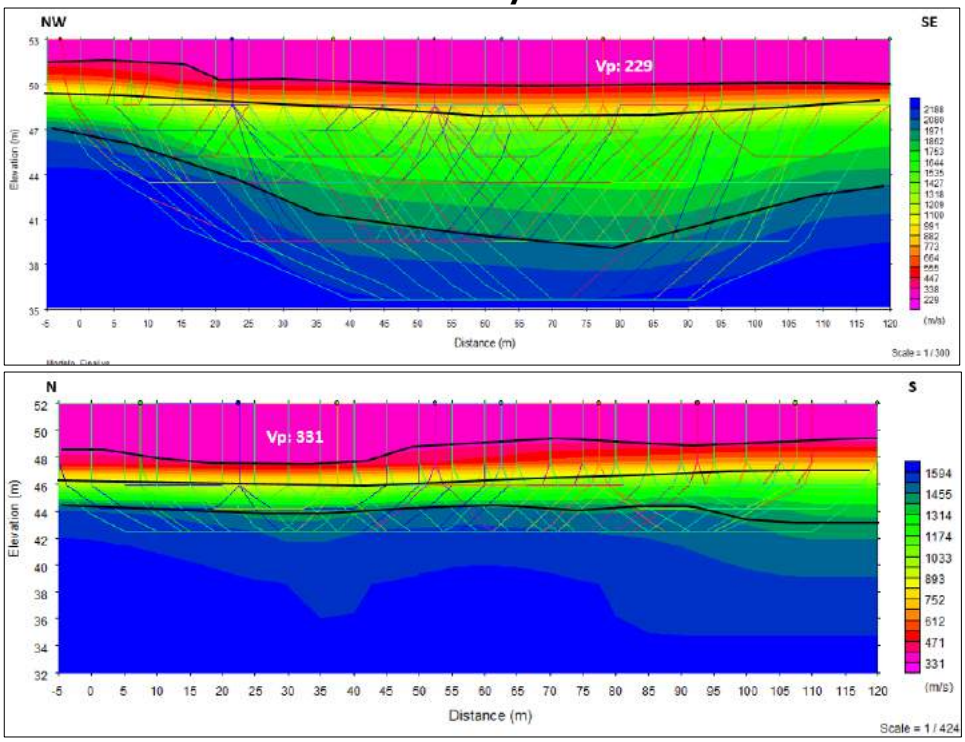
4.3 AREAS TO BE EXPLOITED AND VOLUMES TO EXTRACT

As mentioned in chapter 2, the title area will be divided into 3 phases to carry out the exploitation sequentially, taking into account the characteristics of each area and its degree of exploration. Dividing the polygon into 3 phase is the best alternative in terms of costs, efficiency and mainly, in terms of the environmental care that is proposed for the area. This is how during each of the phases the exploitation of the material of interest will be carried out and the remaining materials will be deposited in the previously exploited areas, giving way to the reconformation, restoration and reforestation of the land and the processes that are part of the closure plan and abandonment, avoiding environmental impacts in the area and protecting in the same way the phreatic levels that increase during the winter seasons. Therefore, each of the phases to be developed are described below:

4.3.1 Phase No. 1

This phase includes the beginning of the exploitation works, which will be developed along the area that comprises the east side of the Caño NN that crosses the mining title (Figure 10). The mentioned area covers a total of 18 hectares, which will be worked with the two-bank exploitation method, taking into account the depths at which the materials of interest are being found. According to the analysis of the results obtained in the exploration phase, the area generally presents a first layer that comprises sterile material, with a thickness of approximately 5 meters, which is related to deposits of quartz sand and gravelly sand, with a wave velocity p, which varies between 229 and 331 m / sec. In this first layer the resistivities of the materials are very high, reaching values of up to 4000 ohm / m, which makes them sterile.

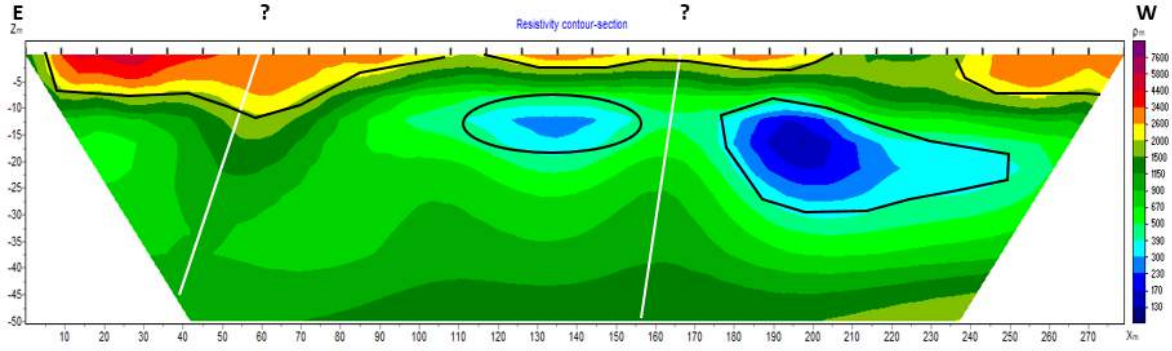
Figure 16. Seismic refraction results, showing the velocities and depths of the first layer

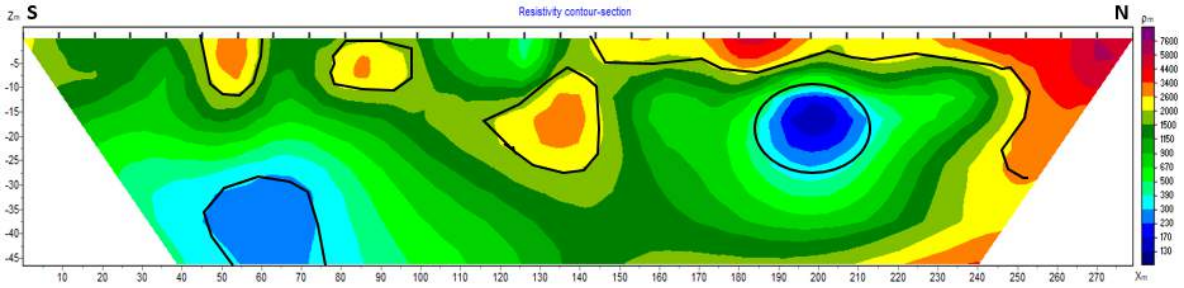


Source: Autors

Once the sterile material has been removed, the areas where the minerals of interest are estimated to be found are then located, which, according to the apiques and trenches developed for the area, can reach thicknesses of up to 5 meters, with wave velocities p between 1583 and 1595 m / s (See the distribution of the lines in Figure 6).

Figure 17. Electrical resistivity tomographies for phase No.1





Source: Autors

In the same way, according to the different apiques and trenches that have been made, after the sterile materials, silty sands of reddish tones are located in depth, lenses of silty materials of grayish colors, and sands with gravel, which correspond to the materials of interest.

Regarding the phreatic levels, in the vicinity of Caño NN and towards the north of the polygon, resistivities were found that indicate wet materials at a depth of approximately 10 meters, while, in the most distant areas, these materials are between 20 and 30 meters deep. Thus, taking into account these hydrogeological characteristics, excavations at depths greater than 8 meters will be carried out in summer, which will allow maintaining the characteristics of the water table without causing any type of environmental impact.

It is important to highlight that according to the closure and abandonment plan, in parallel with the excavations, the restructuring of the land will be developed, transporting the sterile materials and depositing them again in the worked area, mitigating any environmental impact, as well as starting the restoration and reforestation processes in the area.

In this way, below, the thicknesses of stripping, sterile and interest materials for phase No1 are summarized:

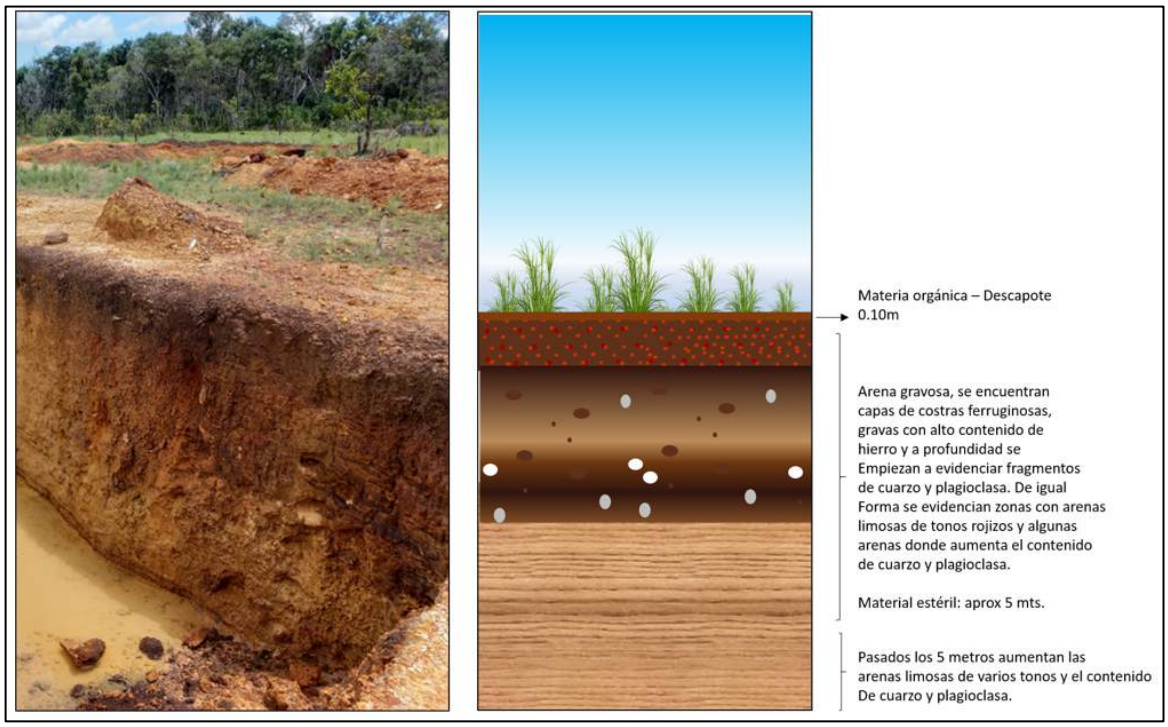
Table 7. Summary of generalized thicknesses for extraction phase No1.

PHASE OF EXTRACTION No1	ZONE 1
STRIPPING	0.10 m
STERILE	Aprox 5 m
MATERIAL OF INTEREST	5-10 m

Source: Autors

A generalized profile for extraction phase No1 is shown below:

Figure 18. Generalized profile for extraction phase No1.

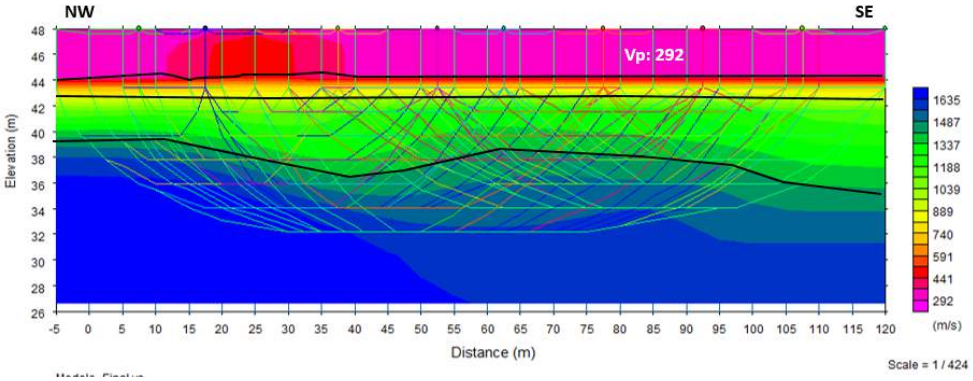


Source: Autors

4.2.2 Phase No. 2

Phase 2 will be developed in the central zone of the polygon, which occupies a total of 40.15 hectares (see Figure 10), which is comprised mainly of two zones. The first area corresponds to a geoform defined as a top which contains an average height of 18 meters above sea level, together with the lower areas that are distributed to the southeast of the polygon, in whose area samples have been carried out that yielded a content of 56% oxides interest. According to the field analysis, the area presents in its first meters a layer with wave velocities p of approximately 292 m / s and an average thickness of 3 to 5 meters, in which the materials of interest are projected to reside. This information could be compared with the materials and the description of profiles obtained in the apiques and trenches that have been made.

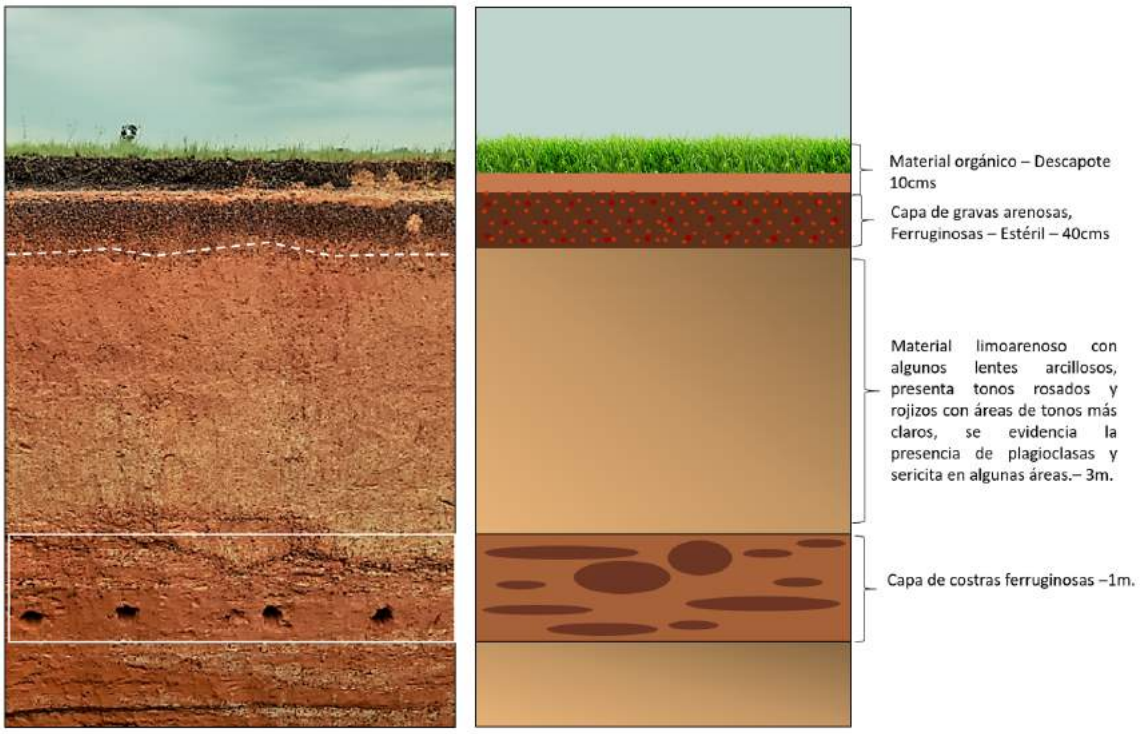
Figure 19. Seismic refraction result showing the thickness of the first layer in the area.



Source: Autors

Below is a generalized stratigraphic profile for the area:

Figure 20. Soil profile observed in trenches north of the phase 2 area



Source: Autors

In this same area, near the hills or inselbergs, it is estimated that the material of interest is located in a shallower way, having as a guide some apiques with depths no greater than 5 meters, where fragments of the Granite of Parguaza

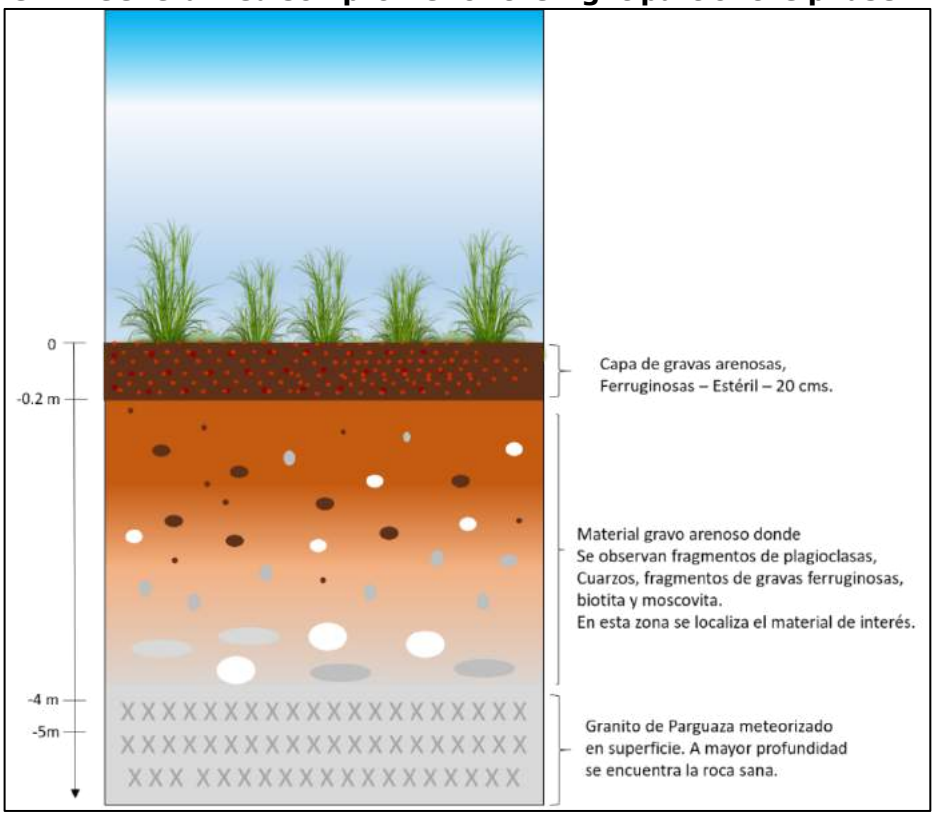
are obtained from 4 meters deep, so it is estimated that the overlying areas contain the volumes of the project's focus material.

Photograph 8. Apiques and samples obtained in the area that comprises the exploitation phase 2.

Source: Autors

For the areas of exploitation near the Caño NN that crosses the polygon, the phreatic levels present average depths of 5 to 6 meters in winter times, so it is planned to carry out extractions during summer times.

Figure 21. Generalized soil profile for the right part of the phase 2 area

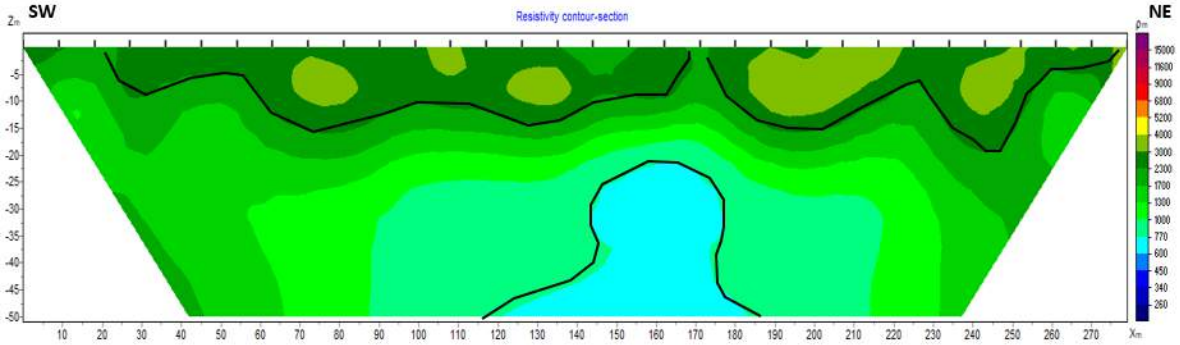


Source: Autors

For its part, the second zone within this phase is located towards the southwest, and according to the tests carried out, there is a much wider thickness of sterile materials (which vary in depth between 0 and 5 meters), followed by the material of interest. For this area, it is planned to carry out an exploitation by the banking method, using two banks, which will allow reaching greater depths to achieve the corresponding extraction.

Regarding environmental characteristics, in this area the most humid materials produced by groundwater levels are located at approximately 20 meters, as shown in Figure 22, which allows working in the area without causing any damage to them.

Figure 22. Electrical resistivity tomography 2, where the increase in conductive materials is observed at a greater depth.



Source: Autors

Finally, and as established in the closure and abandonment plan, in parallel with the excavations the land will be reformed, depositing the sterile materials again in the area from which they were extracted, while immediately starting the restoration plan and reforestation.

In this way, the thickness of the stripping, sterile and interest materials for phase No2 are summarized below:

Table 8. Summary of generalized thicknesses for extraction phase 2

Extraction Phase No2	ZONE 1	ZONE 2
STRIPPING	Aprox 0.40 m	
STERILE	0-1m	0-5m
MATERIAL OF INTEREST	1-5 m	5-10m

Source: Autors

4.2.1 Phase No. 3

This phase will be developed in exploitation zone 3, which is located to the west of the mining title, and comprises a total of 55.6 hectares (see Figure 11). In this area, exploration programs will be carried out in conjunction with exploitation phases 1 and 2, allowing for a greater degree of knowledge of the area, prior to the development of exploitation of the area.

During the analyzes that were carried out in the field, it was evident that in winter times (March - August) the water table is located at an average depth of 2 meters, which corresponds to a measurement parameter for the subsequent analyzes that will be carried out during the summer times.

Therefore, in order to protect groundwater levels and reduce environmental impacts, it is estimated that the extraction of materials will be carried out during

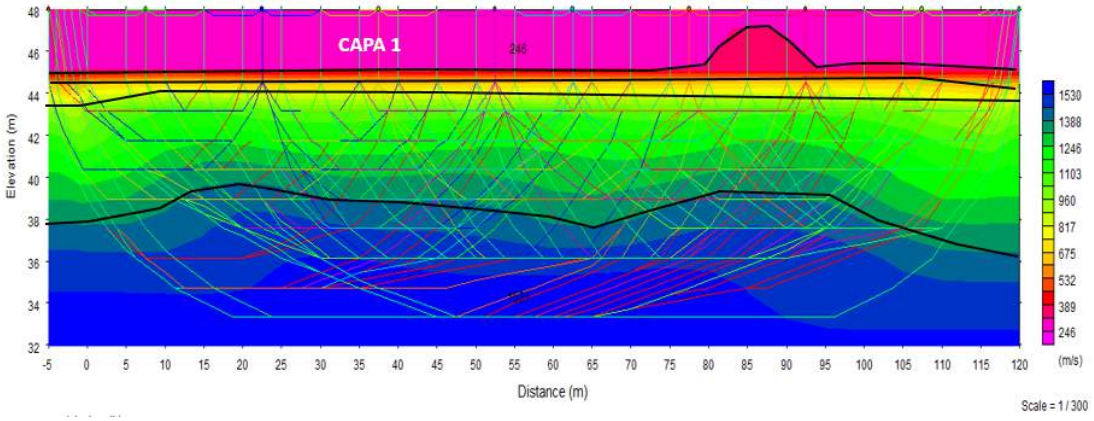
summer seasons, and in parallel, the restructuring works of the area are carried out (in accordance with the proposed exploitation method).

Photograph 9. Sands obtained in trenches made in the area that comprises phase 3

Source: Autors

Regarding the materials found in the area, the results of field tests yielded a first layer of approximately 20 cm, which corresponds to the organic material present there; followed by materials approximately 2 meters thick, composed mostly of quartz and gravelly sands, with fragments of iron oxides and low content of silts, with a wave speed of 246 m / s, and electrical resistivities of between 2000 at 3800 ohm.m Figure 23 and Figure 24.

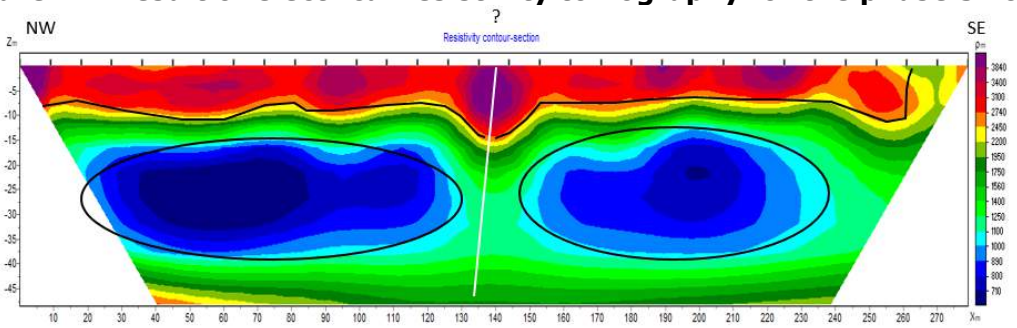
Figure 23. Results of the inverted refraction model



Source: Authors

Following these materials, there is evidence of an area with a lower resistivity range, which may be the result of phreatic levels, taking into account that wet materials are located at approximately 15 meters in depth.

Figure 24. Result of electrical resistivity tomography for the phase 3 zone



Source: Autors

Similarly, in the central part of the area that comprises this last phase, the electrical resistivity tomography and the results of the seismic refraction test yielded a kind of anomaly, which concentrates higher resistivity values and changes in wave velocity. , and at depth it resembles a division in the area, so a more in-depth analysis is planned in this area in order to identify the continuity of this anomaly, which may be an indicator of material changes, mineralizations or faults.

Therefore, it is estimated that the materials of interest in the area are located below 2-3 meters, reaching a depth of approximately 6 meters, this being where deposits of fine, silty material can be found, with a higher degree of conductivity

4.3 LOCATION AND CALCULATION OF RESERVES

4.3.1 Calculation of reserves

The analysis and calculation of reserves for a deposit is an important factor since it allows inferring or projecting the useful life of the exploitation and calculating the economic profits that depend on the demand and supply of the mineral to be extracted. According to international methodologies, depending on the knowledge of the deposit, reserves are classified as proven, probable and possible, or their equivalent terms: measured, indicated and inferred.

Now, reserves are those parts of the deposit that can be known in the entire extension of the exploitation area and generally work with a margin of error corresponding to 10%, unlike probable reserves that work with margins of error between 20 - 40% and that can be known in places of the same area. Likewise,

inferred reserves are defined as those known exclusively by the development of mining works, subsoil explorations or geological assumptions.

There are two methods in the literature to estimate the mineral reserves in a deposit, the classic or geometric methods based on profiles and distances, and the so-called geostatistical methods by specific programs. However, it must be kept in mind that this choice will depend on the geology of the deposit, the exploitation method, the availability and security of data, the purpose of the calculation and the degree of precision required. The calculation of reserves Will be developed through geometrical methods, the first one starting from the analysis of the surface and thickness of the deposit, and the second one from the profiles.

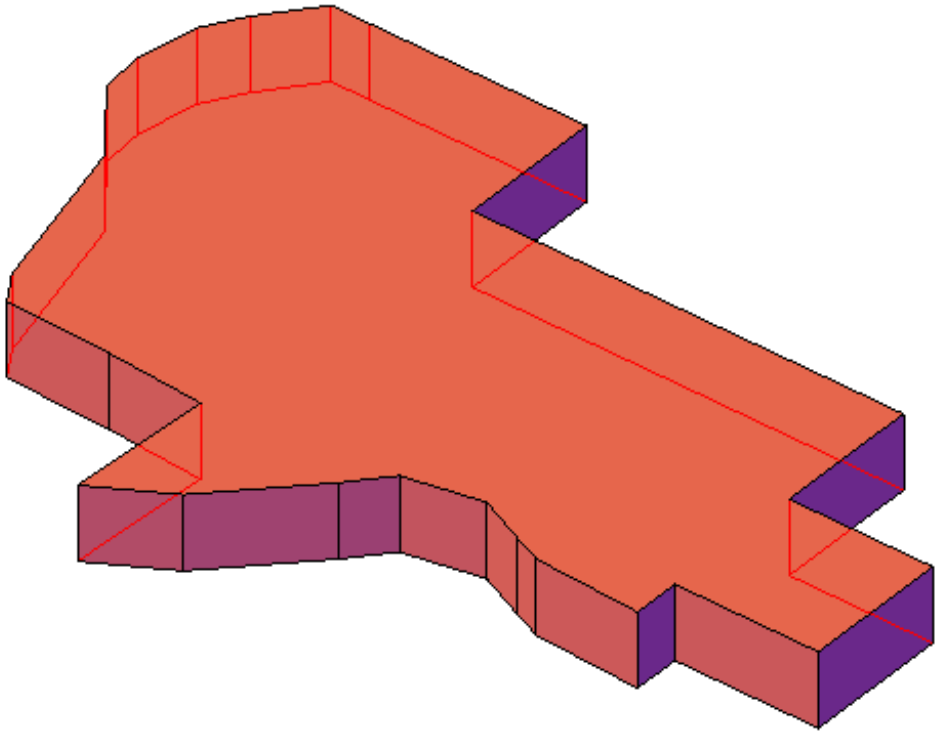
The volume of the possible material to be extracted (sandy-gravelly) is taken as a base for the calculation of the reserves using the arithmetic mean method, which consists of projecting the contour to a plane parallel in the direction of the steepest slope to the deposit. The Surface is defined by the projected contour and is calculated based on the area to be mined. For this project, 3 exploitation zones or polygons have been defined, which for each one will be associated with their respective surface and likewise, the average thickness of the deposit (E) will be defined. Now, these volumes correspond to the material that makes up the deposit in which the gravels of interest (concentrate) are found. For this reason and considering the volumetric relation between the common material and the concentrate (gravels) which indicates that for every 1000 t of material, 40 t of concentrate (4%) are obtained, we proceed to calculate the reserves affecting the volume by this relation.

Another way to estimate reserves is the profile method. This method consists of averaging the consecutive areas of material generated from each individual cut and multiplying it by the separation between profiles and, in turn, by the specific weight in tons of the extracted material.

4.4.1.1 Calculation of reserves for phase 1 of exploitation

For this polygon, the area or surface covers 18.04 Ha and the thickness of the deposit is approximately 5 meters (generalized). Now, the resulting polygon is an irregular geometric figure as shown in Figure 25. Please refer to Table 9 for the calculation of reserves.

Figure 25. Dimensions of the polygon associated with phase 1 of exploitation



Source: Authors

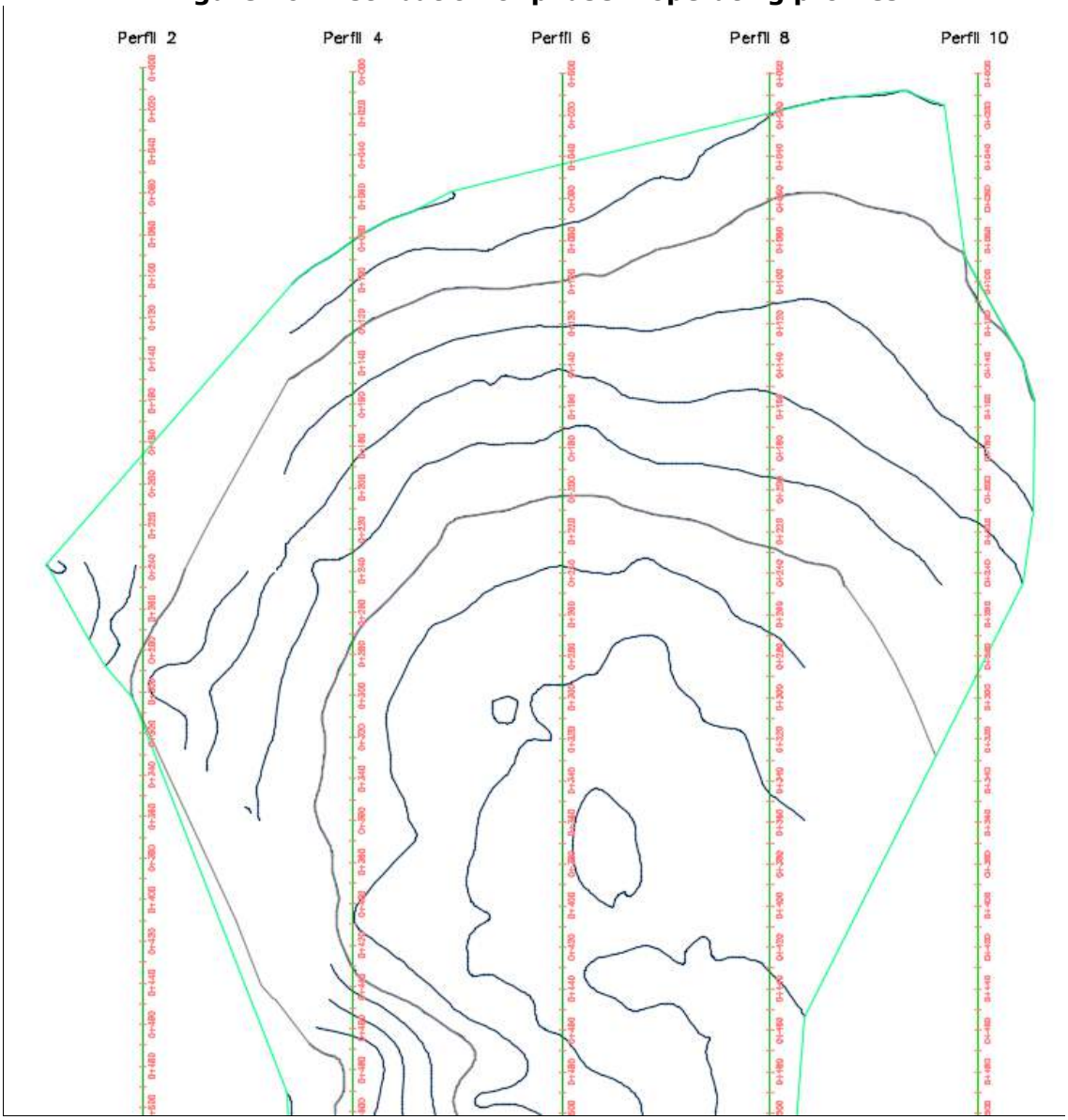
Table 9. calculation of reserves for the phase 1 polygon

Description	quantity	unit
Surface	18.04	Ha
Thickness	5.00	m3
Volume of material (inferred mineral resource)	902,236.54	m3
Ratio factor	4.00	%
Unit weight	1.82	Tn/m3
Concentrate volume (exploitable mineral resource)	**36,089.46**	**m3**
Concentrate volume (exploitable mineral resource)	**65,682.82**	**Tn**

Source: Authors

For the calculation of the profiles, 5 transverse lines were proposed to generate the profiles at soil depth. Each of these projected lines are separated every 100m and will allow the calculation of the afferent areas. The corresponding analyses are shown in Figure 26 and Table 10.

Figure 26. Distribution of phase 1 operating profiles



Source: Authors

Table 10. Calculation of reserves by the profile method for phase 1 of the operation

Profile	Section Area S (m2)	Average Area (m2)	Profile separation (m)	Volume by section (m3)	Specific weight	Volumen by section (Tn)
Profile 2	879.24	6,111.49	50.00	305,574.63	1.82	556,145.82
Profile 4	11,343.75	16,234.00	50.00	811,700.20	1.82	1,477,294.36

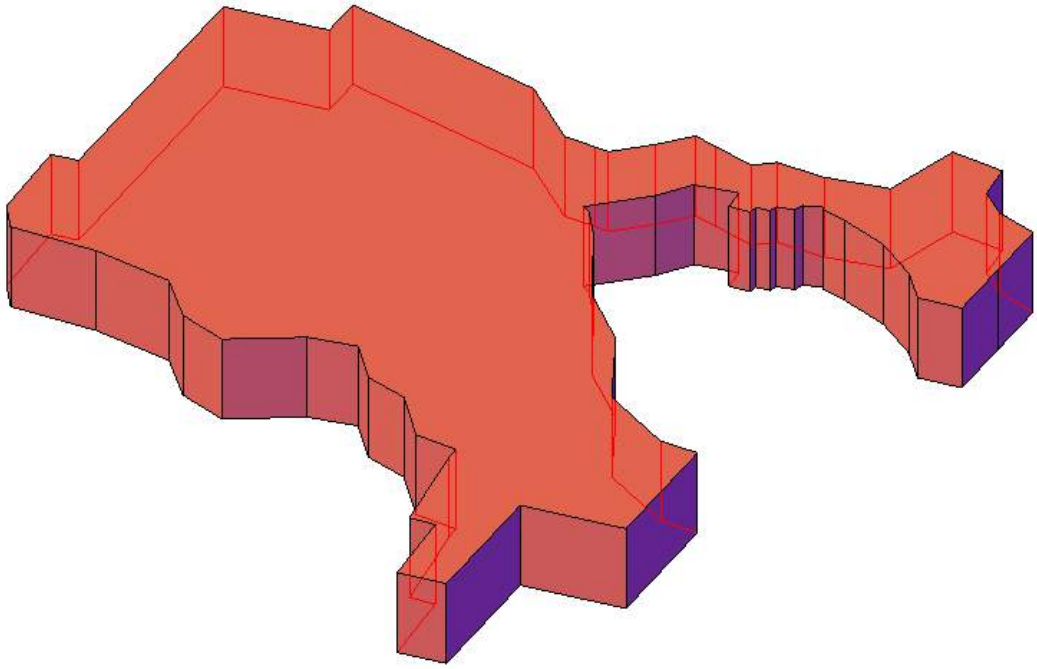
Profile 6	21,124.26	18,658.80	50.00	932,939.78	1.82	1,697,950.39
Profile 8	16,193.33	8,774.49	50.00	438,724.48	1.82	798,478.54
Profile 10	1,355.65	677.83	50.00	33,891.28	1.82	61,682.12
INFERRED MINERAL RESOURCES				**2,522,830.35**		**4,591,551.24**
PROBABLE MINERAL RESOURCES				**756,849.11**		**1,377,465.37**
MEASURABLE MINERAL RESOURCES				**30,273.96**		**55,098.61**

Source: Authors

4.3.1.1 Calculation of reserves for phase 2 exploitation

For this polygon, the area or surface covers 40.15 Ha and the thickness of the deposit is approximately 5 meters (generalized). Now, the resulting polygon is an irregular geometrical figure as shown in the **Figure 27.** Please see the calculation of reserves in **Table 11.**

Figure 27. Polygon dimensions associated with phase 2 exploitation



Source: Authors

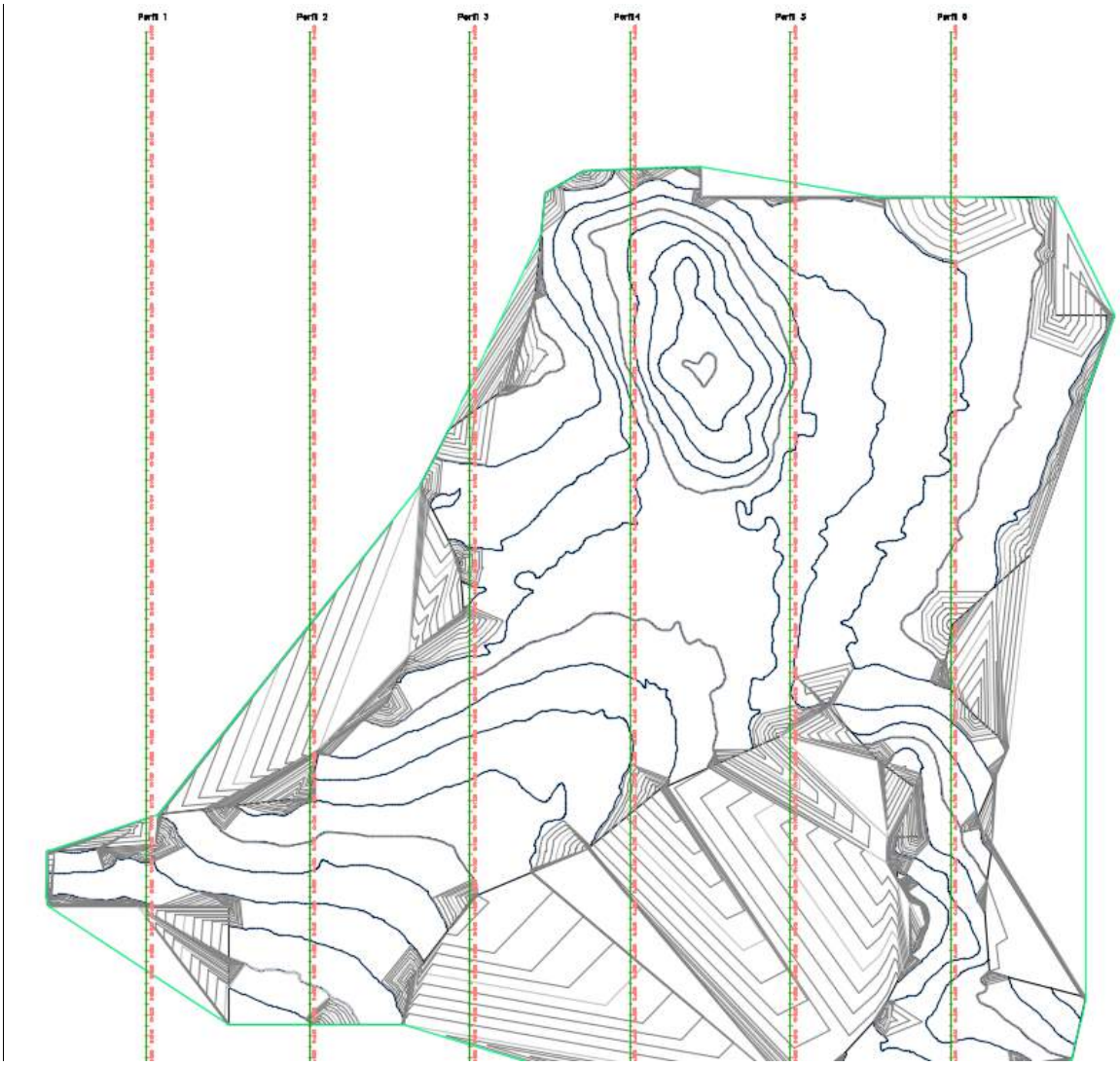
Table 11. calculation of reserves for the polygon of phase 2

Description	Quantity	unit
Surface	40.15	Ha
Thickness	5.00	m3
Volume of material (inferred mineral resource)	2,007,766.00	m3
Ratio factor	4.00	%
Unit weight	80,310.64	Tn/m3
Concentrate volume (mineable mineral resource)	1.82	**m3**
Concentrate volume (mineable mineral resource)	146,165.36	**Tn**

Source: Authors

For the calculation of the profiles in this area, 5 transverse lines were proposed to generate the profiles at soil depth. Each of these projected lines are separated every 100m and will allow the calculation of the afferent areas. The corresponding analyses are shown in Figure 28 and Table 12.

Figure 28. Profile distribution – Phase 2 of the explotation



Source: Authors

Table 12. Calculation of reserves by the profile method for phase 2 of the operation

Profile	Section S area (m2)	Average area (m2)	Profile separation (m)	Volume by section (m3)	Specific weght	Volume by section (Tn)
Profile 1	1,894.73	3,393.04	150.00	508,955.33	1.82	926,298.69
Profile 2	4,891.34	6,005.53	150.00	900,829.50	1.82	1,639,509.69
Profile 3	7,119.72	10,922.08	150.00	1,638,311.85	1.82	2,981,727.57

Profile 4	14,724.44	14,840.83	150.00	2,226,124.05	1.82	4,051,545.77
Profile 5	14,957.22	15,054.08	150.00	2,258,111.63	1.82	4,109,763.16
Profile 6	15,150.94	7,575.47	150.00	1,136,320.20	1.82	2,068,102.76
INFERRED MINERAL RESOURCES				**8,668,652.55**		**15,776,947.64**
PROBABLE MINERAL RESOURCES				**2,080,476.61**		**3,789,467.43**
MEASURABLE MINERAL RESOURCES				**83,219.06**		**151,458.70**

Source: Authors

Now, the calculations presented above correspond to the reserves associated with the gravelly sandy material being this the probable resource values, and by means of the volumetric relation we obtain the volumes of gravels represented in the measurable resources. This is very important when calculating the amount of minerals associated with the gravels (concentrate).

4.3.1.2 Calculation of reserves for mining phase 3

For this polygon, exploration activities are still being carried out in order to identify the thicknesses associated with the deposits of interest for the extraction of the concentrate. Once the exploration stage is completed, this document will be updated with information regarding the mining area and its thicknesses.

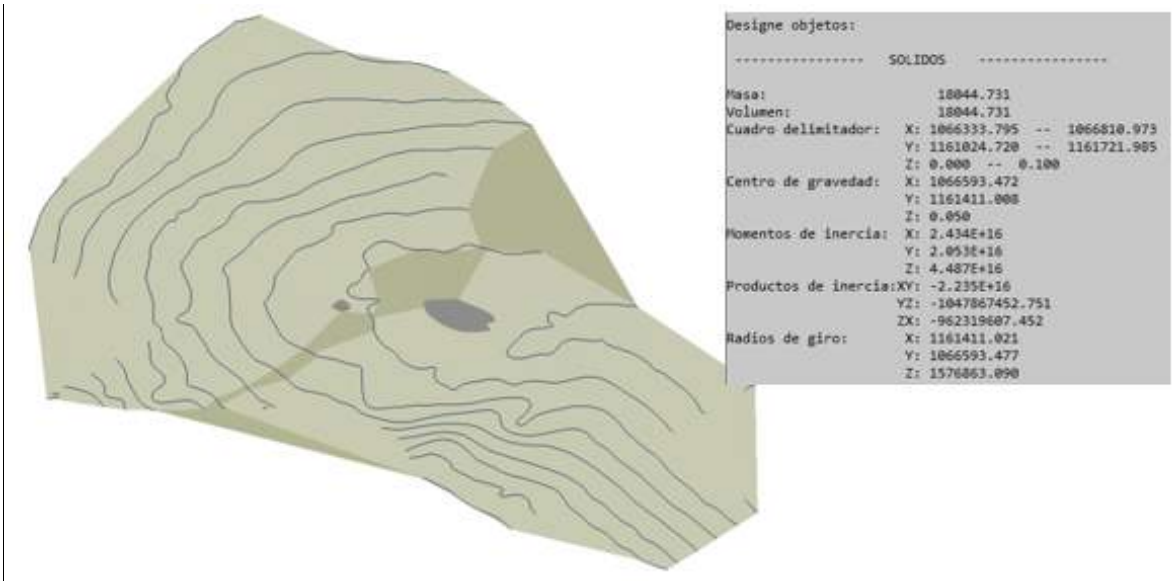
4.3.2 4.4.2 Stripping ratio

Based on the descriptions and analysis carried out for each of the mining polygons (phase 1, phase 2 and phase 3), the following volumes associated with stripping are identified.

4.4.2.1 Phase 1 area stripping

For this area there is an average of 10 cm of overburden material, which, by means of a three-dimensional analysis, a more approximate volume can be obtained, since it is modeled from the surface generated by the contour lines; this allows an estimated thickness to be entered into the software, which for the case of analysis corresponds to 10 cm as mentioned above.

Figure 29. Graphical representation of the stripping volumen for the area corresponding to phase 1 of exploitation



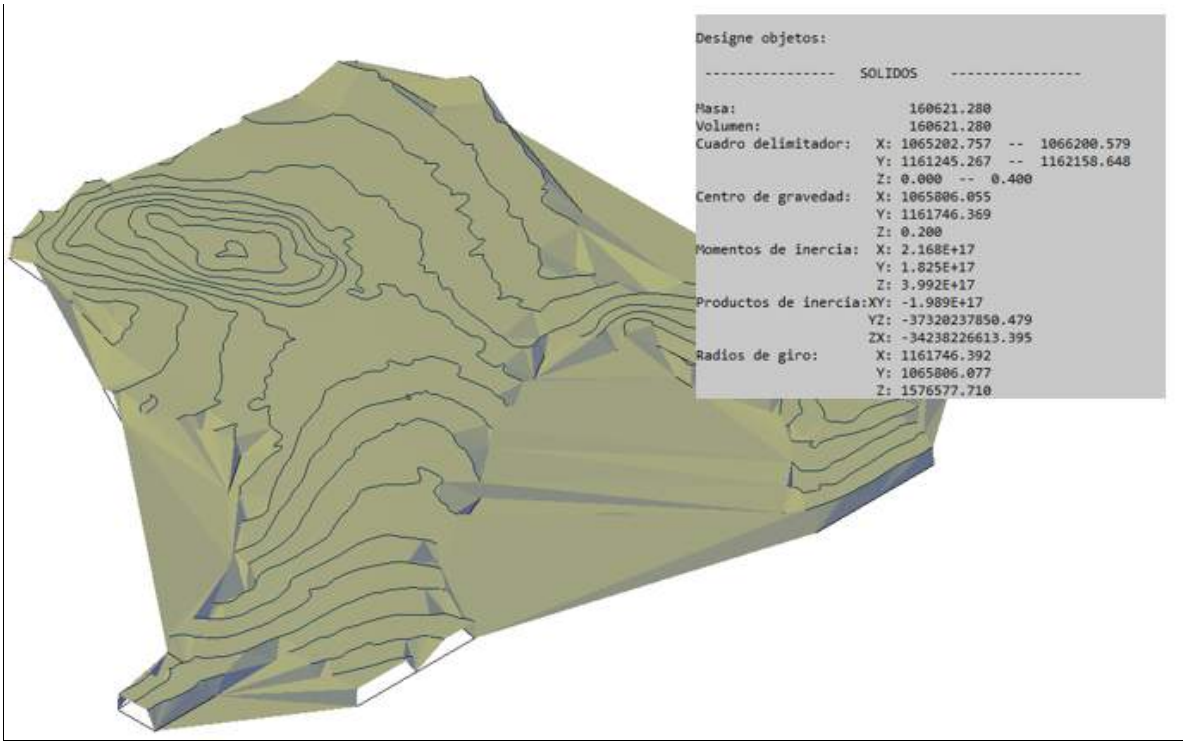
Source: Authors

Summarizing, for this sector of phase 1, there is an extension in area of 18.04 ha and a stripping thickness of approximately 10 cm, which represents a volume of 18044.731 m3.

4.4.1.2 Topsoil stripping for the area of phase 2

For this area, there is an average of 40 cm of material for the stripping, which, by means of a three-dimensional analysis, a more approximate volume can be obtained, since it is modeled from the surface generated by the contour lines; this allows an estimated thickness to be entered into the software, which in the case of the analysis corresponds to 40 cm as mentioned above.

Figure 30. Graphical representation of the stripping volume for the area corresponding to exploitation phase 2



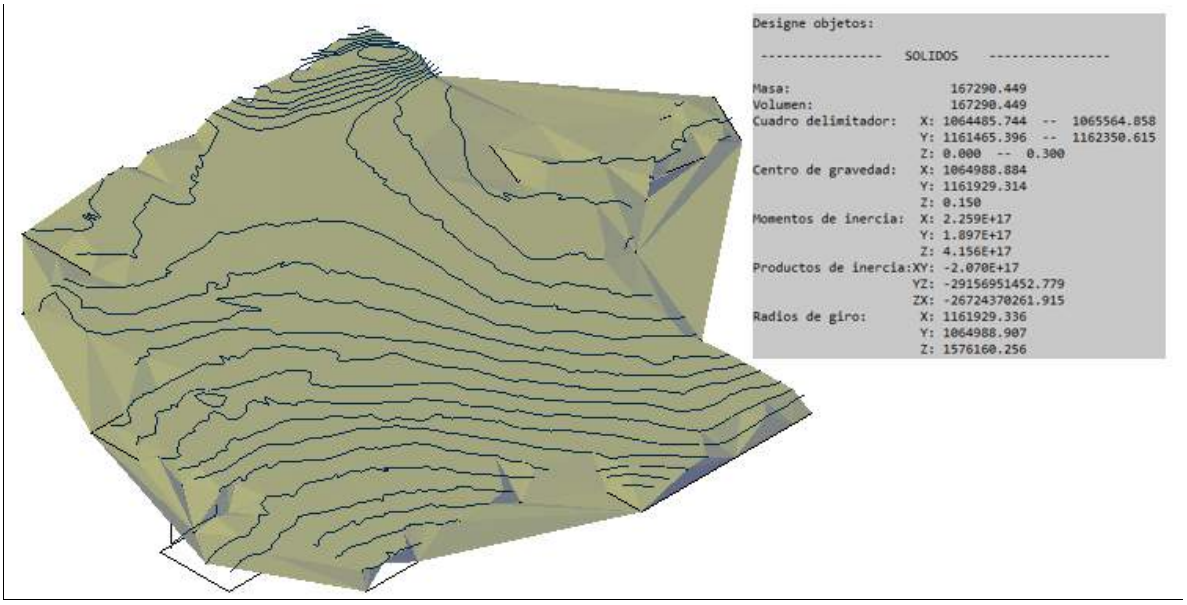
Source: Authors

In summary, for this sector of phase 2, there is an extension in area of 40.15 Ha and a stripping thickness of approximately 40 cm, which represents a volume of 160621.280m3.

4.4.1.2 Topsoil for the area of phase 3

For this area there is an average of 30 cm of overburden material, which, by means of a three-dimensional analysis, a more approximate volume can be obtained, since it is modeled from the surface generated by the contour lines; this allows an estimated thickness to be entered into the software, which for the case of analysis corresponds to 30 cm as mentioned above. However, and as mentioned, this area is still under exploration, so the polygon extension could decrease according to the findings of the deposits.

Figure 31. Graphical representation of the stripping volume for the area corresponding to exploitation phase 3



Source: Authors

In summary, for this sector of phase 3, there is an extension in area of 55.76 Ha and a stripping thickness of approximately 30 cm, which represents a volume of 167290.449 m3.

4.4.2 Useful life of exploitation

Once the mineable ore reserves are known, the stripping ratio, the estimated production during the mining phases, the useful life of the mine is calculated, it must be considered that these data are estimates, since the volume to be mined depends on the mining design. For this, the lower data of the reserve calculations made by the two methods are taken as they are more conservative values. Here it is clarified that the data corresponds to the volumes of material and not of concentrate, since these volumes are the ones that define the exploitation time. Next, the analyses for the calculation of the useful life for extraction are carried out.

Table 13. Parameters for calculating the useful life of a mining operation

Exploitable Reserves	2837325.72 m3
Average Daily Production	572 m3/day
Working days x year	288 days/year

Source: Authors

Thus, the useful life of the mining operation is approximately 17 years as shown in the following analysis.

Useful life=Exploitable reserves m3daysbusiness daysyear*productionm3day=283732.5 m3(288dayyear*572m3day)

≈17 years

5. WORK PROGRAM

5.1 OPERATING ALTERNATIVES

The mining design is essentially a systematic process that integrates the parameters of a deposit such as the geometry of the deposit, the distribution of the tenors, the geomechanical properties of the material, the encasing rock, with the economic, environmental, social and other factors. The selection of a mining system is based on the review and experience of techniques already applied in other sectors with similar deposits that allow analyzing the production rate, since this is a very important factor in the economic scope of the project. The literature points out that the determining factors in the choice of an exploitation method are framed in the geometric characteristics since this parameter is a function of the structure, morphology, morphometry and properties of the deposit. Another factor corresponds to the geotechnical component, since the maximum stable angles in the conformation of the slopes of the structural domains of the reservoir must be taken into account.

The operational factor is also a fundamental part when choosing an extraction method, since it is the machinery that determines the performance, efficiency, safety and production of a mining project. Finally, the factor corresponding to the environmental component, since the aim is to generate the least possible impact on the environment by implementing a system or mining method that facilitates the restoration of the intervened land.

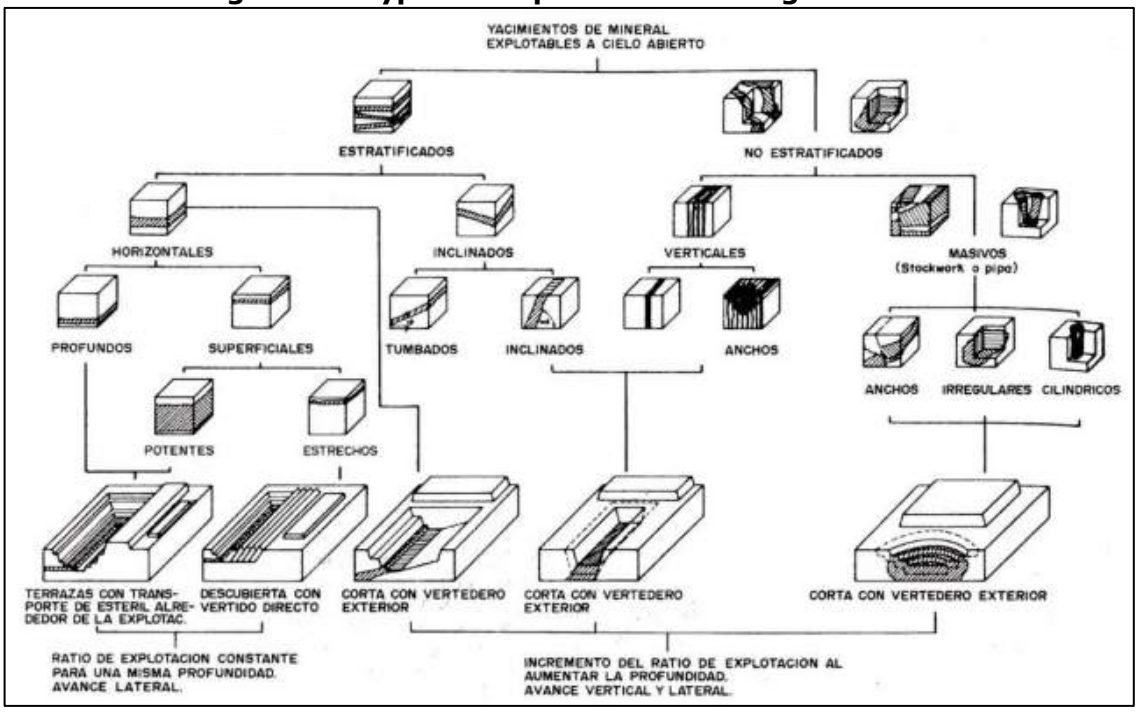
The choice of the mining method is decisive when starting the exploitation work because it will allow to have a spatial vision and a time scale that together with the systematic processes and the machinery will be articulated to achieve an orderly, repetitive and sequential mining operation.

There are different methods for the exploitation of minerals, which are based on the type of inclination of the stratification, the depth of the deposit and the position of the deposit which determines the size of the exploitation both in plan and in depth. For these characteristics, the most applied methods correspond to the terraces with tailings transport around the exploitation, the uncovered with direct pouring, the coasts with external dump and the cuttings with external dump.

Now, taking into account the disposition of the deposit together with the intercalations of the encasing material, which are described in the previous chapters, the type of exploitation corresponds to open pit mining of horizontal deposits.

This type of stratification within a deposit allows the extraction of ore by various methods, which are explained in general terms below.

Figure 13. Types of deposits and mining methods



Source: (Madrid & Herrera Herbert, 2006)

5.1.1 Open pit mining methods

Based on the aforementioned characteristics, this is the first approach for the selection of the classic exploitation method, among which are the Cortas, Transfers and Descubiertas. Next, and in general, each of these methods will be explained.

5.1.1.1 Shearing

This method of extraction applies to deposits whose stratification is inclined and therefore a descending benching with conical sections is required, which allows for very wide depths. Generally, this mining system is used in metal mining and allows the removal of large volumes of material, so the useful life of these quarries is up to 20 years.

5.1.1.2 Uncovered quarries

This method of extraction applies to deposits whose stratification presents some inclination or, on the contrary, is horizontal. The mining system consists of a single bench where the advance is made in one direction only, allowing the self-filling of a previous phase. It allows the start-up with conventional machinery in the case of small mining or with large machines for larger scale productions. From the point of view of land restoration, this method is effective.

5.1.1.3 Terraces

This system essentially uses the same system as described for the uncovered, however, here more than one level or bench can be used for extraction, so great depths can be achieved. One of the advantages of this method is that the benches can be self-filled with the excess material. The equipment to carry out this method of exploitation is variable, since it is possible to work with conventional machinery for starting, loading and transporting, as well as to implement a system of continuous loading by means of straps and crushing within the same area of exploitation.

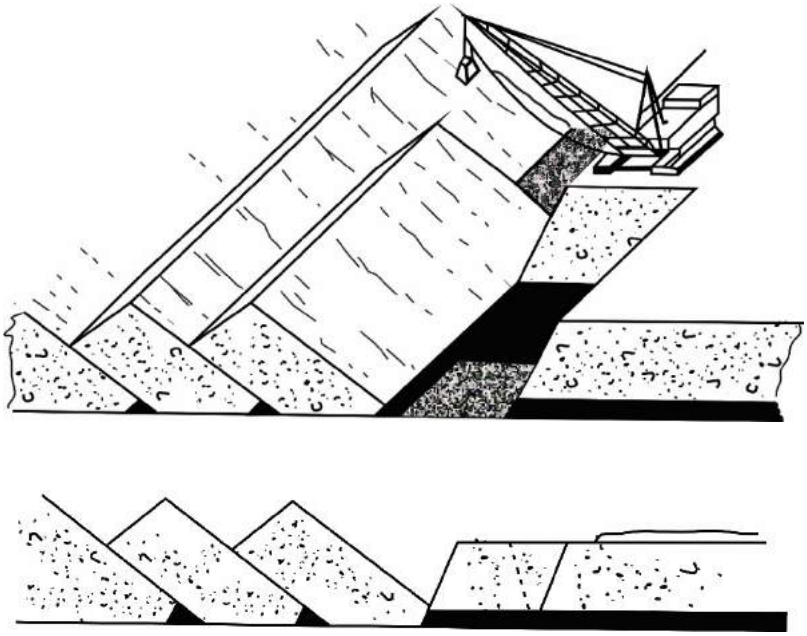
5.1 MINERO DESIGN AND MINING APPROACH

5.1.1 Method and exploitation system

For this analysis, we seek to identify and choose the most appropriate exploitation method for the extraction of the existing reserves within the analysis polygon that guarantees the technical and economic safety of the project. Likewise, the characteristics of the deposit must be satisfied and the orientation must be under the geomechanical criteria of the soil, so that the cuts that are generated guarantee the physical and economic safety of the exploitation. On the other hand, the preparation and operation tasks are established, as well as the definition of equipment and tools. Taking into account the structural, geological and topographic characteristics of the area of analysis, it is again concluded that the exploitation system corresponds to open pit extraction, completely ruling out the possibilities of developing these extractive activities through subway or mixed exploitation systems.

For the selection of the exploitation method, the classification of the deposit was established, taking into account characteristics such as its shape, relief of the original terrain, proximity to the surface and the distribution of minerals in it. Likewise, the deposit is classified as an isometric type deposit, with an original horizontal to flat, superficial, non-uniform relief. These characteristics are typical of open pit mining, for which the open pit or transfer system will be developed, using backhoe excavators.

Figure 14. Overdraft mining method



Source: Taken and modified from Herbert, 2006.

This method of discoveries has a series of positive situations such as, for example:

- A better recovery of the volume of mineable ore.
- As it is a progressive extraction, that is, as the bench advances, it allows for simpler planning.
- By having only one mining bench, the level of risks and/or accidents decreases..
- The mining method allows the use of any type of machinery for the extraction of the material, that is to say, it is possible to work with large-scale equipment or with conventional machinery.
- As for the workers, the physical effort required for the extraction of the mineral is less.
- Higher productivity is obtained.

For the development of this phase, a first excavation will be made, accessing the mineral, originating an initial row and accumulating the sterile material in an external zone of the work area. Once this first excavation is finished and the use of the extracted material has been made, the tailings will be deposited in this first excavation area, giving way to the generation of a second excavation and so on, successively (Mineria Sostenible de Galicia, 2019).

It is important to establish that during the exploitation time the protection zones of continuous water streams will not be intervened, respecting their water round of 30 meters wide from the respective riverbed; likewise, the exploitation will not be developed within the riverbeds of the streams present in the area.

5.1.2 Mining operation activities

These activities together represent the execution system to develop the mining project. The projected exploitation is open pit as mentioned above, for the extraction of Tin, Tantalum, Vanadium, Gold, Coltan and their concentrates within the application polygon. To this end, the following is a description of the minimum activities required to carry out the execution of the mining project.

5.1.2.1 Construction and assembly work

This work corresponds to the previous adjustments such as the adaptation of accesses, the assembly of the surface infrastructure, the assignment of personnel, quotations for the purchase of equipment, delimitation and signaling, and construction of the mining infrastructure.

- **Access roads**

Use will be made of the road corridors belonging to the secondary and tertiary roads that connect the municipality of Puerto Carreño with the village of Casuarito for a distance of approximately 84.7 km. From this point to the mining area there are roads, which will be adapted and conditioned according to the design parameters to facilitate access for machinery for a distance of approximately 5.7 km. For these adjustments, the following must be taken into account as a minimum:

- Design Vehicle which, depending on its dimensions, weight and limitations, will determine the characteristics of the road.
- Design speed projected for the road, which will depend on the radii of curvature, superelevations, speed distances, etc.
- Maximum slope of the road, which, for a single-lane road, is established as a 3% transverse slope, single-water, which allows for effective evacuation.
- The width of the roadway is recommended to be estimated with the following expression.
- A= a(0.5+1.5*n), however, it should be taken into account that the minimum width for a single lane road will correspond to the width of the vehicle plus an increment of 2 meters.
- The radius of curvature will be between the values of 20 and 30m, which guarantees that the machinery circulates without any kind of risk.

The roads will have a periodic and systematic maintenance program that will allow maintaining good safety conditions at all times:

- Conservation and cleaning of drains.
- Restoration of the road surface.
- Elimination of potholes, potholes, ruts, etc.
- Removal of fallen material as a consequence of its transport.

Another access to the polygon is by waterway, which leaves from the port in Puerto Carreño and travels along the Orinoco River by boat for approximately 30 minutes.

- **Infraestructure**

This surface infrastructure consists mainly of the construction of internal roads, construction of the locations, temporary stockpile yard, runoff water control system, communications, among others.

5.2.2.2 Mine preparation work

The preparation work consists of the development of preliminary activities to prepare the area so that the extraction of the identified minerals can begin. For this purpose, the activities corresponding to this preparation phase are described below.

- **Clearing**

This activity consists of removing the underlying vegetation cover in the areas to be intervened with the mining banks or with the construction of the roads. Clearing is done by clear-cutting progressively, that is, as the mining sequence progresses, using manual tools such as chainsaws, axes and machetes. The products from the clearing will be used if the wood is commercial, otherwise they will be chopped and stored for later use as mulch in the recovery of the disturbed area. It is important to keep in mind that the storage sites will be located away from water sources or surface drains.

- **Stripping**

This consists of removing the organic layer of the soil manually and/or mechanically. A backhoe will be used to remove the topsoil, which will then be taken to the temporary storage area for maintenance before being disposed of in the exploitation areas and thus recovering its capacity for growth and integration with the environment. To determine the volume of soil to be removed during stripping, the average values of the effective soil depth and the depth of the first horizon, which vary between 10 and 30 cm respectively in the soils of

the area of influence, must be taken into account, so an average value of 20 cm of soil to be removed is considered.

- **Disposal of waste material**

As mentioned above, temporary areas will be established for the stockpiling of the sterile material, which once the self-filling phase begins, will be incorporated back into the exploited bench. These temporary areas correspond to the margins of the unidirectional exploitation bank, maintaining a safety margin with respect to the edge and ensuring that this material is not close to the watercourses. Taking into account that the exploitation method allows progressive self-filling, this material, due to its proximity to the bank, facilitates and speeds up the process of restoration and recovery of the area.

- **Storage of vegetation cover**

The same applies to the disposal of the vegetation cover, since in these areas described above, the vegetation cover can be stored and maintained in order to improve the initial conditions and then be incorporated into the intervened areas, adding silicates and amendments to improve the characteristics and be able to begin the restoration and reforestation of the area.

- **Stockpile yard**

If required, a stockpile yard will be built in the sector adjacent to the warehouse, which will serve as a support for storing the extracted material to be transported to the processing and transformation site. This stockpile yard will have an area of 200 m2 , since it is expected that the material will be transported sequentially as it is produced.

5.2.2.2 Mining operations

The design of a mining operation normally consists of the extraction of massive volumes of material in order to recover the highest percentage of the minerals present, however, the variability of these strata can influence the design and progress of the operation. An issue that has been fundamental in the mining approach is the presence of water tables identified in the explorations carried out, since the extraction of the material presents a rigorous analysis in terms of the depths of the water table, the depths of excavation and the winter and summer seasons during the year in order to ensure that excavations are carried out above the water table.

To carry out the exploitation design, a complete model of the deposit was elaborated and integrated with the topographic information, the stratification information according to the sector of interest, and the analysis and data

obtained from the pits carried out. It is important to know the geomechanical properties of the bedding materials, since safety must be guaranteed in the work zone, avoiding possible total or partial sliding of the bench.
Therefore, although the depth of the bench is defined by the thickness of the stratum of commercial interest, the inclination and height that guarantee the minimum probability of failure will be verified by means of stability models using the safety factors.

- **Geometry of the exploitation**

In open pit mining, the deposit is divided into benches or steps, whose heights depend on the expected production, the type of ore, the equipment available for start-up, loading and transport and the level of technology established in each case. In the case of the exploitation of the polygons belonging to plate No. LFH-14431X, the exploitation must be carried out in a descending way, forming the bench whose width is sufficient for the loading and transport equipment to work freely.

In the exploitation of horizontal and horizontal mantos deposits, benching is done according to the uniformity of the useful strata and the behavior of the soils. Generally, in steep and inclined mantles the benches have the same height. The following are some of the definitions of the elements involved in the design and calculation of the bench and slope.

Slope: block defined with width and height in ore or tailings, forming an operating level on which work is carried out horizontally in layers.

Bench footing: Line formed by the intersection of the bottom of the slope and the floor.

Angle of repose: Angle of an imaginary line joining all the bench feet, forming an angle with respect to the horizontal.

Slope height: Vertical distance between the crest and the floor. Bench height is a function of the loading equipment. For safety reasons the maximum height recommended in mines and quarries is 15 m and only for special applications it should reach 20 m.

Berm: The berm is the width of the pit and is the space that will be used for the mobilization of the equipment, loading and transport that will be in charge of evacuating the exploited material to the stockpile site. This width is calculated as follows:

$$B = B' + C + K + A + D$$

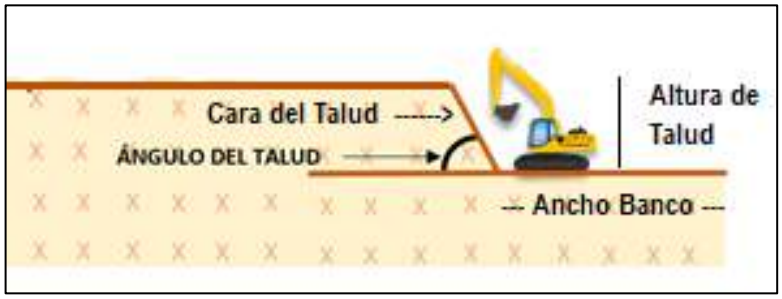
Where,
B=Pit width

B'=Safety berm
C= width of dump truck
K= width of loading equipment
A=Loading equipment turning radius
D=Machine width

Safety berm (B'): It is a safety area that limits the bench towards the part that is exposed to the void. It is used in open pit mining and road construction to prevent any type of fall of machinery or personnel to the cliff.

Bench slope angle (α): Corresponds to the face of the bench, this angle is formed between the slope line of the bench and a horizontal reference plane. The design of the slope face is a function of the orientation and inclination of the existing joints.

Figure 15. Geometry of an open pit mine



Source: Authors

Now, the values to be analyzed for the height and inclination of the bench are shown below, taking into account that it must comply with the safety factors. For this first part, the angle will be analyzed by means of the Hoek and Bray abacuses, starting from a safety factor, which will be verified by means of the limit equilibrium analysis.

- **Bench height definition**

The bench height is defined based on the dimensions of the equipment used in the exploitation process, that is, the starting and loading equipment, in addition to the characteristics of the soil. As mentioned above, in Colombia the bench height is limited to 20m.

For this case, the bench height is considered taking into account the maximum cutting height reached by a conventional 15-ton backhoe loader, which is 9.49m, therefore, the bench height is defined as 10m.

- **Bench width definition**

The width of the work bench is the sum of the spaces necessary for the movement of the machinery working on them simultaneously. For the development of this project only a single bench of 10 m in height will be made in a surface of 50 m X 50 m, which results in a bench of 30 m on the floor guaranteeing the sufficient space for the displacement of the backhoe, the dump truck and its turns.

- **Definition of the bank angle**

The definition of the slope angle or bench angle is one of the most significant geometric parameters in the exploitation of a quarry, because the stability of each of the sectors involved must be guaranteed, for which it is required to maintain an optimal design geometry. The angle of the face of the bench is a function of two factors, the first one is the type of material and the second one is the height of the bench, if a low height bench is planned, the angle of this can be projected more vertical, the opposite case occurs if the height of the bench is considerable, since this angle could be projected more inclined since everything is a function of the structural characteristics and resistance of the materials.

By means of Hoek and Bray's circular breakage criterion methodology, which is based on the use of four breakage abacuses and which takes into account drainage characteristics, homogeneity of the material and geomechanical parameters in the slope of analysis. In this way, the bank face angle is calculated and a preliminary safety factor value is obtained.
The parameters used in the circular breakage abacus 2, which takes into account drainage conditions, are the following:

$$\frac{c}{\gamma * H * tan\emptyset} = \frac{1.979}{1.9 * 10.0 * \tan(27.5°)} = 0.124$$

Where,

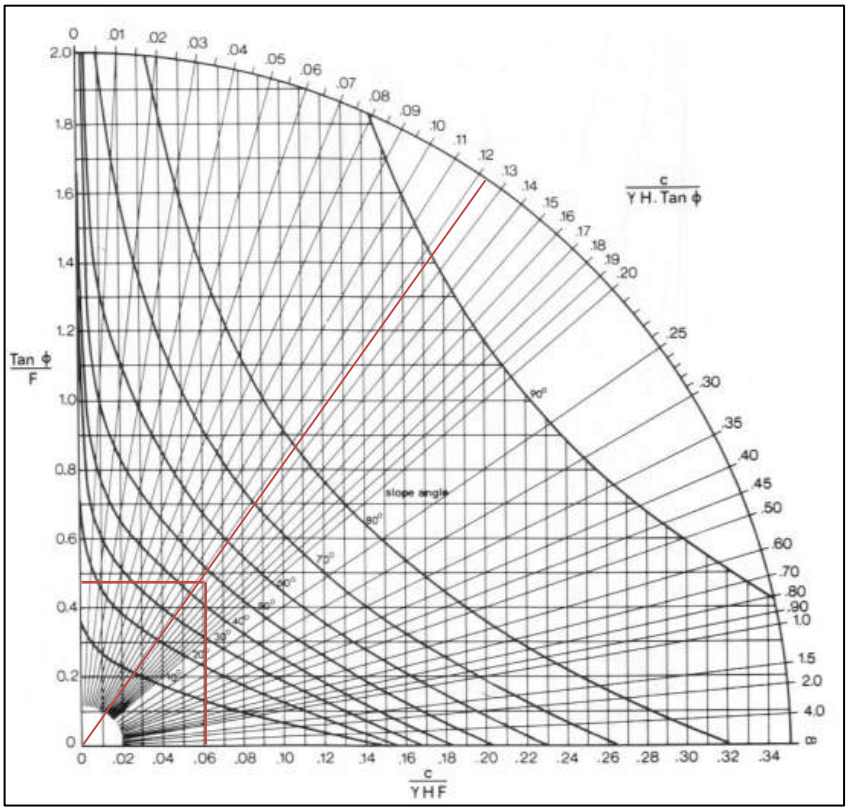
$c = Cohesion\ \left(\frac{kg}{m2}\right)$

$D = Density\ \ \left(\frac{kg}{m3}\right)$

$H = Bench\ height(m)$

$\emptyset = \ \ Angle\ of\ friction(°)$

Figure 16. Calculation of the preliminary safety factor and verification of the bench angle of inclination



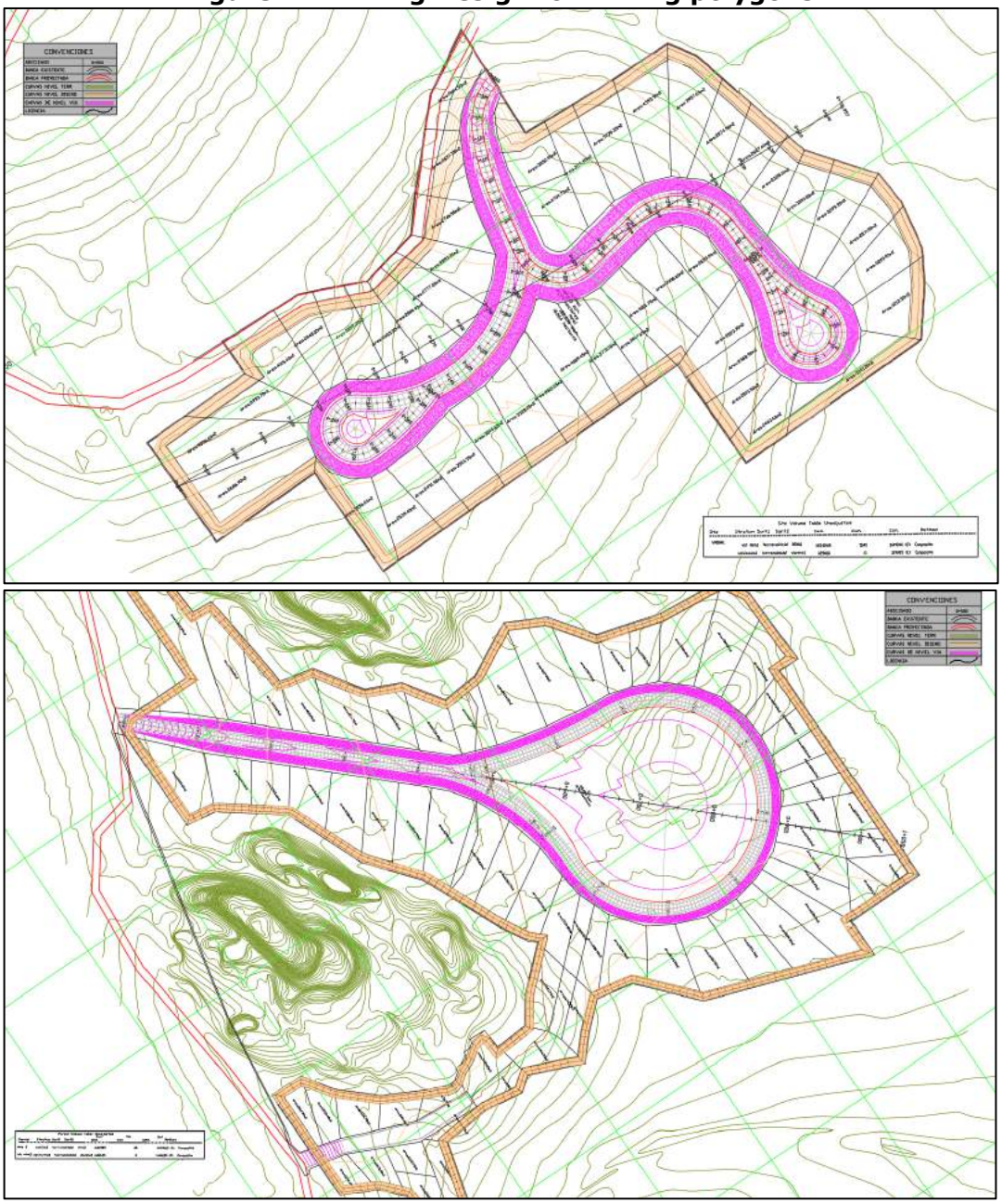
Source: Taken from Hoek and Bray, 1977 and modified by authors

Once the first data is obtained, which corresponds to 0.124, it is complemented with the other two data inferred from the circular breakage abacus, which are for the horizontal axis a value of 0.06 and in the vertical axis a value of 0.49, to finally obtain a value of FS from analyzing these data with an angle of 45°.

$$\frac{\tan \emptyset}{FS} = 0.49 \rightarrow FS = \frac{\tan(27.5)}{0.49} \rightarrow FS = 1.06 \; ok \; for \; an \; angle \; bench \; of \; 45°$$

5.1.3

Figure 17. Mining Design for mining polygons



Source: Authors

Sequence of the operation

To start the material extraction process as proposed in the mining design, it is necessary to develop and prepare the area in order to make the bench in a descending way, which, according to the projected design, has a bench height of 10m and slope angle of 45° being the slope of rest. The exploitation of the

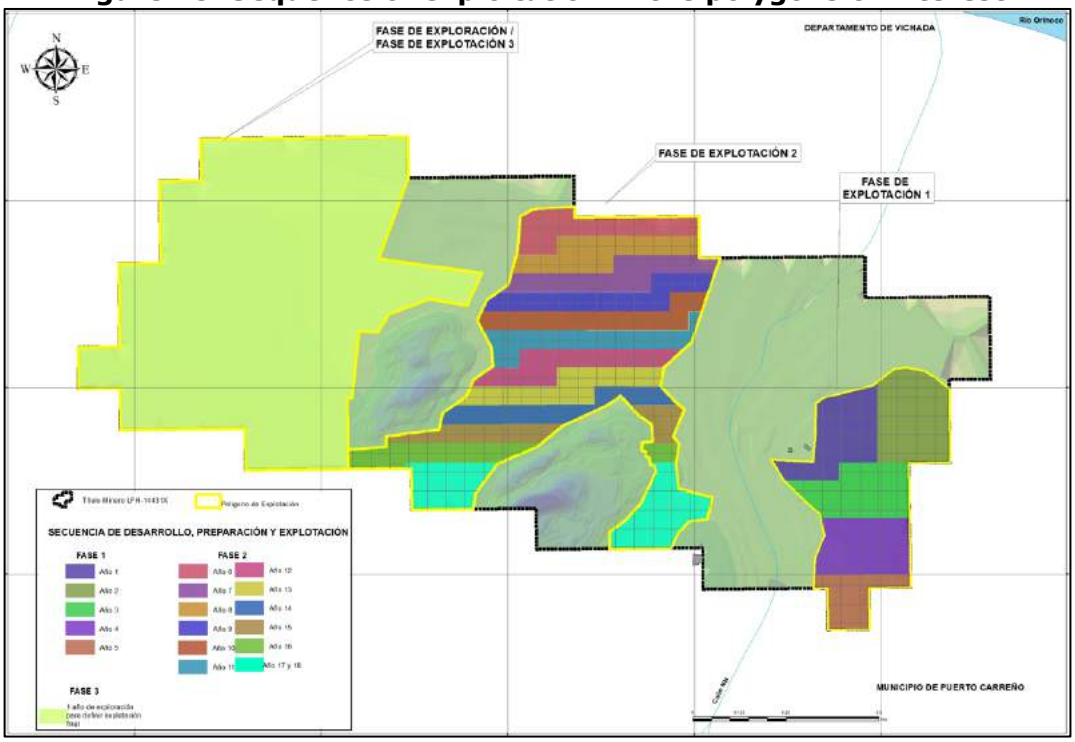
material will be done by mechanical extraction with the use of backhoes since the material to be extracted is a combination of gravelly and silty soil, which is why it will not be necessary to use chemical agents or explosives. The material will be transported using simple dump trucks with a maximum capacity of 6m3. The following is a description of the three sequential moments of the exploitation.

First, the construction of the access roads to the mining sites (phase 1 and phase 2) will be carried out, which have a length of 0.94 km and 1.5 km respectively. These roads will be at the level of the mining excavation to allow mining to begin from there for each of the planned 50 m X 50 m plots. Secondly, the areas to be worked will be cleared and stripped and deposited within the same exploitation polygon, taking into account that these excavations are progressive. The extraction or removal of the material will be carried out by excavators, which will load the material directly into the dump trucks for immediate transfer. The third and final step will be to fill the benches and shape these areas in order to proceed with the restoration and reforestation stage. This mining operation cycle presents as a critical route the duration time of each activity of starting, loading, transporting and filling.

As already mentioned in the "Mining method and system" chapter, the mining alternative is open pit mining using the unidirectional single bank overburden method. The following is a description of the sequence that will be followed in each of the mining stages.

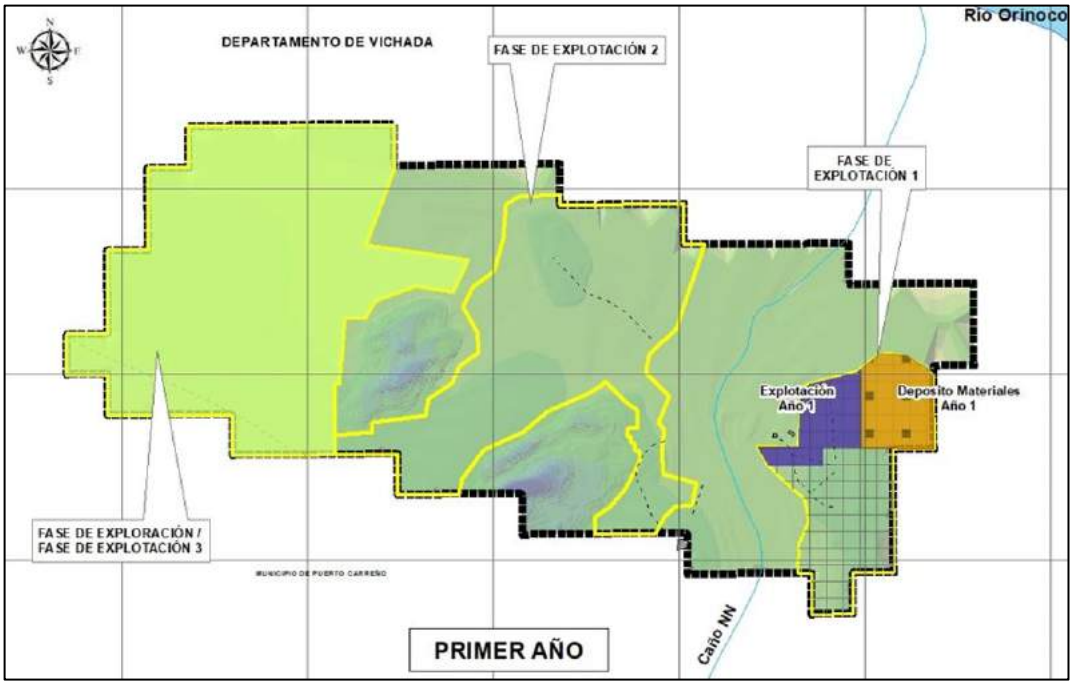
The sequence of the exploitation for the polygons of phase 1 and phase 2 is shown below. **Figure 18**, shows the area to be worked each year. Likewise, and following the exploitation process, **Figure 19** shows the área to be intervened on an anual basis.

Figure 18. Sequence of exploitation in the polygons of interest



Source: Authors

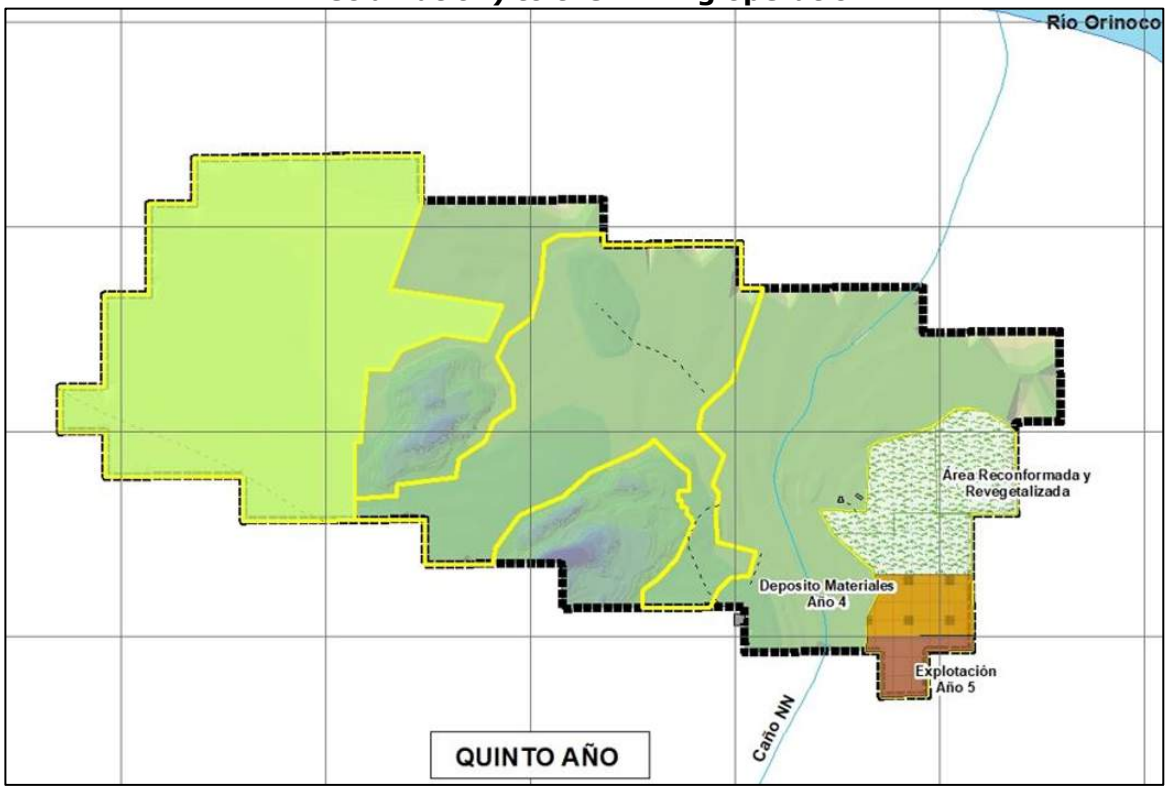
Figure 19. Tailings disposal using the areas within the polygon without intervention

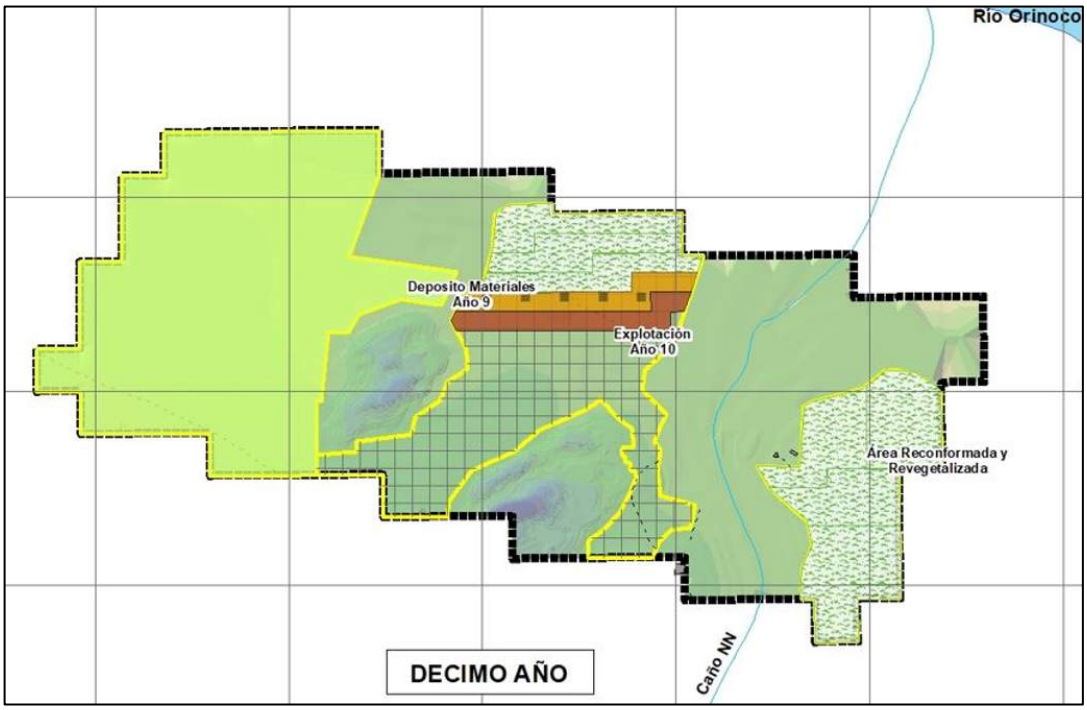


Source: Authors

Finally, Figure 39 shows the evolution of the exploitation, but also the cycle of the extractive method, which allows to exploit, dispose (temporarily) and reshape the intervened areas in parallel to their progress, contributing to the landscape recovery during the same time of the mine's useful life.

Figure 20. Parallel activities (temporary disposal, re-conformation and reclamation) to the mining operation





Source: Authors

- **Bench cut stability** análisis

A slope corresponds to the inclination or slope that results from a terrain once it has been excavated; however, depending on the type of materials that make up the slope, there may or may not be landslides, flows, rock falls or other types of mass movements that may cause problems in the different projects to be developed. Therefore, it is of high importance to know and characterize the areas where slope shaping will be carried out, as well as to carry out an analysis that allows to be sure that such area will not be affected and that, on the contrary, it will behave as a stable slope.

There are different properties that can influence slope stability, among these are: Porosity, density and specific gravity, uniaxial compressive strength, tensile strength and bearing capacity of the soil. In addition to these properties, slope stability is influenced by structural characteristics and water.

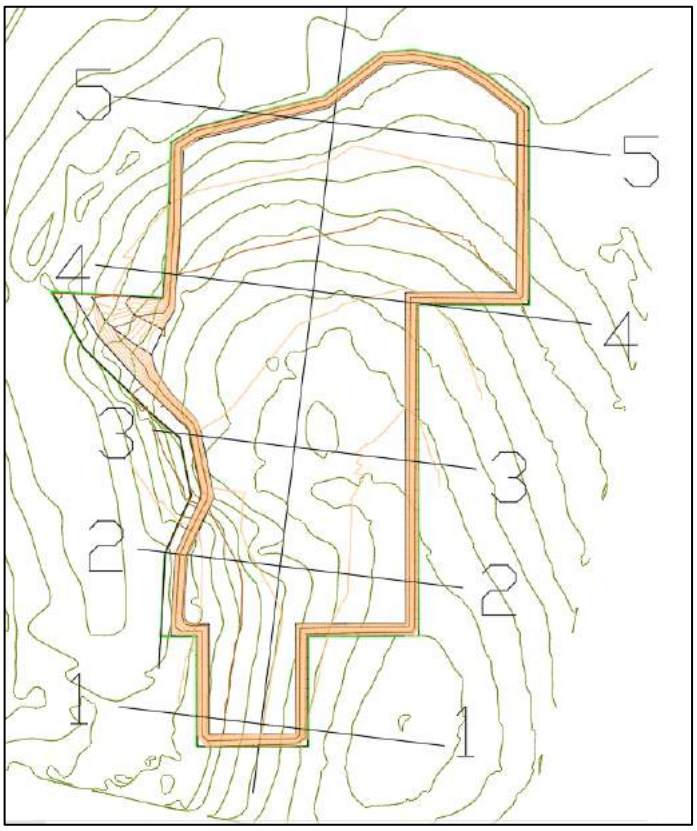
According to (Suarez, 2001), mathematical models have been implemented in the last decade, in order to identify in terms of factors of safety (FS) the stability of a slope. The models must take into account most of the factors that affect stability, including slope geometry, geological parameters, presence of tension cracks, dynamic loads due to seismic action, soil properties, among others.

There are a variety of methodologies for stability analysis, including numerical methods, equilibrium limit methods and dynamic methods. For the present project, the equilibrium limit analysis method was used.

Limit equilibrium analysis

This type of analysis allows obtaining a safety factor, obtaining the values of the shear resistance at the moment of slope failure. The factor of safety is used to know what is the threat factor for a slope to fail in the worst design conditions; therefore, a value of FS greater than 1 must be obtained.

Figure 21. Distribution of slices for the stability analysis of phase 1

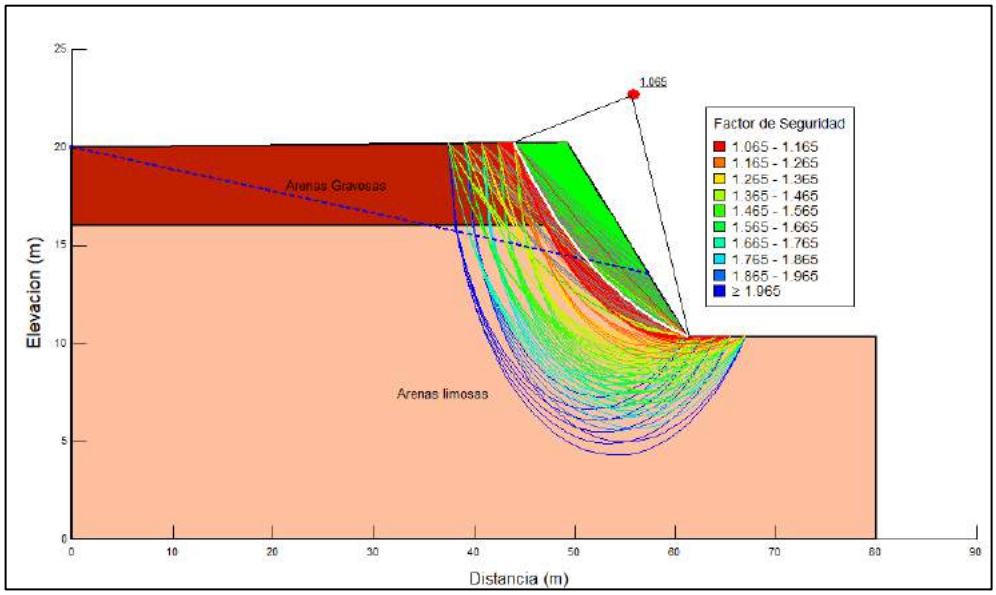


Source: Authors

For the Phase 1 area, a total of 5 slices were analyzed, distributed throughout the area, in order to perform a complete analysis. Each cut was analyzed using the equilibrium limit method, where a model was developed for the terrain with cuts. Each model was developed under critical circumstances, where piezometric level was taken into account, as well as the action of the earthquake in the area. The results of the stability analysis of representative cuts are shown below,

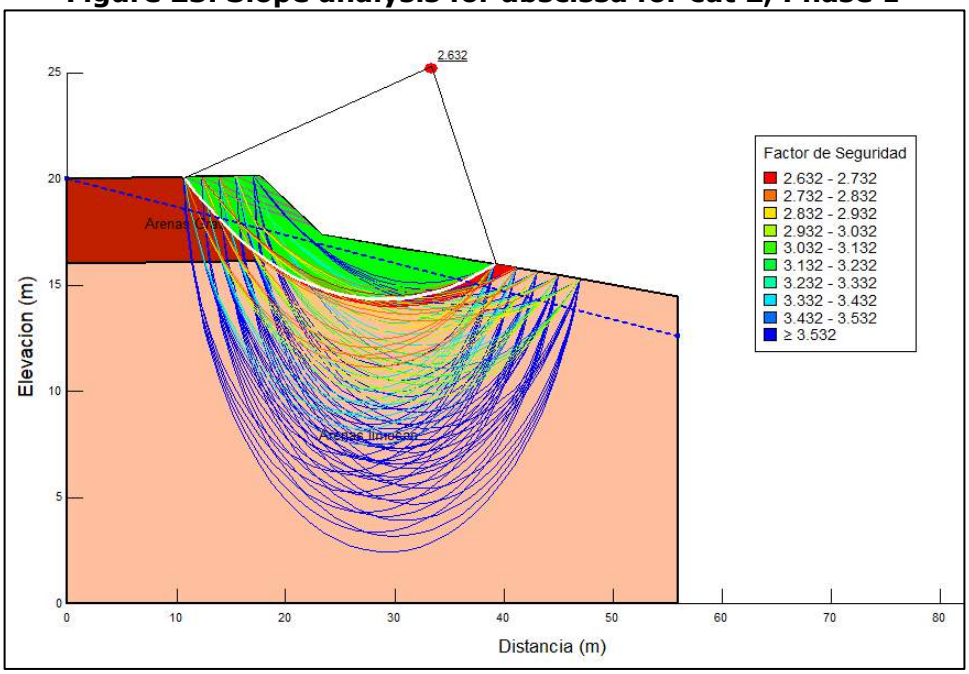
taking into account the degree of slope and the characteristics of the terrain for each cut.

Figure 22. Slope analysis for Cut 1, Phase 1



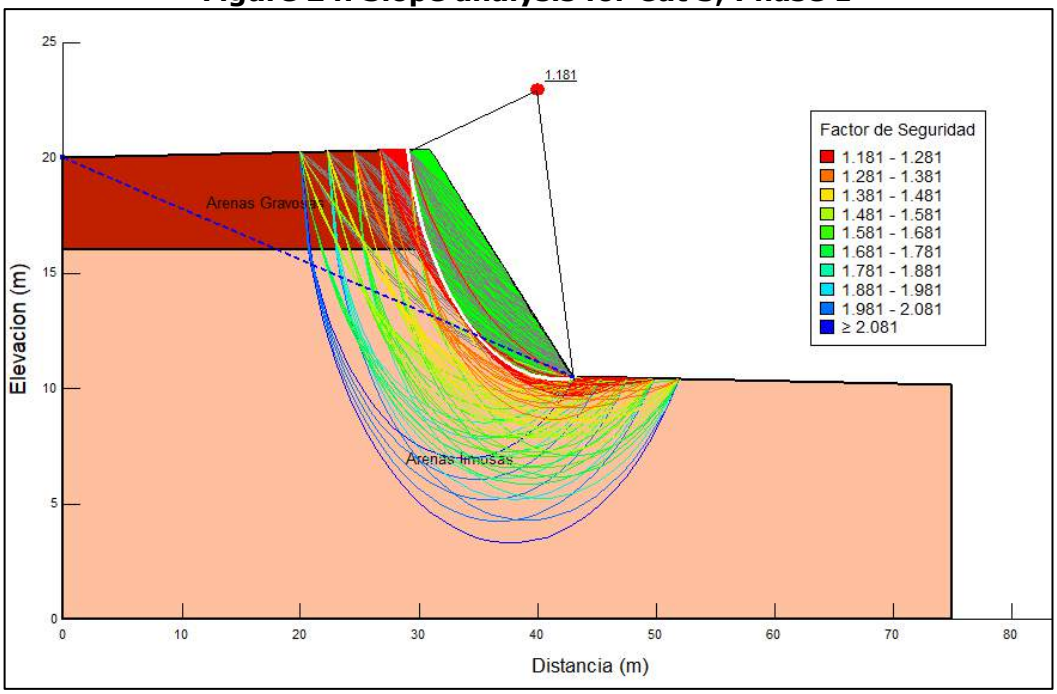
Source: Authors

Figure 23. Slope analysis for abscissa for cut 2, Phase 1



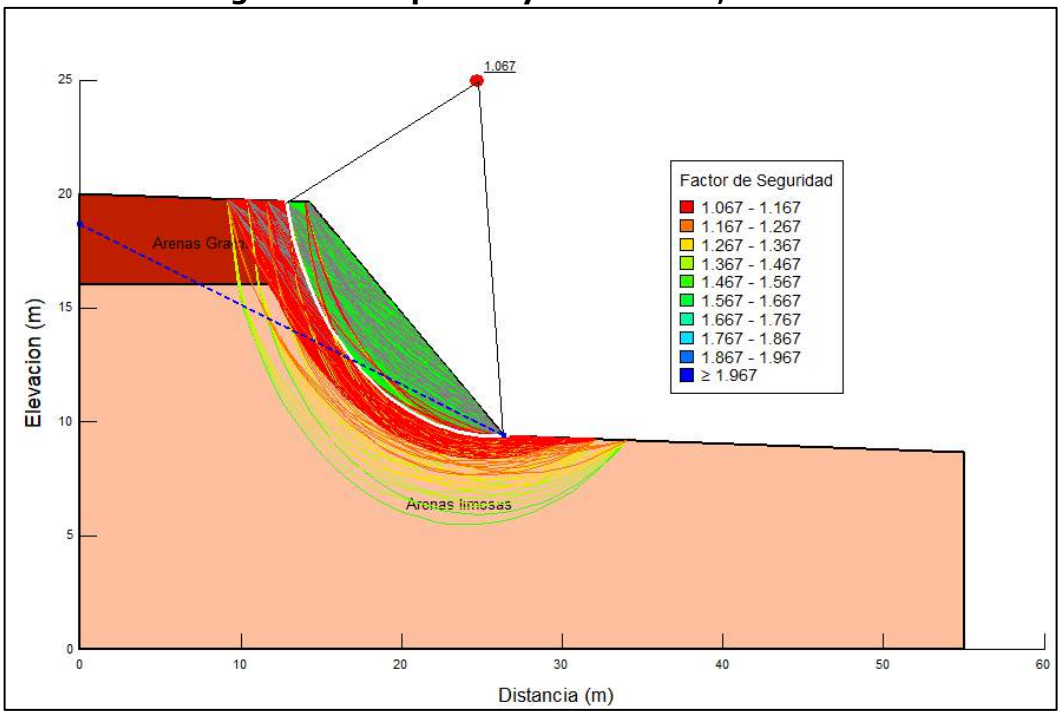
Source: Authors

Figure 24. Slope analysis for Cut 3, Phase 1



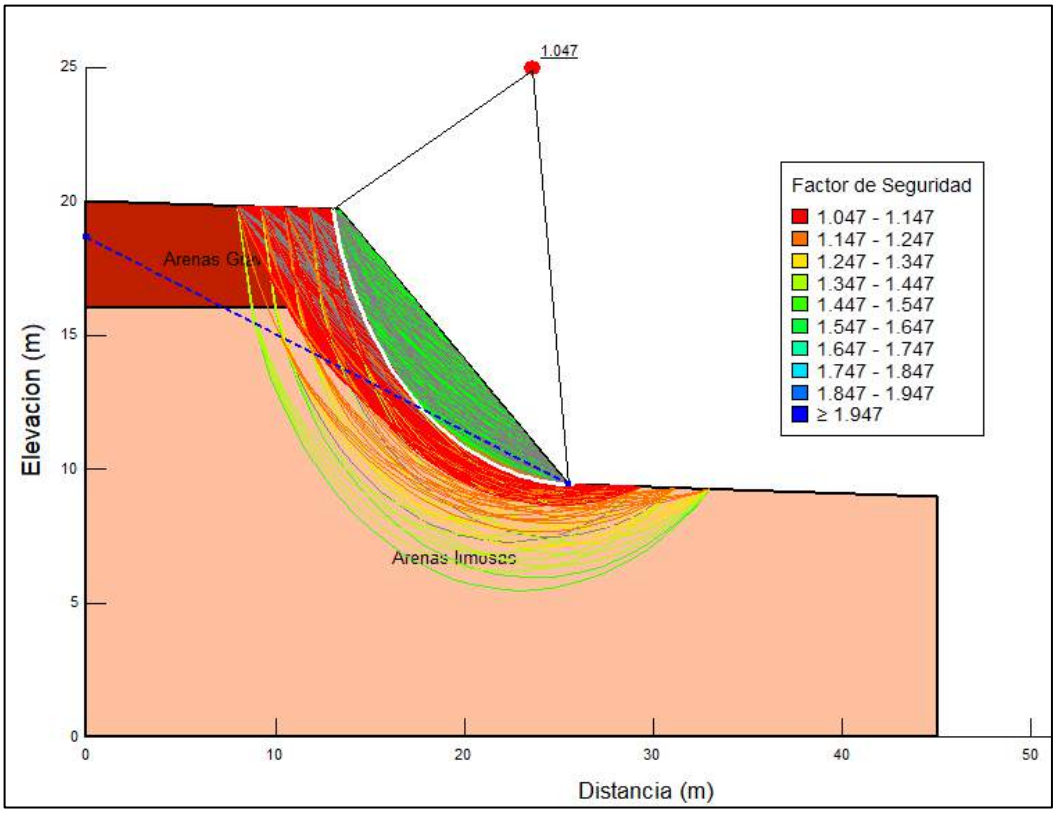
Source: Authors

Figure 25. Slope analysis for Cut 4, Phase 1



Source: Authors

Figure 26. Slope analysis for cut 5, Phase 1



Source: Authors

Thus, it is concluded that the profiles have a very good degree of stability. The safety factors for each cross-section are summarized below:

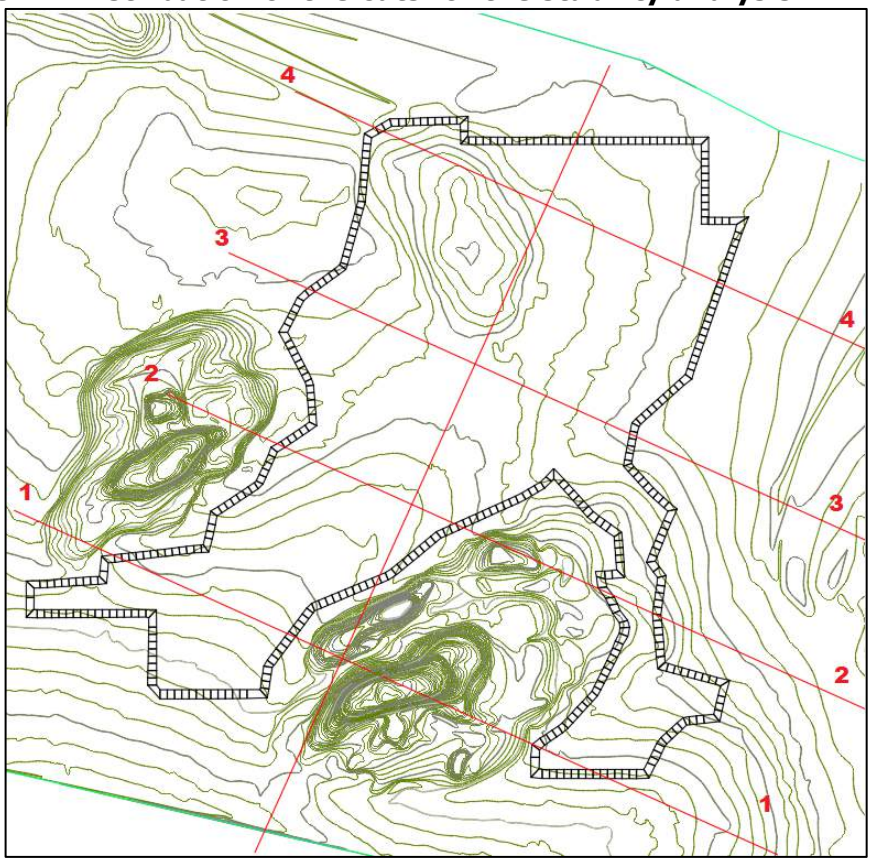
Table 5. Safety factors in natural terrain and once the project is underway.

CUT	SAFETY FACTORS WITH SLOPES
Cut 1	1.065
Cut 2	2.632
Cut 3	1.181
Cut 4	1.067
Cut 5	1.047

Fuente: Autores

The same analysis is transferred for the zone corresponding to the exploitation zone of Phase 2. The respective calculations are shown below.

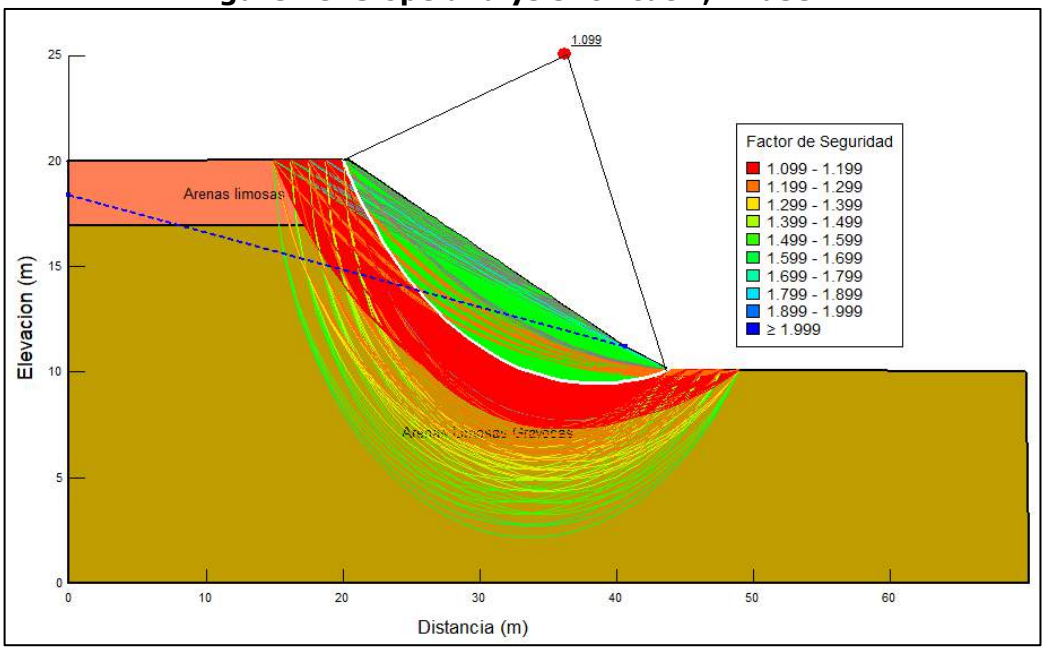
Figure 27. Distribution of the cuts for the stability analysis in Phase 2



Source: Authors

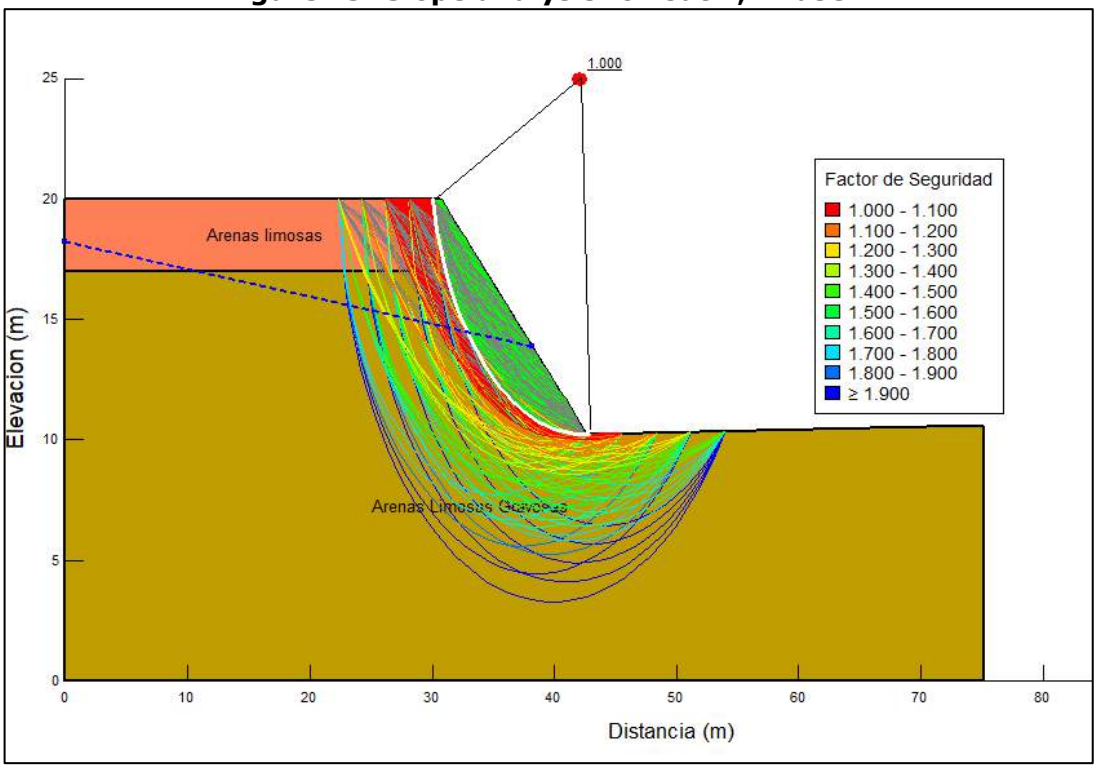
For the Phase 2 area, a total of 4 cuts were analyzed, distributed throughout the area, in order to perform a complete analysis. Each cut was analyzed using the equilibrium limit method, where a model was developed for the terrain with cuts. Each model was developed under critical circumstances, where piezometric level was taken into account, as well as the action of the earthquake in the area. The results of the stability analysis of representative cuts are shown below, taking into account the degree of slope and the characteristics of the terrain for each cut.

Figure 28. Slope analysis for cut 1, Phase 2.



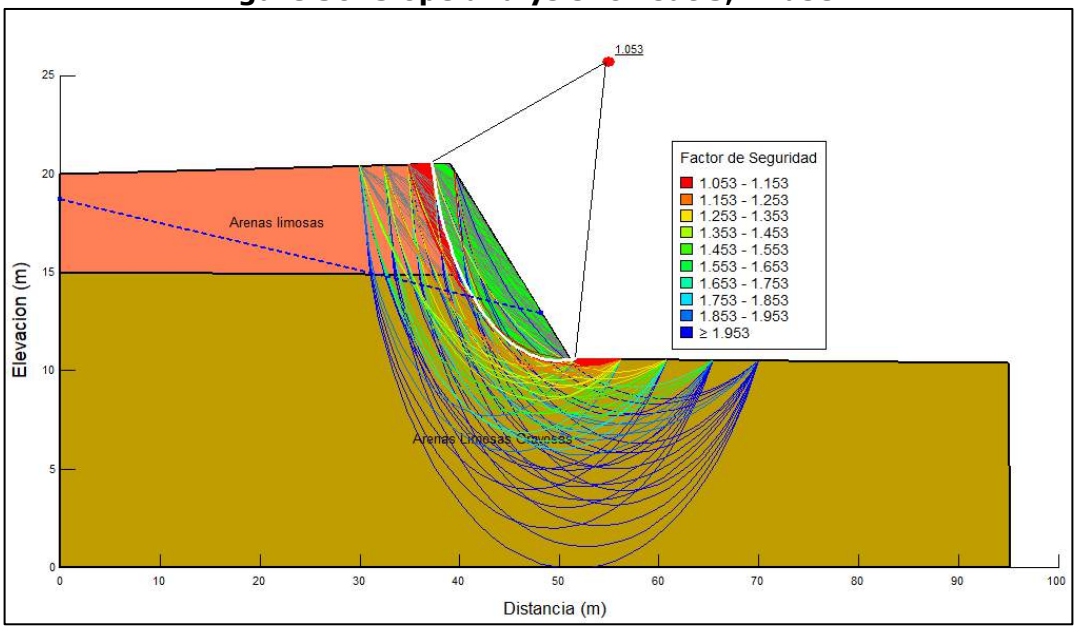
Source: Authors

Figure 29. Slope analysis for Cut 2, Phase 2



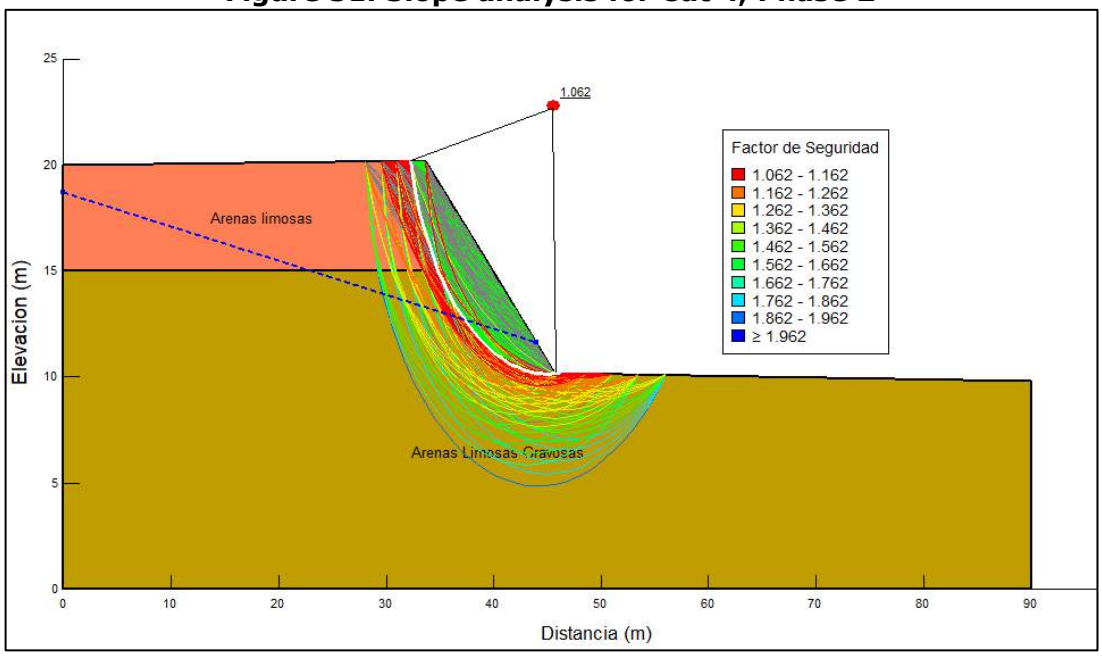
Source: Authors

Figure 30. Slope analysis for Cut 3, Phase 2



Source: Authors

Figure 31. Slope analysis for Cut 4, Phase 2



Source: Authors

Thus, it is concluded that the profiles have a very good degree of stability. The safety factors for each cut are summarized below:

Table 6. Safety factors in natural terrain and once the project has started for phase 2.

CUT	SAFETY FACTORS WITH SLOPES
Cut 1	1.099
Cut 2	1.000
Cut 3	1.053
Cut 4	1.062

Source: Authors

5.1.3.1 Unit operations work

These tasks comprise all the activities that must be carried out in the development of the exploitation and are the central axis of the mining system or process.

- **Preparation of operating areas**

In the exploitation phase, one of the first activities to be carried out is the stripping of the material present in the exploitation zone, which presents variable thicknesses showing areas with thicknesses between 10 cm to 30 cm; this stripping material will be temporarily stored on the sides of the projection of the benches forming geometries that have a disposition slope of 1:1 (45°) and maximum heights of 3.0 m with base dimensions greater than 50 m long by 5 meters wide. It must be taken into account that this stripping is done progressively, that is to say, it is not required to store the entire stripping, but only intervened sectors which correspond to areas of 50 m * 50m as explained in previous chapters.

- **Start-up and loading**

The start-up will be carried out by means of a conventional machine corresponding to a crawler excavator, which will load the dump truck with the extracted material. The development of the mining front will be done by means of a single unidirectional bench whose height depends on the exploitation zone (the geometry of this mining design is detailed in previous chapters), extracting the material with respect to the maximum limits recommended in the mining design.

- **Transport**

The material will be transported by dump truck from the mine face to the area where the sieve and classifier are located, which is within the same perimeter of the mine, using internal roads. In the case of tailings or leftovers from the

classification process, they will be returned to the mining site to begin the backfilling process. These routes are less than 2.5 km.

- **Storage**

The material resulting from the classification and washing process will be stored in the warehouse provided for this purpose in fiber sacks duly stacked.

5.2 INFRATSRUCTURE NEEDS

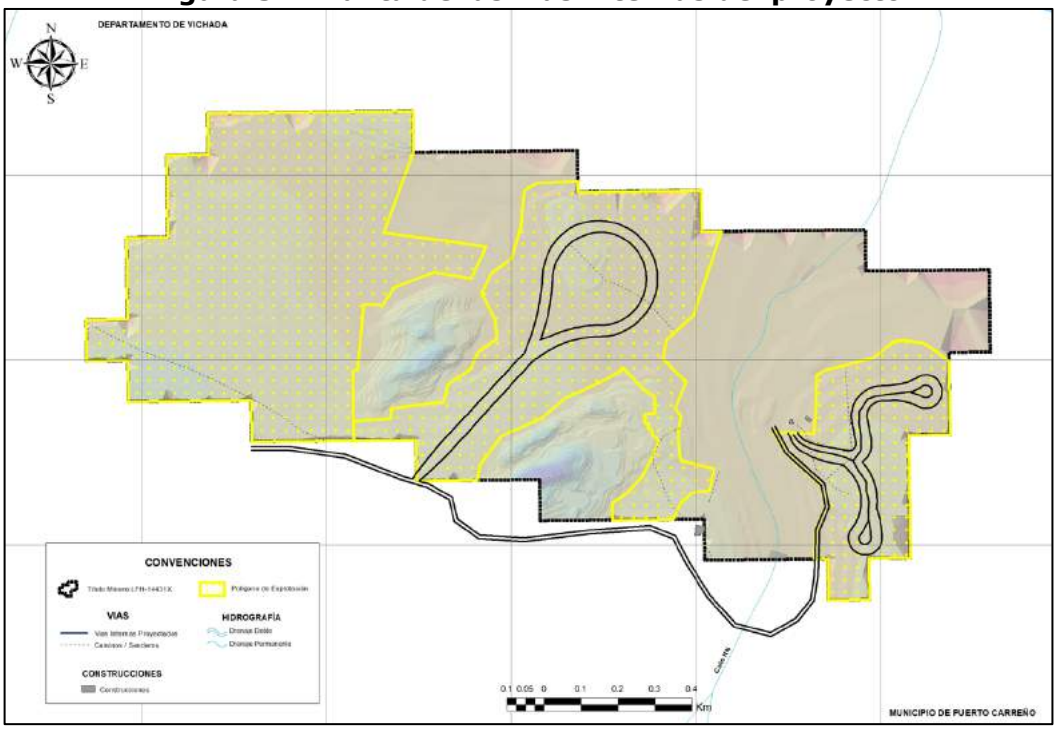
This chapter describes the existing infrastructure in the areas where mining is planned, as well as its current availability and future needs for the project.

5.2.1 ACCESS ROADS

Tal y como se mencionó anteriormente, se necesita de la adecuación de los caminos que conectan la zona de explotación con la vía veredal Puerto Carreño – Casuarito. Las nuevas adecuaciones viales para las conexiones internas que haya necesidad de construir, deberán tener 7 metros de ancho, pendientes ascendentes de 7 - 8% y garantizar facilidad de mantenimiento mientras se utilicen, se construirán tomando en cuenta criterios de seguridad vial, oportunidad y economía para el proyecto. Deberán estar debidamente señalizados durante su utilización y perfectamente cerrados, una vez se abandone la explotación.

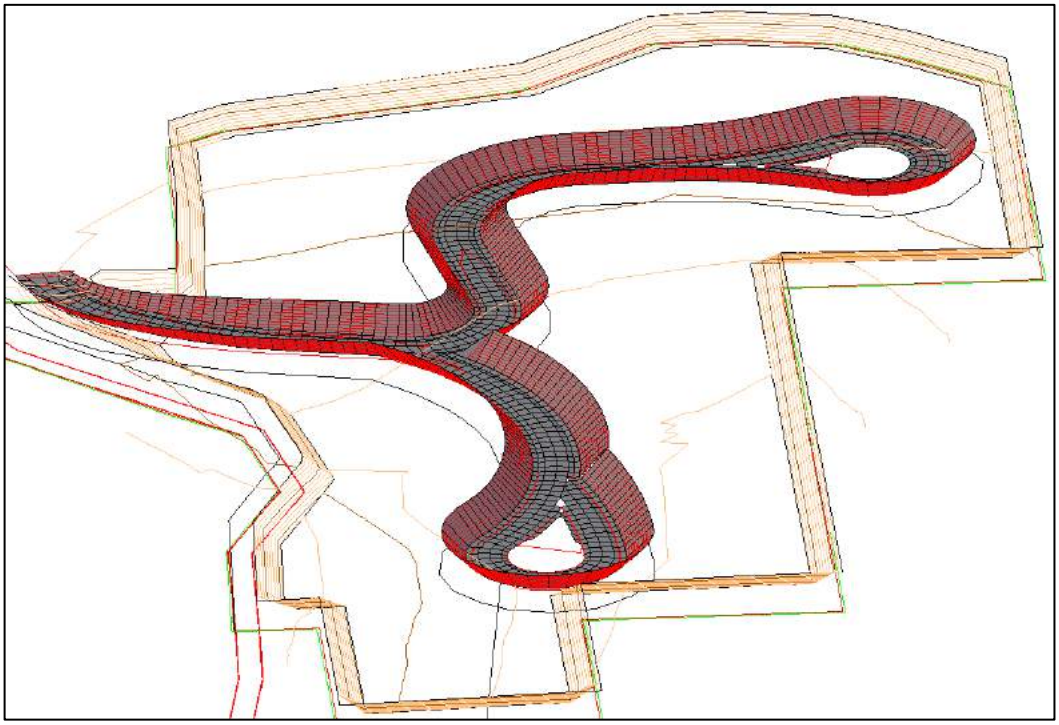
Los recorridos internos dentro de la explotación se encuentran entre 0 y 2500 m hasta la parte más alejada del polígono de explotación y su recorrido es variable según el avance del proceso de extracción de material. A continuación, en la **Figura 32** se muestra una vista en planta de las vías necesarias dentro del polígono de placa LFH-14431X para conectar las áreas de explotación y la vía interna para las fases planteadas (fase 1 y fase 2). De igual forma se presenta una visualización en 3d de etas vías. (**Figura 33**)

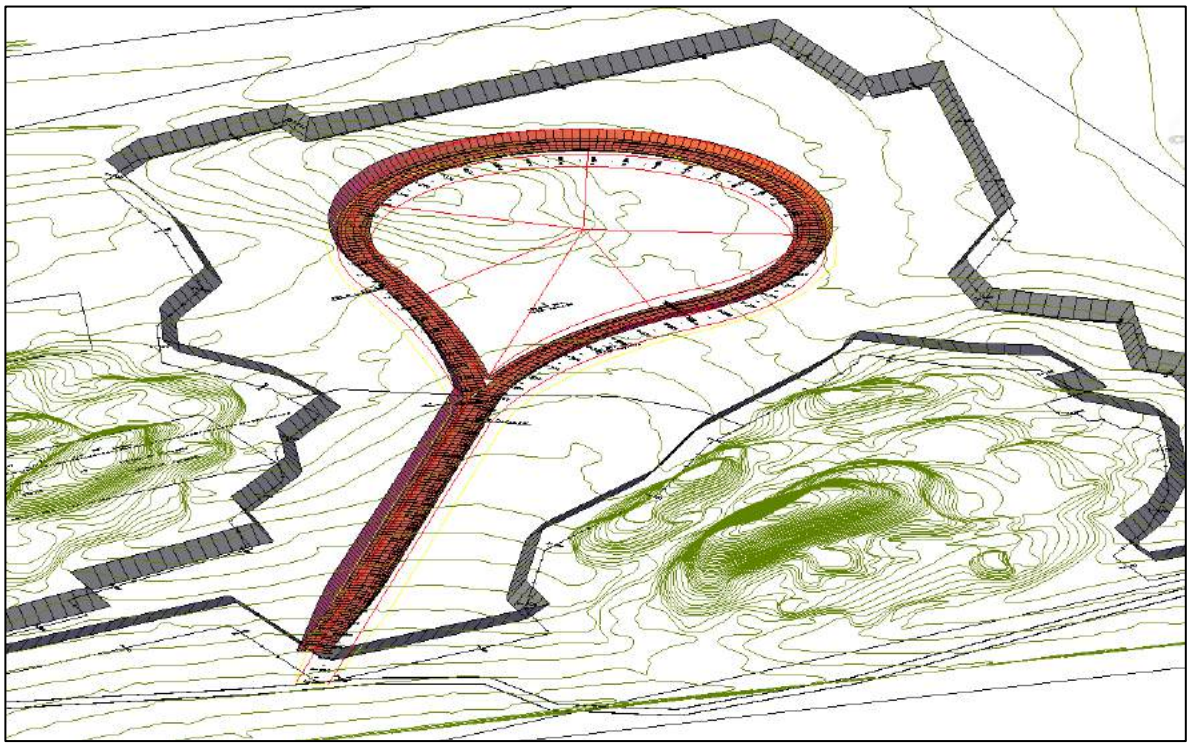
Figura 32. Planta de las vías internas del proyecto



Fuente: Autores

Figura 33. Perspectiva isométrica de las vías internas del proyecto





Fuente: Autores

5.2.2 Camp

For the housing of personnel, hand tools and other supplies and implements, an area of approximately 200 m2 will be set aside within the same exploitation polygon, which has sanitary services, a septic tank and the construction of an artificial wetland.

5.2.3 Warehouse

Within the same area, a sector of approximately 77 m2 will be adapted for the storage of the mined ore. The offices will be located in the same area.

5.2.4 Desander or Sedimenter

A sand trap will be built to decant the sludge generated after washing the material. This settler has dimensions of 8.0 m x 1.70 m x 1.50 m, which will also serve for the recirculation system of the washing water. This system consists of taking the water from the settling tank and transferring it to the hoses where the water will be sprayed again to wash the material, so that water consumption does not generate negative impacts on the stream, from which the water will be collected, with prior permission from the Corporation.

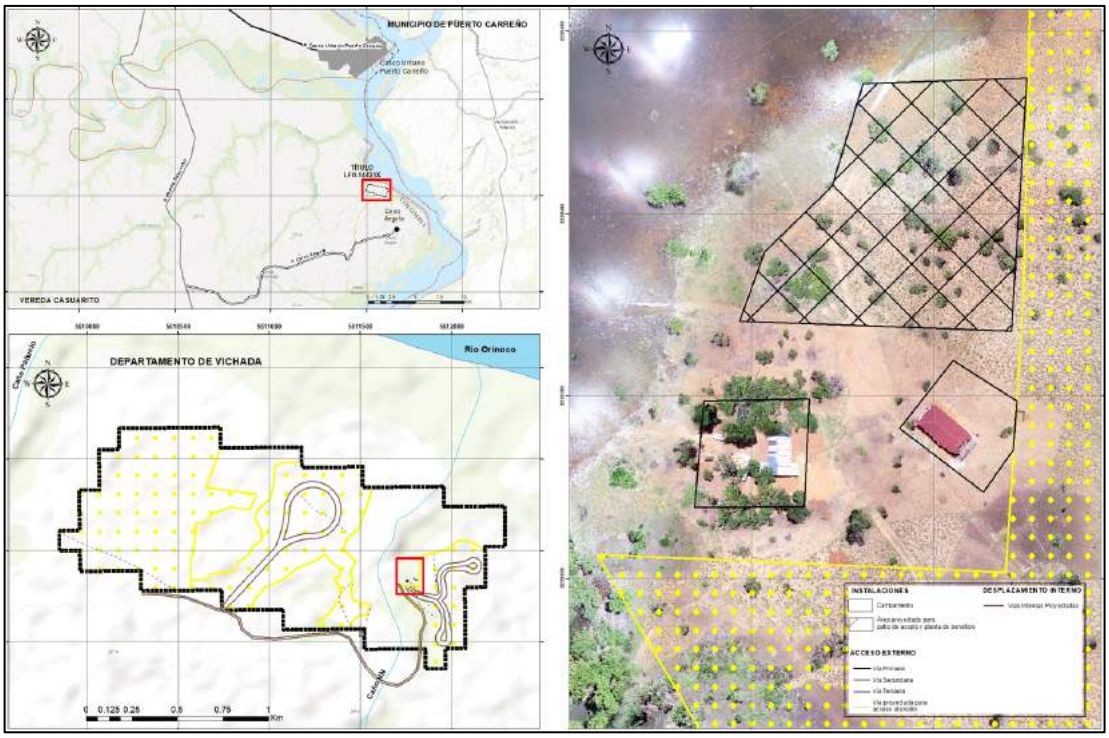
5.2.5 Processing plant

A strategic area will be adapted inside the exploitation polygon, where a sieve will be installed to classify the material and wash it to remove the silt-clay matrix. No energy is required from the power grid for the development of the activity, since the machinery that will be used will be supplied by power plants or solar energy, when required. This plant does not foresee the need to build permanent works of art, major structures, or an aqueduct.

5.2.6 Others

Areas are set aside for the temporary location of topsoil and sterile material. The topsoil will be located in the flat areas within the polygon area and corresponding property, in order to avoid affecting neighboring properties and minimize possible impacts generated during the deposit. Below is the location of the existing and projected infrastructure required for the start of the exploitation works.

Figure 34. Location of existing and projected locations for the LFH-14431X site



Source: Authors

5.3 BENEFIT OF THE MINED ORE

Mineral beneficiation is a process which consists of a series of activities to which the material and/or mineral extracted from the exploitation fronts is subjected for its subsequent transformation. In the description of chapter 4.2 corresponding to the geology of the deposit, the stratification of the mineral of interest is identified. As an effect of this, the initial development of each of the extraction areas has been proposed.

As presented in the mining plan, the ore is loaded by dump truck from the mining front through the internal road that connects the extraction area with the area where the sieve is located. This area will be where the beneficiation stage will take place and is located in the infrastructure and support facilities plan.

5.3.1 Beneficiation process

The beneficiation system is applied to the extracted material to obtain the minerals of interest, however, for the exploitation areas within polygon LFH-14431X only 2 main activities will be carried out.

- **Washing**

This process is carried out to eliminate the mud or organic mineral that surrounds the gravel in which the minerals of interest are found. This washing is done in the sieve using pressurized water which comes out through sprinklers and thus eliminates these residues; the water breaks up the solids and through the sieve the classification of the mineral is done separating it into coarse material (gravel) and fine material which will be used in the self-filling of the pits. Water will be taken from the Quebrada innominada (stream that crosses the polygon) through the concession request; this water will be recirculated to generate a closed-circuit pumping system using motor pumps.

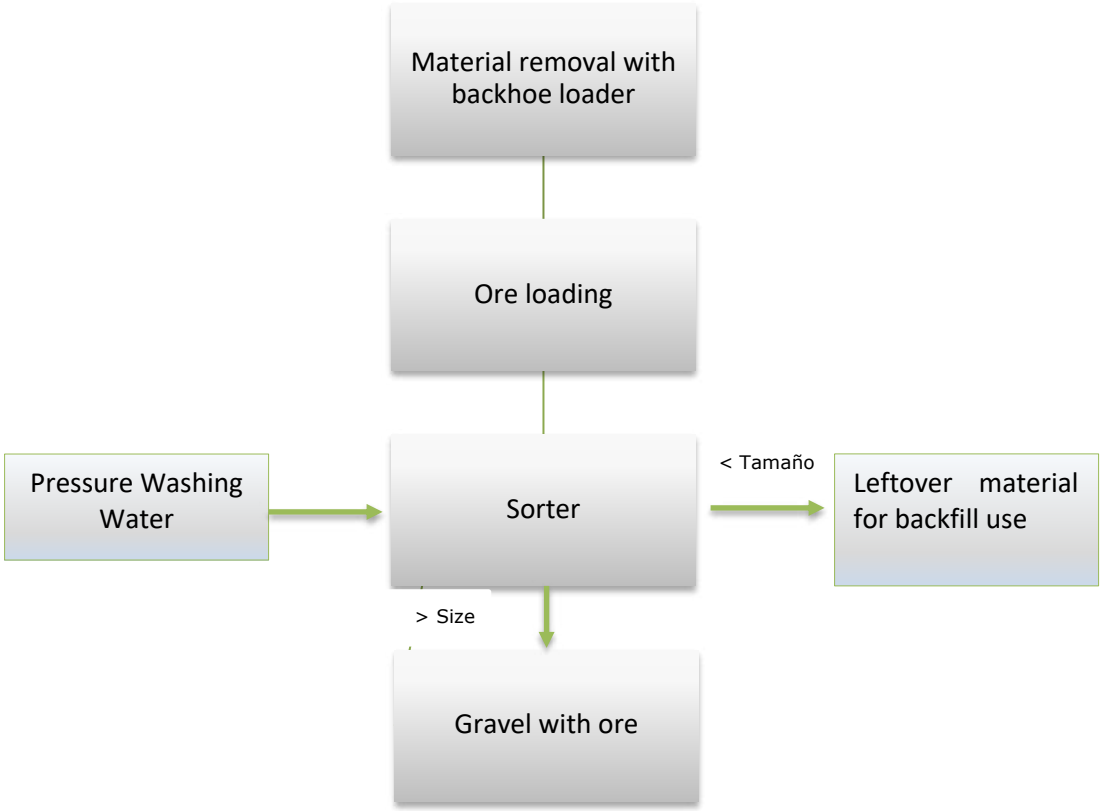
- **Clasification**

This activity consists of separating the components of the extracted material between the gravels where the minerals of interest are found from the finer grain matrix in which they are found. This activity will be carried out by means of a

static sieve screen in which the material is placed on the mesh that according to the opening retains the gravels according to the size.

As can be seen, the beneficiation process is a clean system since there will be no leaching, precipitation or amalgamation process. In addition, the use of water will be controlled considering that it will be recirculated through a closed pumping system where the water resulting from the process will go to the sedimentation pool. Once the process of obtaining the gravels is finished, the washed sands will be deposited in the cuts of the exploitation that are being finished and finally the excavation is filled with this material. The following is a diagram of the mineral beneficiation process to be used in the project.

Figure 35. Ore beneficiation process



Source: Authors

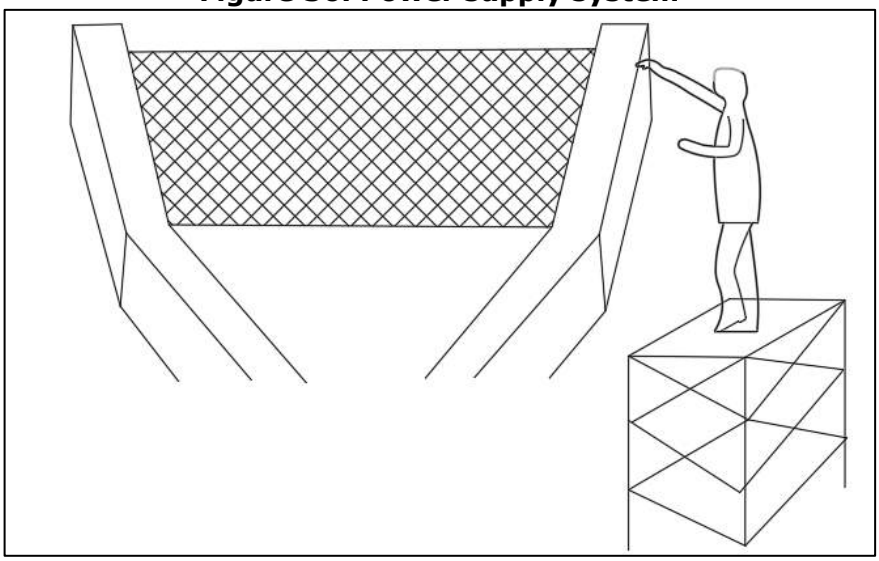
5.3.2 Beneficiatio equipment

Currently there are different methods to separate the materials; however, for the particular case of the mine, this classification process will be carried out by means of a static screen or classifier with 5/8", 3/8", 1/4" and 1/8" meshes. This

first step consists of separating the gravels of interest (concentrates) from the sandy and silty material.

The reception of the material is done through a hopper which stores the material (mixture of gravels, sands and silts) for a moment for its later selection. This hopper is made up of plates which support the loading capacity.

Figure 36. Power supply system

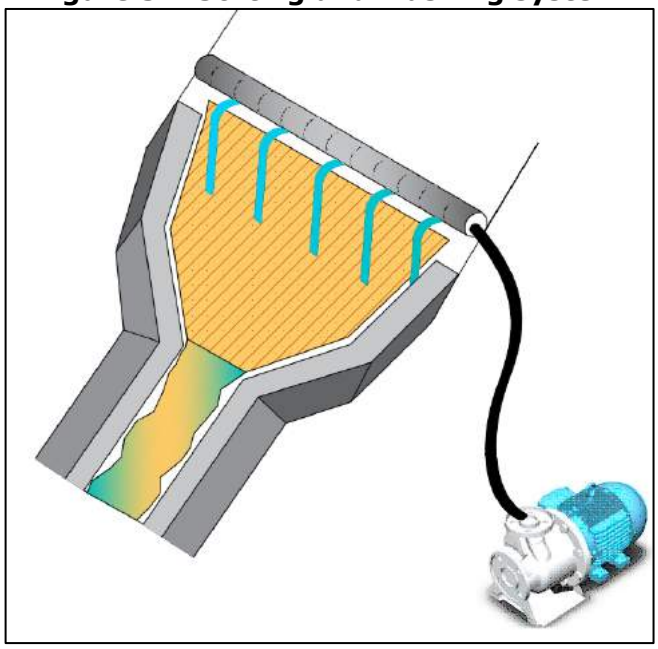


Source: Authors

Now, for the classification of the material the sieve will be used, which by means of the meshes makes the selection of the material that enters the sieve. These meshes are placed one on top of the other and their separations correspond to those mentioned above. The screen will be approximately 2 meters long, 1.80 m wide and 1.50 m high. This screen will be static, so the people in charge of the beneficiation plant will have to feed this equipment.

When the gravels in which the minerals of interest are found are finally obtained, they are washed by sprinklers in order to separate the sand and silt residues adhered to these gravels. Here is where a closed system for the reuse of water will be carried out, by means of recirculation through a motor pump.

Figure 37. Sorting and washing system



Source: Authors

The sludge resulting from this washing process will pass to the sand trap, which has four retention chambers that allow the particles to be retained in stages, first by sedimenting coarse particles, then medium-grained particles, and finally fine-grained particles. In this way, the water for the sprinklers will be pumped again in the last basin.

5.4 PRODUCTION

The production estimate consists of analyzing the monthly and annual evolution of the exploitation and the benefit of the extracted ore, in order to make projections for the mine. However, this production is largely linked to market variations. The activities to be taken into account for the development and estimation of expected production are described below.

5.4.1 Scale and duration of expected production

As mentioned above, the exploitation sequence will be carried out in a descending direction from a single bench, which allows starting the extraction of material from a depth of 5m in some areas and in others almost immediately; the projected slope seeks to guarantee not only the safety of the people and equipment involved in the operation but also that of the deposit, achieving a rational exploitation of the resource according to the desired production

requirements. The duration of the exploitation works as calculated in previous chapters is projected in approximately 17 years, so the projected annual production volume should be approximately 164736 m3, as it is a small scale mine. Based on the above, the following estimation of volumes per mining phase is made as shown in the following table.

Table 7. Projected annual production for operating phase No.1

Year	Annual material production (m^3)	Annual concentrate production (m^3)
First year	164,736.00	6589.44
Second year	164,736.00	6589.44
Third year	164,736.00	6589.44
Fourth year	164,736.00	6589.44
Fifth year	97905.11	3916.20

Source: Authors

Table 8. Projected annual production for exploitation phase No.2

Year	Annual material production (m^3)	Annual concentrate production (m^3)
First year	164736	6589.44
Second year	164736	6589.44
Third year	164736	6589.44
Fourth year	164736	6589.44
Fifth year	164736	6589.44
Sixth year	164736	6589.44
Seventh year	164736	6589.44
Eighth year	164736	6589.44
Ninth year	164736	6589.44
Tenth year	164736	6589.44
Eleventh year	164736	6589.44
Twelfth year	164736	6589.44
Thirteenth year	103645	4145.78

Source: Author

For the exploitation of this second phase, and having financial support from the first phase, it would be possible to increase the machinery and thus double the production and reduce the exploitation time by half. It is emphasized again, that these phases will be developed in a progressive way, once one exploitation area is finished, the next one is started.

5.4.2 Machinery, equipment and tools

As mentioned in the exploitation work, for the execution of the extraction, loading and transport, equipment or tools are needed to allow the efficient

development of the same. Taking into account the analysis of the type and scale of exploitation, the equipment that meets these needs corresponds to conventional machinery. In the case of the project, a tracked excavator of at least 15 tons is used, which provides better efficiency, and a simple dump truck. If required, the number of mining equipment will be increased.

The calculation of machinery performance aims to establish the hourly production of the operating costs of the machinery involved in loading and transporting the extracted ore. This analysis is carried out for the start-up, loading and transport machinery such as the dump truck and the backhoe loader, given their importance in the exploitation.

- **Hourly efficiency (E)**

Generally, the machinery used in the mining process does not work at 100% during a production hour, due to unavoidable delays such as mechanical maintenance, operator rest, transfer to the work site, among others. The mentioned losses and load variations are a key element to determine the real performance of the machinery; for this purpose it is necessary to implement an element of efficiency in minutes per hour, called hourly efficiency, as shown in the following figure. **Table 9.**

Table 9. Hourly efficiency of the equipment designed for the operation of the polygon.

Machinery	Hourly efficiency
Backhoe	50 minutes
Dump truck	50 minutes

Source: Authors

- **Expansion coefficient (I)**

The material being mined undergoes expansion in the start-up phase as it passes from a confined state to a free state. This is why an analysis of the volume of expanded material and the volume of tailings or unusable material must be carried out to determine the volume of minerals to be transported. Generally, a factor corresponding to 30%, i.e. 0.3, is used.

- **Machinery capacity (H)**

The capacity of the machinery depends on the specifications of each of the pieces of equipment to be analyzed; in this case, the capacity corresponds to the size of the bucket of the backhoe and the bucket of the dump truck. Considering that the exploitation is on a small scale, the machinery present in the area will be the

one that allows for the function of grubbing, loading and transporting. This is reflected in conventional tracked machinery and simple dump trucks.

Table 10. Maximum machinery capacity

Machinery	Maximum capacity
Backhoe	1.0 m^3
Dump truck	6 m^3

Source: Authors

Cycle time (c)

The cycle is represented as the time in minutes that the machine takes to load the material into the dump truck where a cycle would be completed; this is for the case of the backhoe loader. For the analysis of the dump truck, the cycle begins at the moment of receiving the load, transporting it to the sieve area, emptying the material and returning to the mining area. That said, these cycles represented in the duration time of a process are shown below.

Table 11. Cycle time of a backhoe loaders

Backoe loaders	Time in minutes
Time for loading	0.18
Turning time with ladle loaded	0.15
Time for unloading the bucket	0.1
Turning time with empty bucket	0.13
Additional time for possible delays	0.22
Total cycle time	**0.78 = 1 min 18 sec**

Source: Authors

Table 12. Cycle time of a dump truck

Single dump truck	Time in minutes
Time for material loading	6.0
Time for full transport	9.0
Time for material unloading	1.0
Empty transport time	7.0
Time for maneuvering	1.0
Machine efficiency	80%
Total cycle time	**30 min**

Source: Authors

Now, taking into account that the duration of the cycles has already been projected, the volume of material per hour can be calculated.

Table 13 Production associated with the equipment per cycle

Machinery	E(min/hour)	I	H(m^3)	C(min)	P(m^3/h)
Backhoe	50	0.3	1.0	1.3	45.5
Dump truck	50	0.3	6.0	30	7.0

Source: Authors

5.4.3 Needed team

The personnel required for the mining operation will be hired with a fixed salary, legal benefits and social security. In addition, a single 8-hour shift is planned, 24 working days per month and 288 working days per year. Below is the minimum personnel required for the development of the mining phases in **Table 14.**

Table 14. Minimum operating personnel required for the mining project

Position	Quantity
Mining Engineer	1
Backhoe Loader Operator	1
Backhoe operator assistant	2
Dump truck driver	2
Beneficio	2
Watchman	2
Warehouseman	1
Kitchen	1
Various trades	2
Environmental Engineer	1
HSE Professional	1

Source: Authors

5.5 SCHEDULE OF MINING ACTIVITIES

In the schedule of activities you can see the different times of the development and exploitation stages that will be carried out during the duration of the project.

Table 24. Schedule of mining activities

STAGES AND ACTIVITIES OF THE PROJECT	YEARS																
	0-5 years					5-10 years					10-15 years					15-17 years	
Construction and Assembly Work																	
Adequacy of internal roads	■		■		■		■		■		■		■		■		■
Assembly of the beneficiation plant	■																
Signaling	■				■					■					■		
Preparation work																	
Clearance	■			■			■			■			■			■	
Stripping	■			■			■			■			■			■	
Adequacy of afferent areas for the deposit of stripping and sterile	■			■			■			■			■			■	
Exploration work																	
Phase 3	■																
Exploitation Work																	
Phase 1	■	■	■	■	■	■											
Phase 2							■	■	■	■	■	■	■	■	■	■	■
Phase 3												■	■	■	■	■	■

Source: Authors

5.6 INVESTMENTS AND OPERATING COSTS

For the development of mining activity, an investment is required for construction and assembly work, exploitation work, profit and also the costs associated with labor. Below is a projection of costs corresponding to the aforementioned activities.

5.6.1Investments

Table 25. Equipment and machinery costs

Team	Quantity	Unit cost USD	Total cost USD
Backhoe loader	2	$91,407.44	$182,814.88
Dump truck	2	$61,895.89	$123,791.79
Camp	1	$7,834.92	$7,834.92
Internal road adequacy (Km)	2.5	$3,917.46	$9,793.65
Processing Plant	1	$141,028.62	$141,028.62
TOTAL			**$465,263.87**

Source: Authors

5.6.2 Costs

The valuation of the different costs associated with the stages of the mining project is observed in the following tables.

Monthly cost of labor

Description	Quantity	Monthly salary USD	Benefits USD	Total month USD
Mine engineer	1	$1,044.66	$501.44	$1,546.09
Supervisor	1	$783.49	$376.08	$1,159.57
Environmental engineer	1	$1,044.66	$501.44	$1,546.09
HSE Professional	1	$783.49	$376.08	$1,159.57
Retro operator	2	$522.33	$250.72	$1,546.09
Retro helper	2	$313.40	$150.43	$927.65
Dump Driver	2	$522.33	$250.72	$1,546.09
Benefit	2	$313.40	$150.43	$927.65
Watchman	1	$313.40	$150.43	$463.83
Mechanical	1	$652.91	$313.40	$966.31
Kitchen room	2	$313.40	$150.43	$927.65
Various trades	1	$313.40	$150.43	$463.83
TOTAL				$13,180.43

Source: Authors

Table 27. Input costs

Supplies	Quantity	Total monthly (USD)
Lubricant	/	520
Fuel	/	9,360
TOTAL		**9,880**

Source: Authors

Tabla 15. Administrative costs

Description	Quantity	Total monthly (USD)
Administration	/	$3,120
Feeding	/	$1,820
Environmental management	/	$2,109
TOTAL		**$7,049**

Source: Authors

Tabla 16. Maintenance costs

Description	Quantity	Total monthly (USD)
Maintenance	/	$2,886
Spare parts	/	$624
TOTAL		**$3,510**

Source: Authors

Tabla 17. Summary of monthly production costs

Description	Quantity	Total monthly (USD)
Administration	/	$7,049
Workforce	/	$10,428
Supplies	/	$9,880
Maintenance	/	$3,510
TOTAL		**$30,867**

Source: Authors

6. MARKET STUDY

6.1 MARKET ANALYSIS FOR COLTAN

The vast interest that technology companies have developed for metallic minerals such as Columbite [(Fe, Mn) Nb2O6] and Tantalite [(Fe, Mn) Ta2O6], the former being a compound of Iron and Niobium Oxide, and the latter It is rich in Tantalum, Iron and Magnesium, in recent years, they have given way to the diversification of mining in different countries, generating a greater tendency to explore new areas with the possible presence of these minerals. The combination of the minerals Columbite and Tantalite make up rocks known as Coltan, which are relatively rare in nature. According to the studies that have been carried out worldwide for the knowledge of Coltan, the main countries that are in charge of the extraction of these rocks correspond to Brazil, Australia and Canada, where the work is carried out in an industrialized way, and to the Democratic Republic of the Congo, where the extraction is mainly done by hand and illegally.

For its part, the extraction of Coltán in Colombia is currently being carried out in the departments of Vichada and Guainía, where the activities are not legalized, taking into account that there is currently no mining title in the exploitation stage of this mineral. According to the Mining and Energy Planning unit (UPME) and the Colombian Mining Information System (SIMCO), in 2012 the Colombian Geological Service identified a potential area of Coltán in the departments of Vichada and Guainía, being the department of Vichada the one produced by Niobio in the years 2014, 2015 and 2016 according to the National Mining Agency (ANM); Therefore, for the year 2016 a total of 9 million pesos in royalties was obtained.

The following is a summary of the national balance in current quantities and pesos for the production of Coltán in Colombia during the years 2012 to 2016.

Table 31. National Balance - Quantities

Unit MEASURE	OFFER		UTILIZATION	
	IMPORT	PRODUCTION	CONSUMPTION	EXPORT
Kg	0	1.463	0	1.463
		7.715		7.715
		1.000		1.000
		22.591		22.591
		702		702

Source: UPME, 2021

Table 32. National Balance - Current Pesos

Unit MEASURE	OFFER		UTILIZATION	
	IMPOR	PRODUCTION	CONSUMPTION	EXPORT
Pesos	0	1'366.109	0	1'366.109
		10'401.223		10'401.223
		1'551.664		1'551.664
		47'403.137		47'403.137
		1'929.385		1'929.385

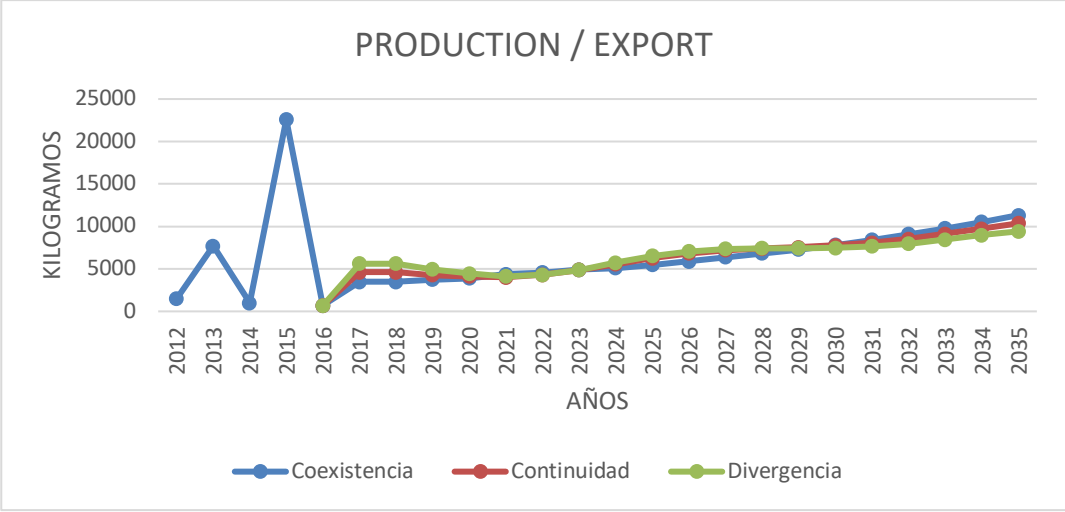
Source: UPME, 2021

Table 33 Analysis of coexistence, continuity and divergence for Coltán

COEXISTENCE	CONTINUITY	DIVERGENCE
For coexistence between 2018 and 2035, Coltán will have a compound annual growth rate of 7.18%. Given the projection made from the GDP of mines and quarries of the UPME; Known the limitations in data on Coltán in the country, the projection was carried out considering also information from DANE and CRU consulting.	For continuity between 2018 and 2035, Coltán will have a compound annual growth rate of 5.69%, based on the projections of the historical series of the mineral	For divergence between 2018 and 2035, coltán will have a compound annual growth rate of 4.10% from the projection made from the GDP of mines and quarries of the UPME; known the limitations of the data on Coltan in the country. The projection was carried out also considering information from DANE and CRU consulting.

Source: UPME, 2021

Figure 57. Analysis of coltan production vs. export



Source: UPME, 2021- Modified by authors

Taking into account that in Colombia there is no industrial activity that requires the implementation of Niobium or Tantalite at this time, the registered productions were used only for export.

6.1.1 Uses of Coltan

Coltan has different uses depending on the chemical element that is extracted from it, corresponding to Tantalum or Niobium. Therefore, the uses for each of these elements are summarized below.

6.1.1.1 Uses and applications of Tantalum

According to the TIC (Tantalum-Niobium International Study Center), Tantalum is used mainly for the aerial part, technology and health. In these three application areas, the consumption of this metal is due to its use in capacitors for electronic equipment. These capacitors correspond to components that store electrostatic energy and are used in a wide variety of electrical and electronic devices that are available to a large part of the world population, such as cell phones, GPS, plasma televisions, laptops, among others. ; likewise, it is used in automobile systems and air turbines to produce electricity.

Table 34. Some of the products, applications and benefits of Tantalum

TANTALIUM PRODUCT	APLICATION	BENEFITS
antalum Oxide	Capacitors, lenses for glasses, digital cameras, mobile phones, X-ray films, printers.	Tantalum capacitors offer high reliability, high temperature resistance, a wide capacitance range, and can be manufactured in very small sizes. Tantalum oxide provides a high refractive index, so the different types of lenses that are manufactured can become much thinner and smaller, versus lenses that are manufactured with other types of elements. As for X-rays, the exposure to them is reduced and the quality of the images is improved. It has positive characteristics against the wear of the materials used in this product.
Tantalum powder	Tantalum capacitors for electronic circuits in:	Tantalum powder works in a wide range of temperatures, going from -55 to +200 ° C, it can withstand very strong vibratory forces, and its main

TANTALIUM PRODUCT	APLICATION	BENEFITS
	- Medical devices such as hearing aids and pacemakers. - Automotive components such as ABS brakes, Airbag activation, and GPS. - Laptops, mobile phones, video, photographic and digital cameras; DVD players, TV's, battery chargers.	characteristic in electronic devices is its great electrical storage capacity vs the size of the elements that use this product.
Sheets, plates, rods and wires made of tantalum	These products are widely used in the health sector, creating devices for humans developed as prostheses for hip joints, skull plates, meshes to repair bones, stents for blood vessels, among others.	Its main benefit is that it is highly bio-compatible.

Source: (TIC, 2021)

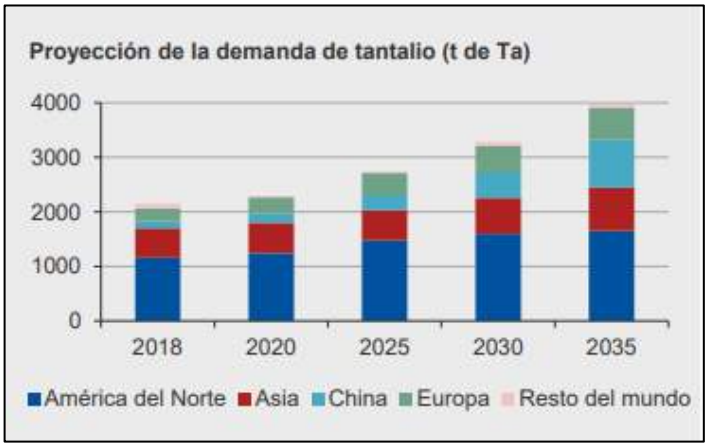
6.1.1.2 Tantalum Industry Overview

- **Demand the Tantalum**

The main marketable tantalum product is tantalum powder, produced from concentrates containing tantalum pentoxide (Ta2O5). This powder is used to produce tantalum wires and sheets, which are then used in the manufacture of capacitors and metallurgical products.

North America will remain the main consumer, followed by Asia and with China emerging as a major player in the market. Tantalum demand is forecast to rise from 2,100 tons to 4,000 tons in 2035. This represents a growth rate of 3.6% per year in line with application demand.

Figure 58. Tantalum demand projection

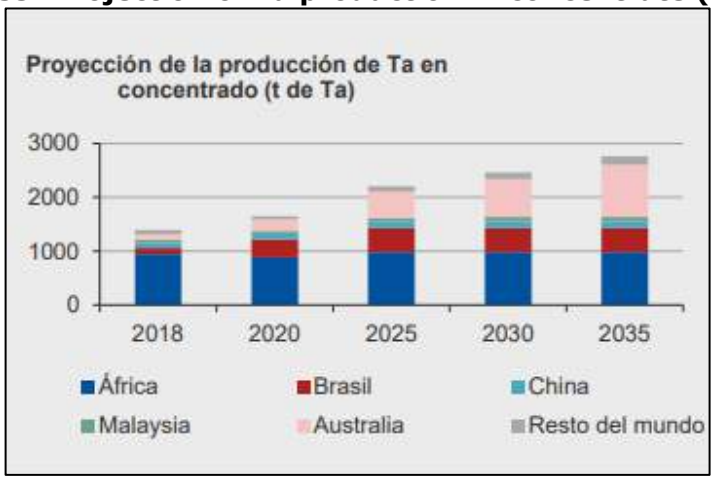


Source: (UPME, 2018)

Tantalum Offer

Future Tantalum production will continue to dominate in Africa followed by Brazil and Australia. The main potential competitor for Colombia is Brazil.

Figure 59. Projection of Ta production in concentrate (t) of Ta



Source: (UPME, 2018)

Tantalum price projection

According to historical records up to 2017, tantalum production has consistently met demand, even with surpluses. An increase in the supply of derivatives is estimated, being able to generate a constant panorama due to the rise in demand for tantalum from 2,100 tons to 4,000 tons in 2035. In addition, it is observed that prices could fall or have some fluctuations, but the projected minimum price would be up to US $ 150 / lb Ta2O5.

Figure 60. Price projection from 2018 to 2035 of Qo2O5

Source: (UPME, 2018)

6.1.1.3 Uses and applications of Niobium

For its part, Niobium is used in the areas of science, in the generation of magnetic resonance images and in constructions that use low-alloy and high-strength steels, according to the information provided by the TIC.

T Table 35. Some of the products, benefits and applications of Niobium

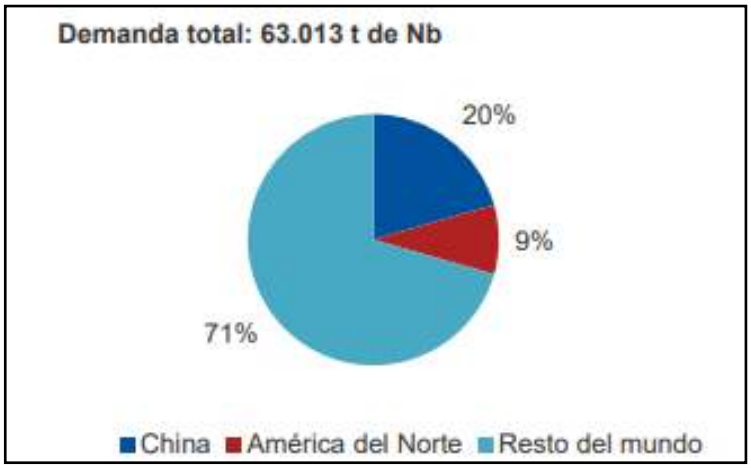
TANTALIUM PRODUCT	APLICATION	BENEFITS
Ferroniobium (FeNb) HSLA	Niobium additive for low alloy steel and stainless steel that presents a high resistance; used in oil and gas pipelines, car bodies, ship hulls and railways.	The addition of niobium increases the strength and toughness of the steels, reducing their weight and generating a refining of the grains that compose it.
Niobium powder	Niobium capacitors for electronic circuits.	High dielectric constant and dielectric oxide stability.
Niobium sheets, wires, rods and pipes	Cathodic protection systems for large steel structures. Chemical processing equipment.	High resistance to corrosion, oxidation and high temperatures.

Source: (TIC, 2021)

- **Niobium demand**

According to a study by the Mining and Energy Planning Unit - UPME, the highest intensity of Niobium use is found in North America, where the steel production industry is more focused on HSLA steels and super alloys. According to this study, an increase in intensity of use of a nominal 2% is expected in China, for North America a growth of 0.5% is expected, due to the fact that the steel industry is more mature than in China. In the rest of the world, a growth factor of 1.5% in intensity of use of Ferroniobio is forecast.

Figure 61. Percentage of Tantalum Consumption by Region



Source: (UPME, 2018)

For the demand for specialty niobium products, a nominal increase of 1% p.a. is expected. between 2018 and 2035. In general, with the increase in the demand for specialized products with niobium, it is observed that the total demand increases from around 60,000 tons in 2018 to 98,000 tons in 2035, which represents an increase of 63% over the period , averaging 2.75% per year.

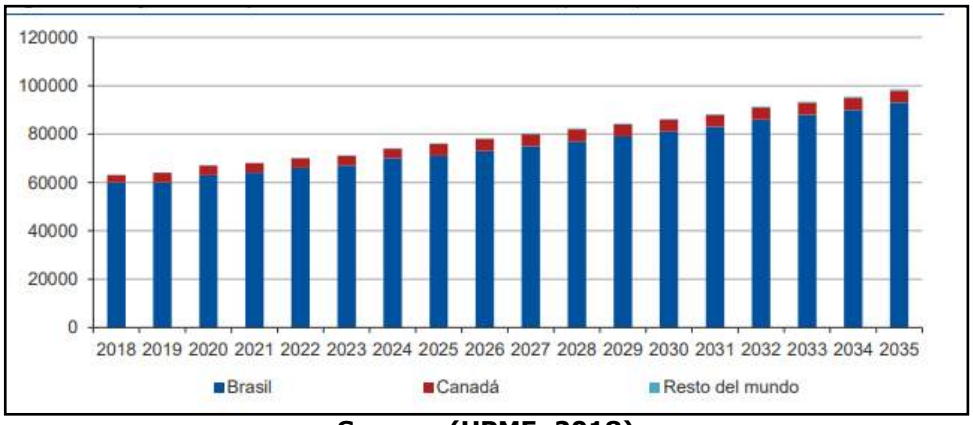
Figure 62. Projection of Niobium demand, 2018 to 2035 (t of Nb)

Source: (UPME, 2018)

Niobium offer

According to historical studies, the Niobium production chain from the mineral to the refined product or specialized product is almost completely integrated and dominated by two companies: CBMM from Brazil and Niobec from Canada.
CBMM is definitely the largest producer and the main competitor for Colombia, producing niobium chemicals and specialized alloys. The current capacity of ferroniobium is about 180,000 tons of Ferroniobium, then the projection of Niobium production from 2018 to 2035 according to a report from the Mining and Energy Planning Unit - UPME.

Figure 63. Niobium production projection, 2018 to 2035 (t of Nb)

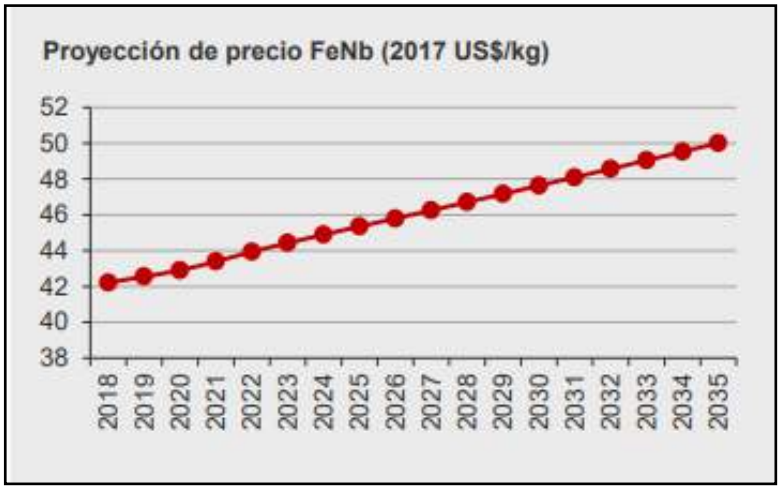


Source: (UPME, 2018)

Niobium price projection

Figure 64 shows a stable trend in the price through the sale control provided by Brazil, it is expected that a stable price will remain with inflationary adjustments of around 3% p.a. A "stabilizing price" is around US $ 40 / kg for Ferroniobio.

Figure 64. Price projection from 2018 to 2035 of FeNb



Source: (UPME, 2018)

6.2 ANALYSIS OF THE GOLD MARKET

Globally, the demand for gold is based mainly on the manufacture of jewelry (72%), to a lesser extent electronic products (12%), coins and medals (12%), dental applications (1%) and other manufacturing (3%). In this sense, the demand linked to manufacturing (whatever the end use) refers to gold that has been manufactured from its initial state, normally gold bars, to a finished or semi-finished product. On the other hand, gold bars without further processing or manufacturing are used for investment purposes due to the intrinsic value of the metal and its considerably lower risk of losing value compared to general currency or paper money.

This mineral is found in a wide variety of forms in nature, including porphyries, mantles, veins, and alluvial deposits. In general the grades are low between 0.6 and 1 gram of gold per ton of mineral. Due to these low grades, a high level of technology is needed to be able to recover the metal from the mined ore.

According to the National Mining Agency (ANM), in Latin America Colombia is the 5th gold producer with an approximate of 41 tons produced in 2017. The main gold producers in the region are Peru with 155 tons in 2017 and Mexico with 110 tons in 2017.

According to BMI Research, it is estimated that by 2027 the production of Gold in Colombia will reach 59.8 Tons, which represents an approximate growth of 23% for the period 2018 - 2027.

Currently, this mineral is exploited in 24 departments of Colombia.

Figure 65. Mineral production by regions

- ✓ Amazonas
- ✓ Antioquia
- ✓ Atlántico
- ✓ Bolívar
- ✓ Caldas
- ✓ Caquetá
- ✓ Cauca
- ✓ Choco
- ✓ Córdoba
- ✓ Guainía
- ✓ Guaviare
- ✓ Huila
- ✓ Guajira
- ✓ Magdalena
- ✓ Nariño
- ✓ Putumayo
- ✓ Quindío
- ✓ Risaralda
- ✓ Santander
- ✓ Sucre
- ✓ Tolima
- ✓ Valle del Cauca
- ✓ Vaupés
- ✓ Vichada

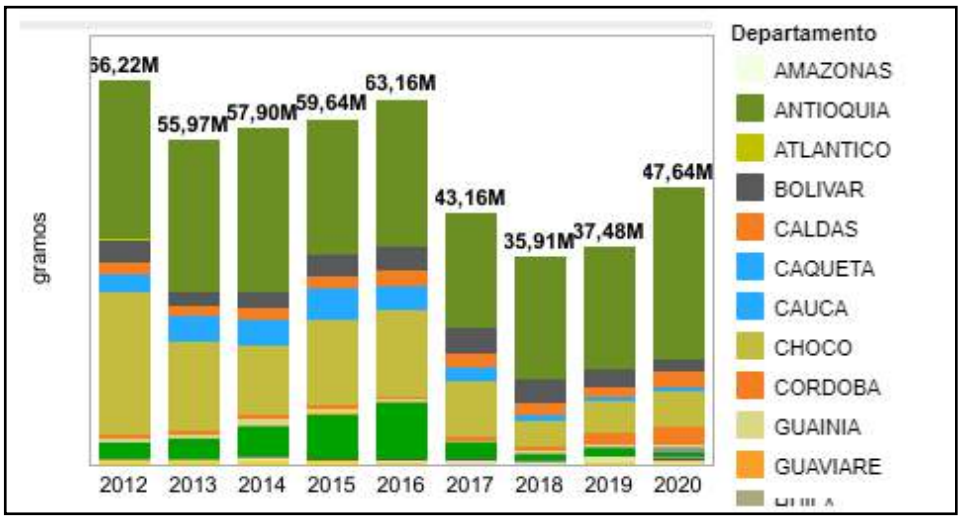
Source: National Mining Agency (ANM)

6.2.1 Gold offer

The Ministry of Mines and Energy, and the National Mining Agency ANM, informed the country about the production of minerals corresponding to the year 2020. As for gold, According to the official figures of the National Government, in 2020 a production of 47, 6 tons of gold, 29.9% more than in 2019 when it registered 36.67 tons.

The record result of the last four years means a significant increase in the generation of taxes and royalties for the Country. Next, the production statistics by department are listed.

Figure 66. Gold production by regions



Source: (UPME, 2018)

Regarding the continuity scenario, coexistence production shows a growing trend between 2018 and 2021 due to the following points:

- Entry into the Buriticá project of Continental Gold in 2019 at an average production rate of 8.2 tons per year, for 14 years.
- Entry into the San Ramón project in 2019 for 12 years at a production rate of 1.6 tons per year. Use of the San Ramón project plant to benefit up to 1.6 tons of production collected from small mining.
- Entry into Anglogold's Gramalote project in 2021 for 12 years at a rate of 8.8 tons per year.
- Cisneros de Antioquia Gold project entry comes into operation in 2019 for 7 years at a rate of 1 ton per year.

However, in 2026 the Cisneros de Antioquia Gold project will go out, causing production to drop by 1 ton, in 2032 the Anglogold's Gramalote project will go out of production, reducing production by 8.8 tons.

It is expected that with these new projects that go into production for this year 2021 and 2030, exports will present a relatively stable behavior and in line with what is evidenced in production and the international price.

6.2.2 Mining and producer titles

An estimated 35% of gold mining titles are in Antioquia, followed by Bolívar (13%), Caldas (11%) and Tolima (11%). Finally, it is estimated that the intervened area for gold exploitation in Colombia corresponds to 0.014% of the national territory

According to the 2017 Mining balance, Colombia currently has:

- 402 titles in Exploration
- 661 titles in Construction and Assembly
- 898 titles in Exploitation.

The country also has 5 main gold producers who are

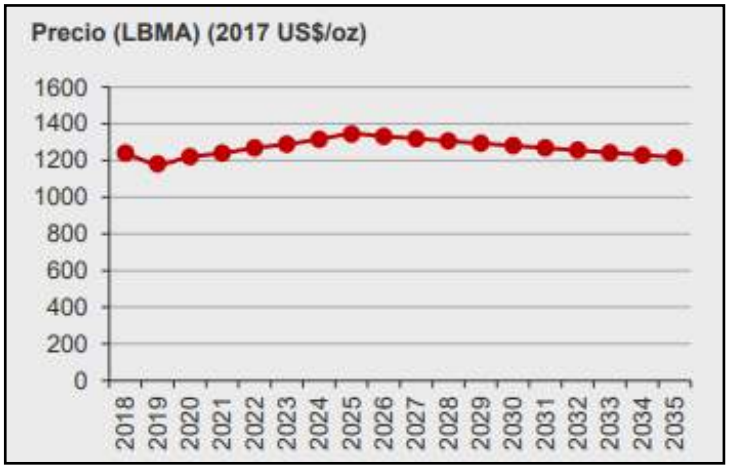
1. Gran Colombia Gold
2. Mineros SA
3. Continental Gold
4. Atico Mining Corp
5. Red Eagle

The main markets to which Colombia exports jewelry are Mexico, Peru, the United States and the European Union, Brazil, Chile, Peru, Costa Rica and South Korea.

6.2.3Gold Price

It is estimated that it should remain in the range between US $ 1,200 and US $ 1,300 / oz. With an increasing trend towards 2025 and then with a decreasing trend in line with the long-term marginal cost of production.

Figure 67. Projection of Gold Price per Ounce from 2018 to 2035



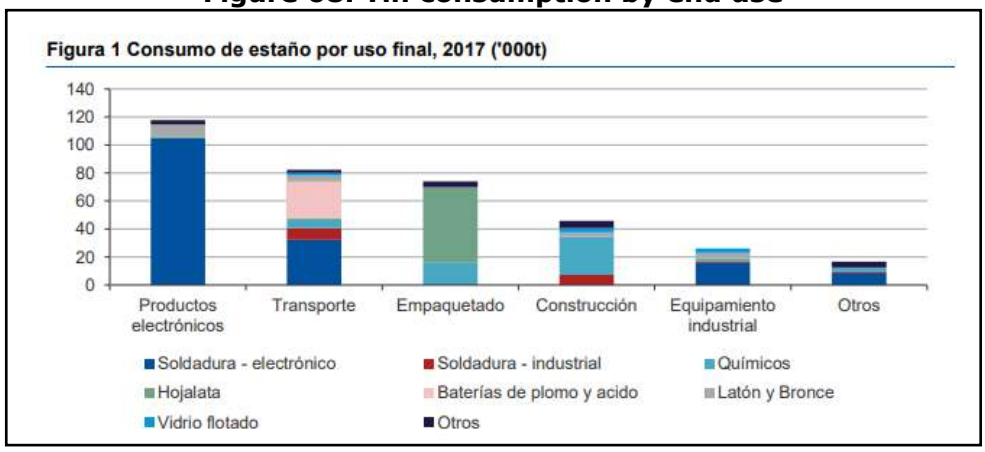
Source: (UPME, 2018)

6.3 MARKET ANALYSIS

6.3.1 Determinants of Tin demand and its final uses

Tin is a vital ingredient in the production of a wide range of products, including computers and other consumer electronic devices, packaging and construction products, automobiles, and other forms of transportation. The demand for tin is driven by a combination of developments in the overall global economy, more specifically by the primary use of the metal in the manufacture of solders, chemicals and tinplate, which account for around 80% of total tin consumption. Some industries see tin as a necessary but tertiary input to the process. The intensity of use for transportation, packaging and construction is low. The mix of production and demand in each segment makes this an unusually diverse market. Furthermore, the increase in lead-acid batteries, which represent a significant portion of the transport demand, results from the increase in the volume of batteries and intensity of use of tin.

Figure 68. Tin consumption by end use



Source: (UPME, 2018)

- Solders are an important end-use market for tin. In 2017, almost 173 kt of tin was consumed in solder production. This sector accounted for almost half of the global demand for refined tin.

- The use of tin in chemicals as a stabilizer for plastics and as an active catalyst is extensive, and one of its main uses is in PVC, especially for window and roof profiles. However, pressure from environmental campaigns and cheaper calcium-zinc products have eliminated the use of tin in technologically specialized sectors, such as clear PVC corrugated roofs.

- One of the most promising developments for tin chemicals is shale gas and oil fracking fluids, where several tin products are already on the

market in the US. When fracking iron-rich areas, tin acts as an Iron Reducing Agent (or Iron Reducing Agent, IRA), preventing iron oxide from allowing fluid flow and improving production.

- The third largest consumer market is tinplate production. This product (steel with a thin layer of tin) is used for the packaging of food, beverages and other elements, and represents 14% of the global demand.

6.3.2 Mining titles and producers in Colombia.

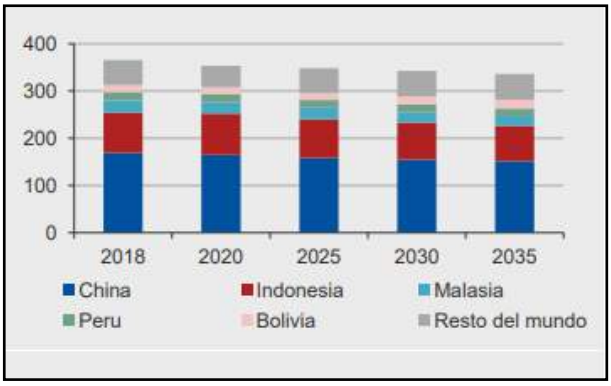
According to the National Mining Agency in the departments of Guainía and Vichada, Tin has been produced since 2014. According to the National Mining Agency, as of 2017 the tin reserves in the country are valued at $ 6.67 million pesos.

As of 2017, RUCOM has published 3 mining titles associated with Tin. All are located in the municipality of Magüí Payán - Nariño and are in the status of "Title in force - in execution". No projects are identified that are currently in the mineral exploration / exploitation phase.

6.3.3 Tin Offer

Global tin production has remained stable in recent years, with a refined tin production of 363 kt and a mine tin production of 316 kt in 2017. The difference between the two corresponds to about 47 kt of tin production secondary refining. Today China and Indonesia dominate production, both accounting for nearly 70% of refined supply and 40% of mine supply in 2017.

Figure 69. Projection of supply in thousands of tons



Source: (UPME, 2018)

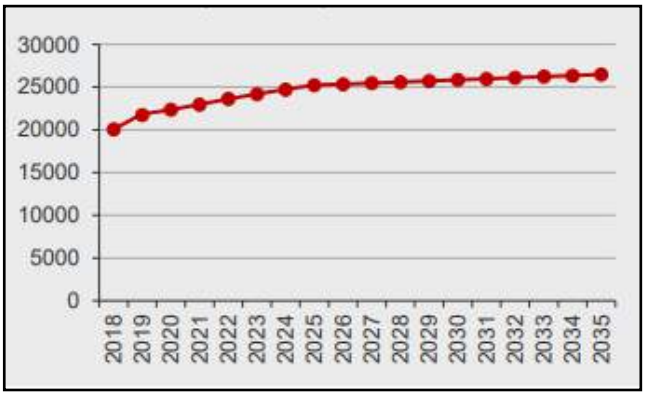
China and Indonesia will remain as the two main producers worldwide, accounting for 67% of supply by 2035. China will remain the main producer. Tin production will fall from 169 kt in 2018 to 151 kt in 2035 due to a drop in

domestic demand and the consequent closure of tin mines. Indonesia's annual production will also fall, from 85 kt to 75 kt for the period 2018-2035 due to a decrease in ore grades, resulting in cost increases and production declines.

6.3.4 Tin Price

Prices are expected to remain supported by resource depletion in major producing countries, such as Indonesia and Peru, and by continued increases in production costs. Prices are projected to rise from USD20,069 / t to USD26,483 / t by 2035 as a result of market availability.

Figure 70. Tin price projection from 2018 to 2035



Source: (UPME, 2018)

7. FINANCIAL EVALUATION OF THE OPERATION

In this chapter the economic and financial part of the project is defined, with determination of the requirements during the extraction phase of the minerals, the production calculation and the profit margin of the same. For the execution of this project, there must be investments and costs associated with extraction, administration and development, as described in **chapter 5.7.**

Table 36. Financial evaluation for the exploitation polygon phase 1

CONCEPT	Year 1 (USD)	Year 2 (USD)	YEAR 3 (USD)	YEAR 4 (USD)	YEAR 5 (USD)
Production (Tn) of concentrate	11992.78	11992.78	11992.78	11992.78	7127.49
Production (Tn) of Sn	351.87	351.87	351.87	351.87	209.12
Production (Tn) of Ta	341.07	341.07	341.07	341.07	202.71
Production (Tn) of Nb	270.8	270.8	270.8	270.8	160.94
Production (Tn) of V	7.8	7.8	7.8	7.8	4.63
Production (Tn) of Zr	56.37	56.37	56.37	56.37	33.5
Selling price Sn (USD) x Kg	$ 22.00	$ 22.00	$ 22.00	$ 22.00	$ 22.00
Selling price Ta (USD) x Kg	$ 300.00	$ 300.00	$ 300.00	$ 300.00	$ 300.00
Selling price Nb (USD) x Kg	$ 43.40	$ 43.40	$ 43.40	$ 43.40	$ 43.40
Selling price V (USD) x Kg	$ 3.50	$ 3.50	$ 3.50	$ 3.50	$ 3.50
Selling price Zr (USD) x Kg	$ 0.40	$ 0.40	$ 0.40	$ 0.40	$ 0.40
Income from the sale of Sn	$ 7,813,861.05	$ 7,813,861.05	$ 7,813,861.05	$ 7,813,861.05	$ 4,643,895.14
Income from the sale of Ta	$ 103,284,164.41	$ 103,284,164.41	$ 103,284,164.41	$ 103,284,164.41	$ 61,383,332.29
Income from the sale of Nb	$ 14,941,775.78	$ 11,863,055.46	$ 11,863,055.46	$ 11,863,055.46	$ 7,050,392.28
Income from the sale of V	$ 27,540.02	$ 27,540.02	$ 27,540.02	$ 27,540.02	$ 16,367.45
Income from the sale of Zr	$ 22,758.35	$ 22,758.35	$ 22,758.35	$ 22,758.35	$ 13,525.63

Total revenue	$ 126,090,099.61	$ 123,011,379.28	$ 123,011,379.28	$ 123,011,379.28	$ 73,107,512.79
Initial investment	$ 465,263.87	$ -	$ -	$ -	$ -
Operating costs	$ 372,063.87	$ 372,063.87	$ 372,063.87	$ 372,063.87	$ 372,063.87
Transportation costs	$ 12,609,009.96	$ 12,301,137.93	$ 12,301,137.93	$ 12,301,137.93	$ 7,310,751.28
Material transformation costs	$ 50,436,039.84	$ 49,204,551.71	$ 49,204,551.71	$ 49,204,551.71	$ 29,243,005.12
Royalties Costs Sn	$ 397,269.96	$ 397,269.96	$ 397,269.96	$ 397,269.96	$ 236,103.51
Royalties Costs Ta	$ 2,179,490.41	$ 2,179,490.41	$ 2,179,490.41	$ 2,179,490.41	$ 1,295,303.93
Royalties Costs Nb	$ 1,730,411.16	$ 1,730,411.16	$ 1,730,411.16	$ 1,730,411.16	$ 1,028,409.38
Royalties Costs V	$ 49,812.54	$ 49,812.54	$ 49,812.54	$ 49,812.54	$ 29,604.34
Royalties Costs Zr	$ 360,183.01	$ 360,183.01	$ 360,183.01	$ 360,183.01	$ 214,062.18
Gross profit	$ 57,490,554.97	$ 56,416,458.68	$ 56,416,458.68	$ 56,416,458.68	$ 33,378,209.17
Depreciation	$ 46,526.39	$ 46,526.39	$ 46,526.39	$ 46,526.39	$ 46,526.39
Taxable profit	$ 57,444,028.59	$ 56,369,932.29	$ 56,369,932.29	$ 56,369,932.29	$ 33,331,682.79
Income tax	$ 20,105,410.01	$ 19,729,476.30	$ 19,729,476.30	$ 19,729,476.30	$ 11,666,088.98
Net profit	$ 37,338,618.58	$ 36,640,455.99	$ 36,640,455.99	$ 36,640,455.99	$ 21,665,593.81
Depreciation	$ 46,526.39	$ 46,526.39	$ 46,526.39	$ 46,526.39	$ 46,526.39
Cash flow	$ 37,385,144.97	$ 36,686,982.38	$ 36,686,982.38	$ 36,686,982.38	$ 21,712,120.20

Fuente: Autores

Table 37. Financial evaluation for the exploitation polygon phase 2

CONCEPT	YEAR 1 USD	YEAR 2 USD	YEAR 3 USD	YEAR 4 USD	YEAR 5 USD
Production (Tn) of concentrate	11,992.78	11,992.78	11,992.78	11,992.78	11,992.78
Production (Tn) of Sn	351.87	351.87	351.87	351.87	351.87
Production (Tn) of Ta	341.07	341.07	341.07	341.07	341.07
Production (Tn) of Nb	270.8	270.8	270.8	270.8	270.8
Production (Tn) of V	7.8	7.8	7.8	7.8	7.8
Production (Tn) of Zr	56.37	56.37	56.37	56.37	56.37
Sale price Sn (USD) x Kg	$ 22.00	$ 22.00	$ 22.00	$ 22.00	$ 22.00
Sale price Ta (USD) x Kg	$ 300.00	$ 300.00	$ 300.00	$ 300.00	$ 300.00
Sale price Nb (USD) x Kg	$ 43.40	$ 43.40	$ 43.40	$ 43.40	$ 43.40
Sale price V (USD) x Kg	$ 3.50	$ 3.50	$ 3.50	$ 3.50	$ 3.50
Sale price Zr (USD) x Kg	$ 0.40	$ 0.40	$ 0.40	$ 0.40	$ 0.40
Income from the sale of Sn	$ 7,813,861.05	$ 7,813,861.05	$ 7,813,861.05	$ 7,813,861.05	$ 7,813,861.05
Income from the sale of Ta	$ 103,284,164.41	$ 103,284,164.41	$ 103,284,164.41	$ 103,284,164.41	$ 103,284,164.41
Income from the sale of Nb	$ 14,941,775.78	$ 11,863,055.46	$ 11,863,055.46	$ 11,863,055.46	$ 11,863,055.46
Income from the sale of V	$ 27,540.02	$ 27,540.02	$ 27,540.02	$ 27,540.02	$ 27,540.02
Income from the sale of Zr	$ 22,758.35	$ 22,758.35	$ 22,758.35	$ 22,758.35	$ 22,758.35
Total revenue	$ 126,090,099.61	$ 123,011,379.28	$ 123,011,379.28	$ 123,011,379.28	$ 123,011,379.28
Initial investment	$ 465,263.87		$ -		$ -
Operating costs	$ 372,063.87	$ 372,063.87	$ 372,063.87	$ 372,063.87	$ 372,063.87
Transportation costs	$ 12,609,009.96	$ 12,301,137.93	$ 12,301,137.93	$ 12,301,137.93	$ 12,301,137.93
Material transformation costs	$ 50,436,039.84	$ 49,204,551.71	$ 49,204,551.71	$ 49,204,551.71	$ 49,204,551.71

Costs Royalties Sn	$ 397,269.96	$ 397,269.96	$ 397,269.96	$ 397,269.96	$ 397,269.96
Costs Royalties Ta	$ 2,179,490.41	$ 2,179,490.41	$ 2,179,490.41	$ 2,179,490.41	$ 2,179,490.41
Costs Royalties Nb	$ 1,730,411.16	$ 1,730,411.16	$ 1,730,411.16	$ 1,730,411.16	$ 1,730,411.16
Costs Royalties V	$ 49,812.54	$ 49,812.54	$ 49,812.54	$ 49,812.54	$ 49,812.54
Costs Royalties Zr	$ 360,183.01	$ 360,183.01	$ 360,183.01	$ 360,183.01	$ 360,183.01
Gross profit	$ 57,490,554.97	$ 56,416,458.68	$ 56,416,458.68	$ 56,416,458.68	$ 56,416,458.68
Depreciation	$ 46,526.39	$ 46,526.39	$ 46,526.39	$ 46,526.39	$ 46,526.39
Taxable profit	$ 57,444,028.59	$ 56,369,932.29	$ 56,369,932.29	$ 56,369,932.29	$ 56,369,932.29
Income tax	$ 20,105,410.01	$ 19,729,476.30	$ 19,729,476.30	$ 19,729,476.30	$ 19,729,476.30
Net profit	$ 37,338,618.58	$ 36,640,455.99	$ 36,640,455.99	$ 36,640,455.99	$ 36,640,455.99
Depreciation	$ 46,526.39	$ 46,526.39	$ 46,526.39	$ 46,526.39	$ 46,526.39
Cash flow	$ 37,385,144.97	$ 36,686,982.38	$ 36,686,982.38	$ 36,686,982.38	$ 36,686,982.38

CONCEPT	YEAR 6 (USD)	YEAR 7 (USD)	YEAR 8 (USD)	YEAR 9 (USD)	YEAR 10 (USD)
Production (Tn) of concentrate	11,992.78	11,992.78	11,992.78	11,992.78	11,992.78
Production (Tn) of Sn	351.87	351.87	351.87	351.87	351.87
Production (Tn) of Ta	341.07	341.07	341.07	341.07	341.07
Production (Tn) of Nb	270.8	270.8	270.8	270.8	270.8
Production (Tn) of V	7.8	7.8	7.8	7.8	7.8
Production (Tn) of Zr	56.37	56.37	56.37	56.37	56.37
Selling price Sn (USD) x Kg	$ 22.00	$ 22.00	$ 22.00	$ 22.00	$ 22.00
Selling price Ta (USD) x Kg	$ 300.00	$ 300.00	$ 300.00	$ 300.00	$ 300.00
Selling price Nb (USD) x Kg	$ 43.40	$ 43.40	$ 43.40	$ 43.40	$ 43.40
Selling price V (USD) x Kg	$ 3.50	$ 3.50	$ 3.50	$ 3.50	$ 3.50

Selling price Zr (USD) x Kg	$ 0.40	$ 0.40	$ 0.40	$ 0.40	$ 0.40
Income from sale of Sn	$ 7,813,861.05	$ 7,813,861.05	$ 7,813,861.05	$ 7,813,861.05	$ 7,813,861.05
Income from sale of Ta	$ 103,284,164.41	$ 103,284,164.41	$ 103,284,164.41	$ 103,284,164.41	$ 103,284,164.41
Income from sale of Nb	$ 14,941,775.78	$ 11,863,055.46	$ 11,863,055.46	$ 11,863,055.46	$ 11,863,055.46
Income from sale of V	$ 27,540.02	$ 27,540.02	$ 27,540.02	$ 27,540.02	$ 27,540.02
Income from sale of Zr	$ 22,758.35	$ 22,758.35	$ 22,758.35	$ 22,758.35	$ 22,758.35
Total revenue	$ 126,090,099.61	$ 123,011,379.28	$ 123,011,379.28	$ 123,011,379.28	$ 123,011,379.28
Initial investment	$ 465,263.87	$ -	$ -	$ -	$ -
Operating costs	$ 372,063.87	$ 372,063.87	$ 372,063.87	$ 372,063.87	$ 372,063.87
Transportation costs	$ 12,609,009.96	$ 12,301,137.93	$ 12,301,137.93	$ 12,301,137.93	$ 12,301,137.93
Material transformation costs	$ 50,436,039.84	$ 49,204,551.71	$ 49,204,551.71	$ 49,204,551.71	$ 49,204,551.71
Costs Royalties Sn	$ 397,269.96	$ 397,269.96	$ 397,269.96	$ 397,269.96	$ 397,269.96
Costs Royalties Ta	$ 2,179,490.41	$ 2,179,490.41	$ 2,179,490.41	$ 2,179,490.41	$ 2,179,490.41
Costs Royalties Nb	$ 1,730,411.16	$ 1,730,411.16	$ 1,730,411.16	$ 1,730,411.16	$ 1,730,411.16
Costs Royalties V	$ 49,812.54	$ 49,812.54	$ 49,812.54	$ 49,812.54	$ 49,812.54
Costs Royalties Zr	$ 360,183.01	$ 360,183.01	$ 360,183.01	$ 360,183.01	$ 360,183.01
Gross profit	$ 57,490,554.97	$ 56,416,458.68	$ 56,416,458.68	$ 56,416,458.68	$ 56,416,458.68
Depreciation	$ 46,526.39	$ 46,526.39	$ 46,526.39	$ 46,526.39	$ 46,526.39
Taxable profit	$ 57,444,028.59	$ 56,369,932.29	$ 56,369,932.29	$ 56,369,932.29	$ 56,369,932.29
Income tax	$ 20,105,410.01	$ 19,729,476.30	$ 19,729,476.30	$ 19,729,476.30	$ 19,729,476.30
Net profit	$ 37,338,618.58	$ 36,640,455.99	$ 36,640,455.99	$ 36,640,455.99	$ 36,640,455.99
Depreciation	$ 46,526.39	$ 46,526.39	$ 46,526.39	$ 46,526.39	$ 46,526.39
Cash flow	$ 37,385,144.97	$ 36,686,982.38	$ 36,686,982.38	$ 36,686,982.38	$ 36,686,982.38

CONCEPT	YEAR 11 (USD)	YEAR 12 (USD)	YEAR 13 (USD)
Production (Tn) of concentrate	11992.78	11992.78	11992.78
Production (Tn) of Sn	351.87	351.87	351.87
Production (Tn) of Ta	341.07	341.07	341.07
Production (Tn) of Nb	270.80	270.80	270.80
Production (Tn) of V	7.80	7.80	7.80
Production (Tn) of Zr	56.37	56.37	56.37
Selling price Sn (USD) x Kg	$ 22.00	$ 22.00	$ 22.00
Selling price Ta (USD) x Kg	$ 300.00	$ 300.00	$ 300.00
Selling price Nb (USD) x Kg	$ 43.40	$ 43.40	$ 43.40
Selling price V (USD) x Kg	$ 3.50	$ 3.50	$ 3.50
Selling price Zr (USD) x Kg	$ 0.40	$ 0.40	$ 0.40
Income from the sale of Sn	$ 7,813,861.05	$ 7,813,861.05	$ 4,916,136.10
Income from the sale of Ta	$ 103,284,164.41	$ 103,284,164.41	$ 64,981,832.42
Income from the sale of Nb	$ 14,941,775.78	$ 11,863,055.46	$ 7,463,710.30
Income from the sale of V	$ 27,540.02	$ 27,540.02	$ 17,326.97
Income from the sale of Zr	$ 22,758.35	$ 22,758.35	$ 14,318.55
Total revenue	$ 126,090,099.61	$ 123,011,379.28	$ 77,393,324.33
Initial investment	$ 465,263.87	$ -	$ -
Operating costs	$ 372,063.87	$ 372,063.87	$ 372,063.87
Transportation costs	$ 12,609,009.96	$ 12,301,137.93	$ 7,739,332.43
Material transformation costs	$ 50,436,039.84	$ 49,204,551.71	$ 30,957,329.73
Costs Royalties Sn	$ 397,269.96	$ 397,269.96	$ 249,944.70
Costs Royalties Ta	$ 2,179,490.41	$ 2,179,490.41	$ 1,371,239.06
Costs Royalties Nb	$ 1,730,411.16	$ 1,730,411.16	$ 1,088,698.24

Costs Royalties V	$ 49,812.54	$ 49,812.54	$ 31,339.85
Costs Royalties Zr	$ 360,183.01	$ 360,183.01	$ 226,611.24
Gross profit	$ 57,490,554.97	$ 56,416,458.68	$ 35,356,765.20
Depreciation	$ 46,526.39	$ 46,526.39	$ 46,526.39
Taxable profit	$ 57,444,028.59	$ 56,369,932.29	$ 35,310,238.81
Income tax	$ 20,105,410.01	$ 19,729,476.30	$ 12,358,583.58
Net profit	$ 37,338,618.58	$ 36,640,455.99	$ 22,951,655.23
Depreciation	$ 46,526.39	$ 46,526.39	$ 46,526.39
Cash flow	$ 37,385,144.97	$ 36,686,982.38	$ 22,998,181.61

Source: Authors

8. ACTIONS AND MANAGEMENT MEASURES FOR THE WATER, SOIL AND AIR COMPONENTS

8.1 PROTECTION

Partiendo de la definición de Ronda hídrica la cual comprende la faja paralela a la línea de mareas máximas oa la del cauce permanente de ríos y lagos, hasta de 30 m de ancho (Ministerio de ambiente y desarrollo sostenible, 2017), se enfatiza que por ningún motivo las fases del proyecto ni las áreas dispuestas para la construcción de locaciones y / o planta de beneficio, intervendrán o invadirán estas zonas de aislamiento correspondientes a las corrientes hídricas presentes en el área de influencia del proyecto minero.

8.2 AGUAS RESIDUALES DOMESTICAS E INDUSTRIALES

El tratamiento y disposición de aguas residuales domésticas e industriales para las zonas de explotación contemplan las siguientes medidas las cuales se implementarán una vez se dé inicio a las actividades:

8.2.1 Tratamiento de aguas para consumo doméstico e industrial

- Update, maintain and control the systems for gauging the flow of water used in the washing process, which includes the wastewater from the processing plant, in order to comply with Article 73, Decree 1594 of 1984 and the Law 373 of 1997 on saving and efficient use of water or that environmental legislation that replaces or modifies it.

- Use the water strictly necessary in the different stages of operation of the industrial process. That is why a closed water circulation system is designed in order to use smaller quantities.

- Implement water reduction systems in urinals and sinks.

8.2.2 Disposal of domestic wastewater

- Structuring and implementing a schedule of inspection activities and, if necessary, updating the project's domestic wastewater management system, in such a way that they comply with the current environmental standard for domestic wastewater discharges.

- Implement systems and / or mechanisms that allow effective monitoring of domestic wastewater treatment systems
- Carry out periodic monitoring of domestic wastewater discharges generated to verify compliance with current environmental regulations.

- Avoid the increase in contamination of existing water sources (possible receivers of domestic wastewater discharges) and promote the improvement of the quality conditions of said water sources.

8.2.3 Disposal of industrial wastewater

- Monitor and maintain the efficiency in the sedimentation systems of the suspended solids of the desander and / or sedimentation pool.

- Inspect and carry out periodic maintenance to the pipelines, equipment and elements associated with the process of conducting industrial water (from the beneficiation process and exploitation areas).

- Periodically monitor the industrial discharges generated by the project.

- Minimize the generation of suspended solids through the implementation of irrigation systems on roads and vehicle roofs.

- Implement a management and treatment system for wastewater product of mineral washing, in order to guarantee a closed conduction circuit to a single sedimentation system. Likewise, the sedimentation time of the water must be the minimum necessary to remove the suspended solids, in order to comply with the environmental standard at the dumping site.

- Form drainage channels inside the internal circulation routes of the FM, with a 1% cant towards the slope in such a way that the runoff waters drain towards the perimeter channels to be conducted to the drainage and treatment circuit of the project.

8.3 HANDLING, TREATMENT, TRANSPORTATION AND FINAL DISPOSAL OF DOMESTIC AND INDUSTRIAL SOLID WASTE

The management, treatment, transport and final disposal of solid, domestic and industrial waste for the project includes the following measures:

- Adopt the guidelines for a rational use of products and promote the program for separation at the source of waste; managing with companies in the sector endorsed by the municipality, the delivery of the same.
- Manage the delivery of hazardous waste with authorized companies that have the corresponding permits and licenses. In particular, the delivery to an authorized manager of 100% of the hazardous waste generated.

- Implement and maintain ecological points with labeled colored containers that allow classification at the source of generation. Emphasis will be

placed on the delivery of 100% of recyclable waste for its use.

- Develop training and awareness-raising for staff in order to reduce the generation of solid waste and to reuse those that may be.

8.4 C CONTROL OF ATMOSPHERIC EMISSIONS AND NOISE MANAGEMENT

The control measures are made up of specific activities and procedures to prevent or mitigate environmental impacts from atmospheric emissions and noise.

8.4.1 Control of atmospheric emissions

The objective of these measures is to avoid atmospheric pollution generated by the mobilization of machinery and equipment. The control of atmospheric emissions includes the development of the following activities:

- The goal of controlling atmospheric emissions is to comply with the Colombian regulations for emissions established in Resolution 1377 of 2015 and / or the one that modifies and / or replaces it.

- Comply with Colombian regulations for air quality and / or those that modify and / or replace it.

- All vehicles must have gas emission certificates in accordance with current regulations.

- The traffic of vehicles in the work areas must be subject to speed limits to guarantee not only safety, but also to avoid the drag of particles. For all types of vehicles, the limit allowed in internal accesses is 20 km / h. In the access roads to the area to be recovered, the restrictions established by the competent authorities must be taken into account.

- Informational signs must be installed in the areas of vehicular traffic to indicate the permitted speeds.

- The internal accesses and recovery areas must be humidified to avoid the dragging of particles by the action of the wind or the movement of vehicles and machinery.

Drivers will have to participate in an introductory talk about safety regulations, authorized roads, schedules and speed limits.

The moment of application of these measures will be during the entire mining cycle of the project (exploitation, benefit and transformation, closure and recovery).

8.4.2 Noise management

The goal is to avoid nuisance in neighboring communities. Managing noise requires considering the following actions:

- Comply with environmental noise levels in accordance with Resolution 627 of 2006 and / or current regulations.
- Perform the respective measurements of the sound pressure levels every six months.
- Follow up on the complaints of the communities in the area of influence of the project that they establish when they are affected by noise.
- Perform periodic maintenance of all the machinery, equipment and vehicles of the project.
- Vehicles and machinery must guarantee the adequate operation of the silencers to control the noise levels emitted.
- The use of horns or horns that emit high noise levels should be prohibited.

The moment of application of this measure will be during the entire mining cycle of the project (exploitation, benefit and transformation, closure and recovery).

8.5 MANAGEMENT AND MEASURES FOR RUNWAY WATER

Efficient management of runoff and subsurface waters where required is one of the most reliable measures to guarantee the stability of cuts made in extraction areas. When a balance is achieved between flow velocities and their carrying capacity, the conditions conducive to vegetation growth are generated, providing an additional measure of erosion control.

8.5.1 Management measures for runoff water

The management and disposal measures for runoff waters in the project areas are:

- A collecting channel must be designed in such a way that all the waters that may appear in the start-up front can be captured, thus, the waters received by the ditches of the internal road.

- Ditches should be placed on the inside of each berm and built in such a way that they resist erosion of solids carried by water and facilitate cleaning tasks.

- The structure of the desander or sedimentation pool must be cleaned periodically and more frequently during the rainy season, therefore, they must be located in places that facilitate the access and transport of the settled solids.

Some recommendations are presented for designing ditches, channels, and grit traps.

8.5.1.1 Design of channels and ditches

Since the drainage works required to collect and conduct the runoff waters that reach the mining excavation areas are relatively small, the Rational Method is used to estimate the design flow, with the following expression:

$$Q = \frac{C * I * A}{3{,}6}$$

Where:

Q: Flow, m3 / s
I: Intensity, mm / hr
A: Afferent area, km2
C: Runoff coefficient
In order to design the hydraulic section of the ditches and channels, the Colebrooke-White and Manning equations, respectively, can be used for the fully developed turbulent flow condition:

$$v = -\sqrt{32R * S * g * \log_{10}(k/14{,}8 * R)}$$

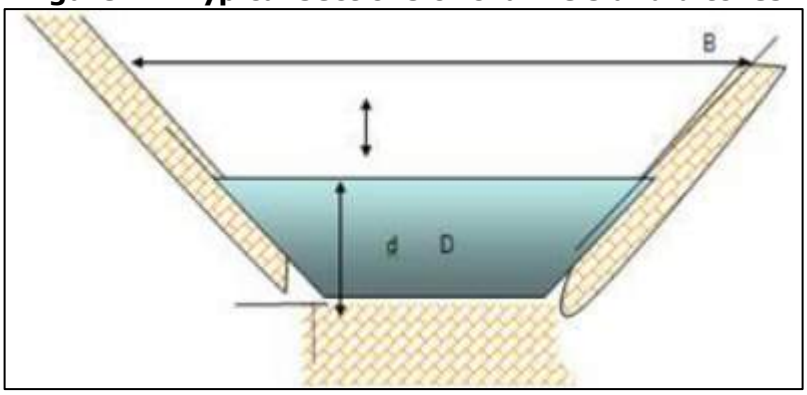
$$v = \frac{R^{\frac{2}{3}} S^{\frac{1}{2}}}{n}$$

Where:

v: Average flow velocity in the channel.
A: Hydraulic radius (wet area / perimeter).
S: Average slope of the channel.
g: Acceleration of gravity.
k: Average height of the channel roughness.
n: Manning's roughness coefficient.

The most used sections in canals and gutters are trapezoidal and triangular. In each case, the expressions for the hydraulic radius, R, are used, which are given in the Colebrooke-White and Manning equations.

Figure 71. Typical sections of channels and ditches



Source. Authors

8.5.1.2 Design of grit traps

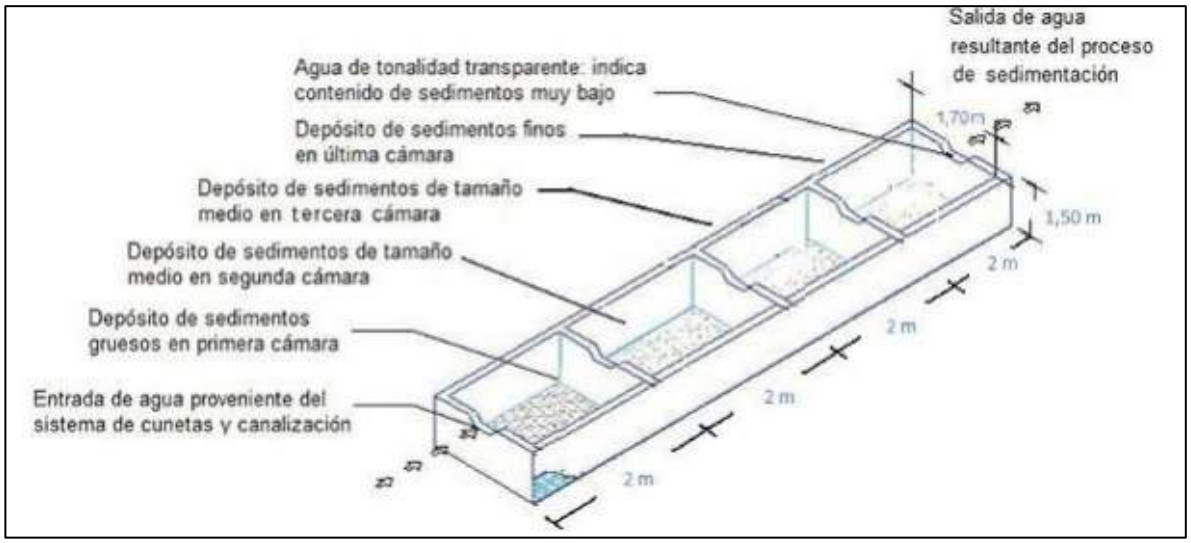
The grit tanks are built with the purpose of retaining the solids that the runoff water can carry, before it is delivered to the sewage system. As the recovery processes of the extraction area progress, these structures will lose importance, and the areas will be protected by vegetation.

The hydraulic design of the grit tanks is carried out for a flow rate equal to 75% of that estimated with the rain return period of 10 years.

The large particles carried by the water settle at the bottom of the tank, where the speed of the water decreases and it loses its greater transport capacity. The desander is made up of four zones: inlet, sedimentation, sludge and outlet, as indicated in **Figure 72.**

The inlet area of the grit trap serves to slow down the water and return excess water. It consists of a side weir, dissipation chamber and perforated partition. The dissipation chamber reduces the speed of entry of the water to the sedimentation zone, while the perforated partition distributes it throughout the section. The sedimentation tank must have dimensions such that a theoretical retention time, to, is met so that the larger solids settle to the bottom, which is the sludge area. The outlet area is made up of a weir that connects to a channel or conduction pipe.

Figure 72. Zones of a desander tank



Source: Authors

9. MINING-ENVIRONMENTAL TECHNICAL GUIDES

In accordance with what is established by the Ministry of Mines and Energy, the mining-environmental technical guides are available that will be used in the different affected environmental components, and in the development of the construction, assembly and exploitation activities of this project, giving way to the planning, execution and monitoring of the environmental activities that will be carried out according to the mining activity.

It is highlighted that within the Environmental Management Plan contained in the Environmental Impact Study that is delivered to CORPORINOQUIA, a detailed description of the control measures is made, with their respective sheets to be applied, in addition to the effects to be mitigated, causes of the themselves, time and moment of execution, costs of the works, follow-up, control and monitoring and responsible for the audit

The specific handling sheets to take into account in the development of the project are summarized below:

9.1 WATER COMPONENT

- **CME 07-03 Rainwater management:** Perimeter ditches built on land are proposed to treat them, preventing runoff from causing erosion in areas designated as yards for disposal of material of interest.

- **CME 07-04 Domestic wastewater management:** It will be used to treat domestic water produced by the camps located in the area, through the implementation of septic tanks.

- **CME 07-07 Management of bodies of water:** Although no type of intervention will be carried out in water courses and / or water rounds, the appropriate protection measures will be carried out when the exploitation process is in nearby areas, with the in order to avoid at all times any type of contamination in the water resource.

9.2 AIR COMPONENT

- **CME 07-09 Noise Management:** Developed to mitigate negative impacts on environmental factors caused by the use of machinery and transport vehicles.

9.3 SOIL COMPONENT

- **CME 07-10 Fuel Management:** Developed in order to establish the loading, transportation and handling of fuels used for machinery and vehicles, in order to avoid spills that could generate environmental damage.

- **CME 07-11 Soil management:** These activities are intended to give adequate management to the soil that may be found, covering the areas to be exploited and adapted for storage yards and other infrastructure, in such a way that it can be reused in the subsequent process of morphological restoration. and landscaping of the areas affected by said infrastructure required for the development of the project.

- **CME 07-15 Waste and Debris Management:** The objective is to give the correct management to the sterile material resulting from the same exploitation fronts, which as explained in previous chapters, will be deposited in the areas already exploited for the morphological restoration of the ground.

- **CME 07-16 Road Management:** It is proposed to maintain the access roads to the exploitation fronts and the facilities, mainly developing ditches for the correct treatment of rainwater.

- **CME 07-17 Solid waste management:** It is about giving proper waste management through the strategic location of bins at the operation sites and recycling them to be delivered to the municipal cleaning service.

- **CME 07-18 Flora and fauna management:** This includes the adequate management of existing flora and fauna communities, conserving forested areas. Likewise, reforestation of a sector and maintenance of the existing flora.

- **CME 07-24 Landscape management:** Includes reforestation, restoration, maintenance and conservation of existing wooded areas, enrichment with herbaceous species in areas affected by mining exploitation and installation of living fences.

- **CME 07-25 Recovery Plan:** It forms the morphological, landscape and forest recovery works plan established in chapter 7.

9.4 SOCIAL COMPONENT

- **CME 07-20 Environmental Education:** It is developed with the objective of educating workers about the importance of the project and the management of natural resources that will be extracted, including the

Environmental Management Plan to mitigate environmental impacts that the project may generate.

- **CME 07-21 Institutional strengthening:** This is intended to advance agreements with the municipal mayor's office to carry out priority works that directly benefit the community of the village where the project is being developed.

- **CME 07-22 Hiring of labor:** It is intended to link unqualified personnel from the area to the project.

- **CME 07-26 Mining safety and hygiene:** In addition to compliance with the obligations established by the Law, related to the affiliation of workers to the entities that provide health, pension and occupational risks services, all current regulations will be implemented in what regards mining industrial safety.

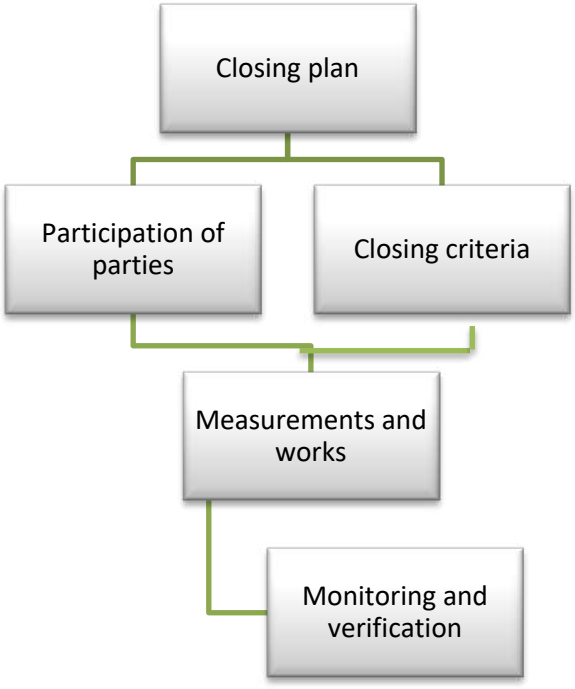
10. CLOSURE AND ABANDONMENT PLAN

Any mining extraction activity carried out by humans causes impacts to a greater or lesser extent to the environment. That is why once the extraction of minerals is carried out in the exploitation area, it is necessary to carry out the restoration of the intervened pits so that in this way the lands are not degraded and without the possibility of a later use. This reconditioning of the land is understood as a responsibility that must be carried out to achieve a balance between the economic development of the activity with the conservation of nature, which for this specific case, is carried out in parallel with the mining exploitation.

10.1 STRATEGIC FRAMEWORK OF THE CLOSURE PLAN

Taking into account the positive and negative impacts generated during the exploitation activity, the process to carry out the proposal of the mining closure is proposed, involving the participation of the actors (company, community, institutional, government), the closure criteria associated with the identification of impacts generated, the remediation designs or proposals, the implementation of the measures and finally, the post-closure monitoring.

Figure 73. Approach for the mining closure



Source: Authors

10.2 DEVELOPMENT OF THE MINING CLOSURE PLAN

The Mineral Exploitation Closure Plan integrates the conditions of the area before starting the extraction work (baseline), during the development of the activity and in the final phase of the same to analyze the subsequent soil. It is for the above, that the activities that arise, will be developed from the initiation and during the execution of the works. Each of the strategies contained in the approach for the mine closure is described below.

10.2.1 Participation of Parties

In the mine closure stage, the participation of all those involved in the development of this activity is important, so the strategy involves integrating both the operational participants (mine employees), the community and institutions. Next, the identification of each of these actors and their participation in the mining closure stage will be carried out.

Table 38. Participation of actors in the mining closure

ACTOR IDENTIFICATION		PARTICIPATION
Mining company	Employees	They will participate directly in the construction of the works and the closure of the activities, supporting the mining closure.
	Commissioning Engineer	He will direct the different activities to be developed and will coordinate all those involved.
Community	Direct actors in the mining project	A regular channel of communication will be carried out and planned with the providers of the different services to communicate the closure and minimize the impacts due to expectations on the continuity of the work.
Institutions	Autonomous Corporation	Delivery will be made to this entity, which will approve the works and tasks scheduled in the Environmental Impact study.
	Mining Authority	Terminate the concession contract.
	Alcaldía municipal	The municipality will be notified of the termination of exploitation work for the purpose of non-payment of royalties, monitoring of the effective closure.

Source: Authors

10.2.2 Closing criteria

This stage considers the physical, chemical and land use aspects; That is why the closure criteria will correspond to the minimization of impacts generated through physical stabilization, which involves guaranteeing long-term stability, safety in structures, and erosion prevention; Regarding the chemical aspect, it will take into account that concerning the quality of the water and regarding the use of the territory, this space will be recovered for the appropriate use according to its vocation.

The objective is to ensure that once the mine ends its useful life, the place where the exploitation works were carried out represents a minimum risk in terms of the safety and health of the community; a minimal or no risk to the environment, and that, in addition, complies with all applicable laws and regulations, that is, that is consistent with all codes, guides, recommended practices, and that does not represent an inadmissible responsibility for present or future administrators of the land.

10.2.2.1 Aspects of closure of the mining operation

- **Physical stability**

Slopes: Ensure that the surfaces are stable, if there are areas with slopes of considerable heights, access to these areas should be restricted.
Erosion: Control erosion of the shaped slopes and of the intervened surface in general through revegetation and / or reforestation.
Safety: Maintain water quality, adapt ditches in order to channel rainwater into the foot of the slopes and make an adequate delivery.

- **Chemical stability**

Pollutants: Maintain water quality and also comply with water quality standards.

- **Use of the territory**

Productivity: Recover the extraction areas in order to generate an alternative use.
Visual impact: Minimize the impact of the infrastructure and recover the drainage patterns.

10.2.2.2 Aspects of infrastructure closure

- **Physical stability**

Roads: The internal roads generated for the transport of the mineral, the access control will be carried out to maintain security in the area.

- **Chemical stability**

Fuels: Surplus or accumulated fuel materials will be evacuated if they are still within the area and they will be disposed of in authorized sites, this in order to avoid altering the quality of water or soil.

- **Use of the territory**

Productivity: Recover the extraction areas in order to generate an alternative use.
Visual impact: Minimize the impact of the infrastructure and recover the drainage patterns.

10.2.2.3 Closure aspect compared to sterile

- **Physical stability**

Slopes: Ensure that surfaces are stable to prevent failures, landslides and the production of particulate matter.
Erosion: Control erosion of the shaped slopes and of the intervened surface in general through revegetation and / or reforestation.
Safety: Maintain water quality, adapt ditches in order to channel rainwater into the foot of the slopes and make an adequate delivery.

- **Chemical stability**

Pollution: The quality of the water will be maintained, in order to prevent its contamination.

- **Use of the territory**

Productivity: Recover the land for alternative use.
Visual impact: Define surfaces for revegetation.

10.2.2.4 Closure aspect with respect to water management

- **Physical stability**

Ditches, channels or ditches: hydraulic control works will be carried out in order to prevent the destabilization of the slopes and in the same way as a method of prevention against erosion.

- **Chemical stability**

Pollution: The quality of the water will be maintained, in order to prevent its contamination.

- **Use of the territory**

Productivity: Recover drainage patterns.

10.2.3 Measures and works for the Mining closure

Based on the above, the specific measures for abandonment, dismantling and restoration are described, associated with the activities of mineral extraction for the proposed legalization zone.

10.2.3.1 Workforce separation activities

For this closure phase, the organization will inform the community and the municipal authorities associated with the project's area of influence, with a period of not less than 6 months before the closure, dismantling and abandonment, the mechanisms established for the progressive reduction of personnel. . All information of interest will be provided to interested parties on issues of criteria for reducing the demand for employment, reducing jobs, in addition to the social benefits that apply.

10.2.3.2 Delimitation and signaling activities

While the activities of closure, dismantling and abandonment are being carried out, the intervened sites must be delimited and marked. This closure of mining activities will be reported through a poster which indicates the risks involved in entering the area. Next, the way in which the implementation of these actions should be carried out is described, which will remain in the area during the closure in order to prevent accidents to the population that enters the place.

- Access points: The access points to the exploitation area will be identified, which will be dismantled and later abandoned, and will be marked with informational signs where the characteristics of the land will be exposed, in the same way, the access restrictions will be indicated.

- Internal roads: It will be indicated that this area is in the process of mining closure and the characteristics and topographic conditions that may generate risk will be indicated.

- Excavation area: The installed signage will indicate that the area is in the process of mining closure and will also alert people who enter it of possible risks.

- Isolation of the population: Isolation between the closure areas and the population must be maintained until the mining closure is completed in

order to reduce the accessibility of people outside the project.

It is important to ensure the maintenance of the places where this signage is installed in order to prevent visual obstruction of it. Similarly, guarantee the conditions of functionality of the signage, replacing or substituting elements that are in poor condition.

10.2.3.3 Infrastructure and equipment dismantling activities

The Dismantling and Abandonment Plan for the LFH-14431X mining legalization polygon is formulated to be implemented when the useful life of the mine ends. The activities will be carried out in the exploitation areas, sterile areas, camps and the processing plant (Washing). This phase is carried out progressively and is consolidated once the end of the extraction is reached. When the infrastructure requires closure prior to the phase of abandonment and final restoration, the corresponding dismantling activities will be carried out immediately upon abandonment or disuse of the infrastructure.

In the total area of intervention, it is obliged to remove all traces of facilities and temporary locations associated with the exploitation tasks, which are listed below:

- The equipment and materials must be dismantled, removed, and structures demolished, such as the processing plant, machinery or elements associated with its operation (conveyor belts, screens, hoppers, feeders, pumps, and loaders), fuel storage tanks, among others.
- Remove construction waste, waste and any type of waste left in construction areas.
- Restore and carry out the final maintenance of the sections of the existing roads that have been affected during the construction of the project.
- Remove surplus materials and supplies from temporary storage sites.
- Additionally, there should be no residues of the following elements:

- Machinery and equipment in general
- Tools
- Objectionable materials of various kinds
- Garbage and solid and liquid waste in general (dangerous and non-dangerous)
- Temporary signage elements
- Metallic elements such as scrap metal, rods, wires, etc.
- Electrical wiring not necessary
- Tarps, geotextiles, polyshades, etc.
- Various plastic elements
- Various wooden elements and components

Regarding the handling of the different waste, it is carried out as follows:

- The management of the solid waste generated will be carried out in accordance with the provisions of project CMR-07-17 (Management of solid domestic, industrial and hazardous waste) indicated in the EIA.
- The construction waste generated during this phase will be disposed of according to what is contemplated in the project "Handling and disposal of Excavation Material" with code CMR-07-15.
- The transport of special or dangerous waste that may be generated during the dismantling stage will be done following the security protocols established in Decree 4741 of 2005 and Decree 1609 of 2002 (or that regulation that modifies or replaces it), through of a company that has environmental authorizations.
- Waste may not be disposed of in surface water bodies.
- Removal of all types of vestige of intervention.
- Proper use of personal protective equipment PPE.
- Avoid affecting vegetation cover adjacent to the site where dismantling activities are being carried out.

As stipulated in the regulations, the final conditions will be of absolute cleanliness and order. Once this is guaranteed, a record or record will be signed where the receipt to satisfaction of the respective dismantling is confirmed, leaving a record of commitments or subsequent management related to environmental restoration or sanitation actions.

10.2.3.4 Activities for disconnecting the water supply and disposing of pipes

The water supply to the mine will be cut off and the pipelines for this supply will be dismantled. Similarly, the other pipes are dismantled taking into account the measures for the disposal of non-hazardous solid waste. Only the connections necessary for the closing stage will be left in operation.

10.2.3.5 Landscape and morphological restoration activities

The activities in this stage will begin after the demolition process of the temporary infrastructure (Camps, plant and exploitation front) and thus begin processes of leveling, morphological conformation and revegetalization of the same in accordance with the original use.

- **Camp**

Once the exploitation stage has been completed and the mining closure stage has begun, the camp will be dismantled and the procedure will be as indicated below:

Dismantle and remove installed equipment if it exists, such as sanitary batteries. Remove surplus materials and supplies from temporary collection sites, clean and store solid waste in accordance with the provisions of the project CME-07-17 (Management of solid domestic, industrial and hazardous waste) of the WFP contained in the EIA of this application for legalization. Finally, the transport and disposal of these will be carried out in accordance with the previously arranged actions.

Remove construction waste and any debris left in the area prepared for the camp. If required, decontamination and industrial and hazardous waste management actions will be developed.

Finally, the morphological restoration of the areas where the camp was built will be carried out. If required, drainage works must be implemented to manage runoff water.

- **Beneficiation plant**

The proposed scenario consists of the projection of an area within the polygon to be legalized in which the temporary copying of the mineralized material will be carried out to start the first and only washing for its extraction. Next, the measures for the management of the morphological and landscape reconformation and the final use of the soil are described.

The management and morphological and landscape reconformation of the area will be carried out seeking homogeneity with the adjacent areas in order to reduce the degree of modification caused in the landscape. For this, the temporarily stored organic soil layer will be applied; This layer must be at least 10 cm thick to allow the established seeds to find a suitable place to start their germination and development stage.

In the area where the processing plant is located, the general empradization of the entire area will be carried out, for which the stripping material will be returned to its original site. Subsequently, reforestation will be carried out with native species of these areas, trying to recover the vegetation cover that was affected by the installation of the same.

It is important to guarantee the reestablishment of the vegetation cover and landscape reconformation of all the areas to be rehabilitated, to take into account the following measures:

- In order to guarantee the success of the revegetation, prior conditioning of the intervened areas must be done, this preparation involves the following activities:

- Collection of construction waste and / or elements foreign to the environment that make planting difficult.
- Leveling the ground by disaggregating the soil, eliminating large clods or blocks, bumps or sharp depressions.
- The practices of leveling and physical adaptation of the terrain can be carried out manually or mechanically, depending on the accessibility and its extension.
- Before sowing it is necessary to moisten the work area by watering.

- The establishment of lawns consists of the provision of grass units stored during stripping activities and that have been duly protected; otherwise, they must be obtained from neighboring properties with prior authorization from the environmental authority. The lawn must be cut into homogeneous rectangular blocks of dimensions not exceeding 0.5 m on each side and must be previously pruned. It is important that the grass have healthy roots to facilitate adherence to the slope. Additionally, it should be taken into account:
  - The grass will extend over the surface of the slope starting at the top and descending as the process progresses. This activity must be carried out in an orderly manner, avoiding overlapping and leaving empty spaces, to guarantee a covered and uniform surface.
  - Another important aspect is the holding of the grass blocks on the slope, for which stakes will be used to prevent their movement while the roots are fixed to the ground. It is worth noting that cuttings of species that grow vegetatively easily should not be used because they can reproduce and affect the objective of planting.
  - Once the lawns have been established, abundant watering should be applied, twice a day in the summer periods and repeated as many times as necessary to guarantee the necessary humidity conditions for the taking of the grass; It is recommended to do this activity during the winter period.
  - It must have the collaboration of experienced personnel in similar tasks.

- The sowing of grass seeds will be carried out by the so-called broadcast method, trying to cover the surface evenly, it must be taken into account that prior to sowing, the soil must be completely moistened.

- The seed will be mixed with very loose soil, sawdust, sand, rice husk or any other substrate that is easily obtained in the area, in order to achieve a better distribution on the surface, given its low weight and its susceptibility to be blown away by wind and water. sowing at the

beginning of the rainy season is generally recommended.

Exploitation area

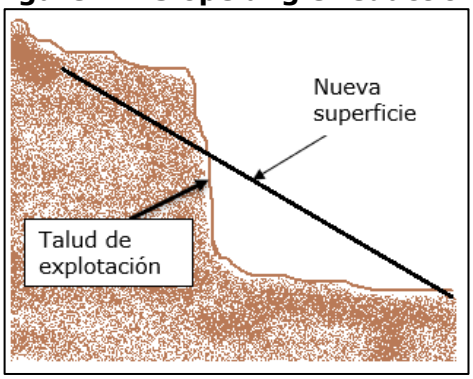
Once the area where the exploitation activities were carried out has been cleared, the profiling of slopes and the morphological reconformation of the excavations carried out, as well as the removal of mounds, improve the view of the mining area at the landscape level. in order to give way to the next phase. Taking into account the chosen exploitation method, this recovery process can be carried out in parallel with the exploitation activities, in addition to generating minor impacts on the landscape.

The excavated areas of the mining exploitation, which are not able to fill with the sterile ones, must be left in safe and stable conditions before proceeding with the landscape recovery. It is for this reason that each exploitation pit will have slopes and runoff water management as described below.

Slope Angle Reduction

This measure focuses on reducing the erosion surface by controlling surface runoff due to the decrease in water velocity, thus achieving greater retention of moisture by the soil. Likewise, it reduces the inclination of the working slope of each exploitation pit, guaranteeing its stability over time.

Figure 74. Slope angle reduction

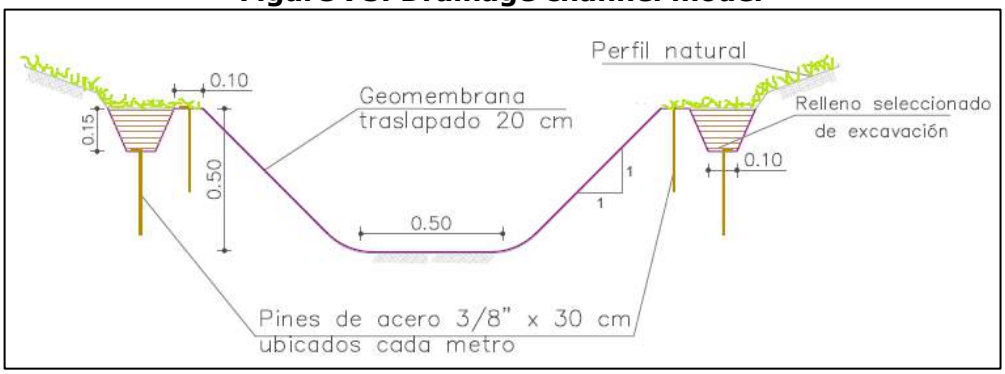


Source: Authors

Runoff water control

The instability of a slope is generally associated with the increase of moisture in the water content in the cohesive materials, causing the weakening of the soil mass. This runoff control will be carried out by installing channels or ditches in the leg or crown of the slope with sufficient capacity to allow the flow of the quantity of fluid.

Figure 75. Drainage channel model



Source: Authors

After carrying out the morphological reshaping, the plant cover layer that had been removed before starting the exploitation work is proceeded to extend, when the exploitation work lasts a long time, this plant cover layer has already been integrated into the place where it was laid, For this reason they should be arranged in the form of rectangular grass and anchored to the faces of the slopes, the ideal in this phase is that the regeneration of the vegetation cover occurs, naturally with the vegetation of the region. This restoration of the soil through the implantation of vegetation will be carried out as mentioned below:

Soil restoration

As mentioned above, before starting with the plant implantation, the areas to be revegetated must be outlined and reshaped. On the final grade, a layer of organic matter and nutritional elements of a thickness not less than 30 cm will be applied. The spreading of this material will be carried out with machinery that causes minimal compaction, therefore, heavy machinery will not be able to pass through these areas once the spreading begins. If the soil is very worn, an organic fertilization of the soil will be carried out to help the implantation of the vegetation.

Organic fertilization

Organic matter has significant effects on the physical and chemical features of the surfaces to be recovered due to its nutrient content. This organic material improves water retention capacity, reduces surface runoff and improves germination. Some sources for the acquisition of organic material are listed below.

- Compost from farms
- Mushroom residues
- Domestic waste
- Wood waste

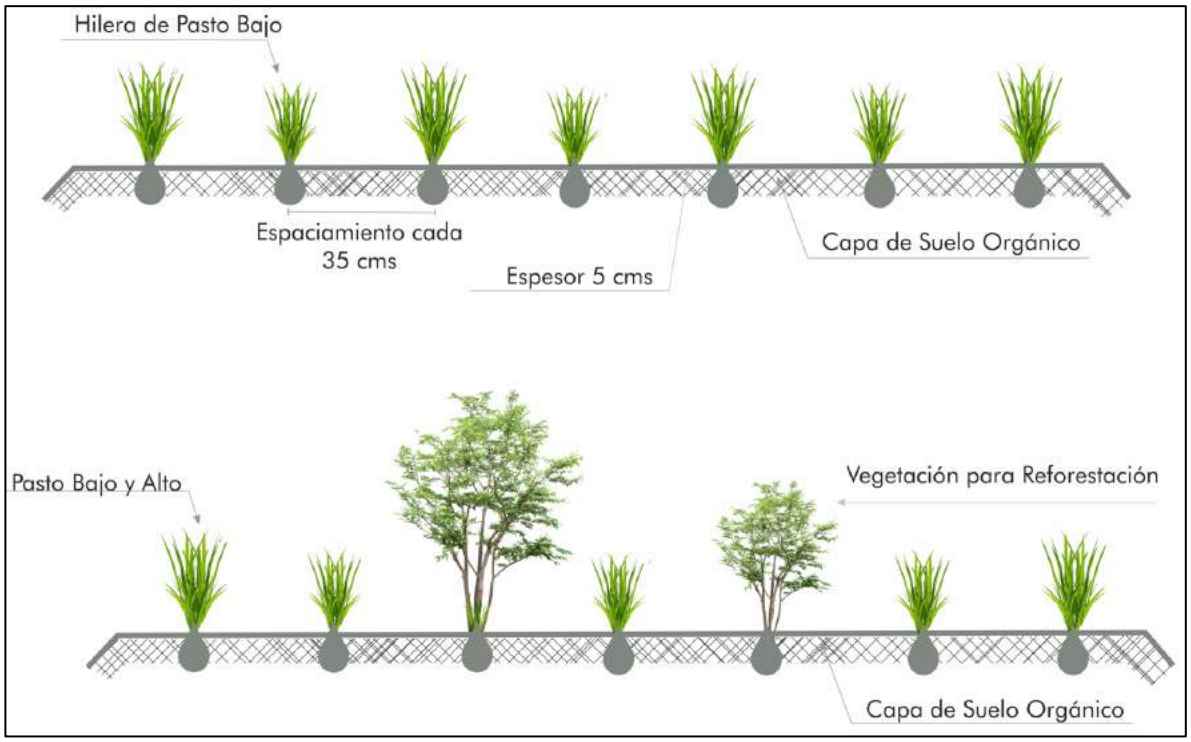
Vegetation implantation

Any type of vegetation used in the implantation must be of native species. In the first instance, creeping vegetation will be used, herbaceous species with deep roots, after this, we will proceed with the use of shrub species in order to control erosion and attract fauna. The recommended species are Oenocarpus bataua and Pinus Caribaea Var. Hondurensis.

Next, the recommendations and the management that should be followed in order to have a successful implementation are listed.

- Plant medium trees. with good lignification and considerable volume of foliar mass.
- The planting should be carried out in the rainy season so that this humidity is used for the establishment.
- The planting hole must be filled with organic matter and tamped to eliminate voids and thus avoid the proliferation of pathogens.
- The neck (Union between the root and the stem) must be flush with the ground.
- The planting will be done with plants free of phytopathological affectations.
- Carry out the mortality review and carry out the respective replacement of the lost material.
- It must be paid during the first 2 years at minimum intervals of 6 months with one shovelful of organic fertilizer per tree and with chemical fertilizer applied to a crown 30 cm away from the tree.

Figure 76. Vegetation implantation



Source: Authors

10.2.3.6 Activities for the communication strategy

It is necessary to design an information strategy to the communities and authorities of the area of influence, about the completion of the project and social management. Some recommendations to keep in mind in said formulation are described below, however, this design should be considered, in the terminal phase of the project, which is when it is feasible to observe and assess the real conditions of the project's social environment:

- Evidence "SOCIO-ENVIRONMENTAL PEACE AND SAFE", that is, that there are no environmental liabilities left within what is feasible, avoiding assuming future problems.
- Know and solve the concerns or requirements of the community; Although it is true that said care scheme must be permanent, it must be verified at the end of the process that 100% of conflict or concern situations were attended to and / or responded to.
- Verify the strict and adequate fulfillment of the commitments acquired with the community.

Prepare the environmental closure document in charge of the project's socio-environmental team, which will be formally known to ANLA, MADS and CORPORINOQUIA. This document will clearly contain the environmental monitoring actions and also indicate the statistics, traceability, results and trends of the environmental indicators that must be exercised until the closure phase.

10.2.4 Cost projection for closure, decommissioning and abandonment activities

To estimate the costs related to the activities of closure, dismantling and abandonment, they were grouped into main activities where the unit value and the required quantity are obtained. These costs, as mentioned, refer to projections, which may vary given the operating conditions during the project, and therefore may be adjusted according to the new needs that arise in the closure plan.

Next, the costs associated with the activities of the mining closure for the exploitation polygon are presented.

Table 39. Costs for mining closure activities

Ítem	Activity	Unit	Quantity	Unit value	Total
1	**Access control**				
1.1	Fence construction	m	1,500.00	$ 34,710.00	$ 52,065,000.00
1.2	Signaling type SP, SR, SI	Und	50.00	$ 260,000.00	$ 13,000,000.00
2	**Dismantling of equipment and infrastructure**				
2.1	Equipment disassembly, structure disassembly, camp demolition, debris removal	%	3.00	$ 30,000,000.00	$ 90,000,000.00
3	**Adequacies for runoff control**				
3.1	Construction of drainage system and runoff control	m	3,342.00	$ 46,800.00	$ 156,405,600.00
4	**Restoration of degraded areas**				
4.1	Scarification, stabilization, reconfiguration and restitution of the soil	m3	235,958.00	$ 4,000.00	$ 943,832,000.00
5	**Revegetation**				
5.1	Revegetalization of degraded areas	ha	84.6	$ 45,000,000.00	$3,807,000,000.00
6	**Detail engineering**				
6.1	Detailed closure design	Gb	1	$500,000,000.00	$ 500,000,000.00
7	**Unforeseen**				
7.1	Design and construction of unforeseen works, implementation of additional measures and /	Gb	1	$278,115,130.00	$ 278,115,130.00

Ítem	Activity	Unit	Quantity	Unit value	Total
	or attention to contingencies				
TOTAL COSTS					**$5,840,417,730.00**

Source: Authors

The previously established calculations are based on assumptions, therefore, as mentioned above, the amounts may be modified according to the operation phase. The assumptions taken into account are listed below.

- The construction of fences will be carried out in part of the exploitation areas. To calculate the length, the perimeter of the works was assumed.
- The costs of dismantling equipment and structures are considered 3% of the cost of the civil works of the project assuming a value of $ 1,000,000,000. Additionally, it is assumed that the contractor will earn income from the reuse of scrap metal and used equipment.
- The drainage and runoff systems will be carried out for the following final slopes of the exploitation area. To calculate the length of these systems, the perimeter of the works was assumed.
- Soil rehabilitation is required and the revegetation of approximately 85 hectares will have an average cost of $ 45,000,000 pesos per hectare, assuming a revegetalization with herbaceous and native species.
- Contingency costs are estimated at 5% of the total value of the mine closure plan.

10.2.5 Cronograma de actividades para el cierre minero

Teniendo en cuenta las actividades planteadas en el cierre minero, se adjunta el cronograma para la programación y ejecución de

Table 40. Schedule of activities for the mining closure

STAGES AND ACTIVITIES OF THE PROJECT	MESES																																										
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	3
ABANDONMENT AND CLOSURE																																						
Job separation																																						
Operators operation phase																																						
Closing phase operators																																						
Final closing																																						
Enclosures and Signaling																																						
Rehabilitation of final slopes																																						
Recovery and adaptation of areas																																						
Dismantling and demolition of infrastructure																																						
Soil recovery																																						
Revegetalization of the intervened areas																																						
Adequacy of residual components																																						
Monitoring																																						
Slope monitoring																																						
Water quality monitoring																																						
Monitoring the recovery of the landscape																																						

Source: Authors

10.2.6 Monitoring and verification of the mine closure

The monitoring will consist of making visits to the project intervention area, to evaluate the effectiveness of the implemented measures every six months. To ensure compliance with the above recommendations, the company's Socio-Environmental Group will carry out the final monitoring of the closure of both the exploitation front, as well as the temporary installation sites. This group will deliver an act or certificate equivalent to a "closing environmental peace and safe" that will serve to prove the correct completion of the work.

Finally, the information must be consolidated into a document and a complete report must be presented to the community. It is important to clarify that the aforementioned programs are developed taking into account the guidelines, however, improvement programs may be implemented when technology, the regulatory framework or the progress of the project warrant it.

10.2.6.1 Slope stability monitoring program

This program contemplates the activities for the follow-up and monitoring of the previously proposed treatments focused on the physical stability of the final slopes of the exploitation. The factors to be monitored correspond to environmental processes that may affect their stability, causing atypical behaviors; These parameters are the outcrops of water and the erosive processes that trigger mass movements.

The main control to take into account is the observation of the appearance of cracks, fissures and mass movements, so these controls should be carried out periodically, especially after prolonged periods of rain. Taking into account that these reviews are carried out visually, the following recommendations are made:

- Make a photographic record of the follow-up.
- Carry out an inventory where the evolution and / or changes of the recorded geomorphological processes are defined.
- In the event of evolutions, instrumentation must be carried out for detailed monitoring.
- Keep records of the analysis and results obtained.

10.2.6.2 Water quality monitoring program

The objective is to evaluate the physical, chemical and microbiological quality of the bodies of water that were intervened in the project. These measurements will make it possible to quantify the change in characteristics and thus improve the efficiency of the environmental measures defined to minimize the impact. The parameters to take into account in these measurements correspond to pH, conductivity, dissolved oxygen, temperature, BOD5, COD, total nitrogen, total

phosphorus, suspended solids, total solids, fats and oils and floating material. For this, water samples will be taken in sufficient quantities in plastic or amber bottles, as the case may be, guaranteeing their preservation so as not to alter the results during transport. In the same way, the entire chain of custody will be documented from the taking of the sample to the analysis in the accredited laboratory.

The monitoring will be carried out by comparing the results with the reference values according to the current legislation and in this way being able to establish the quality levels.

10.2.6.3 Monitoring program for the restructuring, rehabilitation, recovery of the landscape

The sites for monitoring and follow-up correspond to the exploitation and location sites. For this monitoring, the herbaceous cover and the establishment of native species will be evaluated. The parameters to be monitored correspond to the rehabilitated area, survival of the seeded individuals, survival of the seeded individuals by overseeding, physical and phytosanitary state of development of the seeded individuals, sowing density, sown species and growth of the sown species. This frequency of monitors will be carried out as follows:

- The verification of sowing and replanting will be carried out one month after each activity.
- During the first year, the verification will be every 4 months.
- After completing the first year, this verification will be carried out 1 time per year until reaching 3 years of age.

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