NATIONAL UNIVERSITY OF ENGINEERING

COLLEGE OF GEOLOGICAL, MINING AND METALLURGICAL ENGINEERING

Senior Design Project Report

“MEDIUM-TERM UNDERGROUND MINING DESIGN AND PLAN FOR A NARROW MINE VEIN APPLIED IN THE MINING UNIT *‘LAS PALMAS’*, CUZCO, PERU

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ABSTRACT

The present thesis presents a technical - economic analysis of the income, costs and investment involved in the mining sector, for this was taken as a case study a narrow vein mining median located in the department of Ica (El Sol Naciente Tercero) property of the mining company S.M.R.L. Gotas de Oro.

This report analyzes the increase of 100% of the total production of the mine, due to the start of operation of the Rosita vein; but without significantly reducing the contribution of ore tonnage, of the other mineralized bodies in operation (Vein Gino I, Gino II, Icas I and Icas II).

It is scheduled for 2017 to gradually increase the monthly production of the mine, with the aim of reaching 4000 tons per month. For the year 2018 and 2019 it is proposed to maintain this production, prioritizing the exploration work due to the presence of 02 additional veins to the aforementioned, in addition to virgin mineralized bodies that could adequately support future growth projects.

So the present work, first, analyzes the price expectations of the metals involved in this thesis; Second, it describes the geological characteristics of the mining site; third, an updated calculation of the resources and reserves with which the deposit is available is presented. Then the geomechanical studies are presented in a concrete way to carry out an adequate design of the Ascending Cutting and Filling method. The aspects of ventilation are summarized, depending on the requirements of the personnel, equipment and types of work; the auxiliary equipment and services necessary to perform the mining operation are also specified. With all this technical information, we proceed to carry out the program of advances and production on the veins in operation, to comply with the tonnage proposed in this thesis.

Obtained the production program and laws per month for the years considered, proceeds to make the valuation of it, considering the market price of metals, involved in the investigation; obtaining income from sales of the concentrate.

With the income and costs calculated, the economic evaluation of the El Sol Naciente Tercero mine is performed, that is, the Cash Cost is determined, to determine the operating margin of the mine. In addition, an analysis is made of the necessary investments (Capex) to meet the objectives set.

Finally, a one-dimensional sensitivity analysis, conclusions and recommendations of the results obtained are presented.

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GLOSARIO

S.M.R.L.	Limited Liability Mining Company
UTM	Universal Transverse Mercator
TMF	Fine metric tons
TMS	Dry metric tons
$ / lb	Dollars per pound
Oz / Tn	Ounces per ton
$ / Oz	Dollars per ounce
m.s.n.m.	Meters above sea level
^{0}C	Celsius Degrees
m	Meters
Km	Kilometers

m^2	Square meter
Km^2	Square kilometer
KW	Kilowatt
HP	Horsepower
Tn	Tons
Gln	Gallons of oil
m^3	Cubic meter
Yd^3	Cubic yards
$pies^3$	Cubic feet
CFM	Cubic feet per minute
gr / cm^3	Grams per cubic centimeter
KN / m^3	Kilonewton per cubic meter
Kg / m^3	Kilograms per cubic meter
m / min	Meters per minute
m^3 / min	Cubic meter per minute
$ o US$	American dollars

INTRODUCTION

This thesis is focused on the El Sol Naciente Tercero mining unit, which belongs to the mining company S.M.R.L. Gotas de Oro, is an underground mine of narrow veins (1.5 - 3 meters) that produces copper, gold and silver; It is located in the province of Ica, department of Ica, southern Peru.

It is in this context that a medium-term technical-economic plan is carried out, which involves: expectations of the price of copper, gold and silver, mine geology, reservoir geomechanics, mining method, ventilation design and auxiliary services; which will allow to analyze the sales, costs and investments. In this study the application of the knowledge acquired in the university will be shown; In addition, this work will become one of the main tools for decision-making in the project proposed in the mining company S.M.R.L. Gold drops

The objective is to increase the monthly production of ore from 2000 to 4000 tons, taking advantage of, in the first place, the maximum capacity of the ore processing plant which is 6000 tons per month.

Second, so far the mine has five veins explored and in operation, two veins under exploration, all of them with important copper, gold and silver contents; in addition to other mineralized bodies that are counted as indicated and inferred resources.

Thirdly, the increase in the international price of copper, gold and silver registered since mid-2017 and the high expectations of the price of these metals. In this way we want to properly plan the monthly production, increase the profit obtained from the exploitation of the mineral and take advantage of the current and future favorable context, by which they are estimated, the metals involved in this study will pass (Copper, Gold and Silver).

CHAPTER I: GENERALITIES

1.1. BACKGROUND AND JUSTIFICATION

In June 2008, the title of the El Sol Naciente Tercero mining concession was granted, with code N0 01-01947-03 in favor of the mining company S.M.R.L. Golden Drops comprising 400 hectares of extension and whose UTM coordinates corresponding to zone 18 were formulated entirely over the Los Tres Socios de Chincha No. 6 mining right area, which at that time was already an extinct mining concession.

In 2009 the economic viability project of the mining unit of the company S.M.R.L. Golden Drops, as a result of the increase in the price of the main commodities, which is why explorations were carried out in the area and in 2010 it was decided to carry out the Semi - Detailed Environmental Impact Study (EIA - sd); said EIA - sd was approved in May 2011 by directive resolution N0 003 - 2011 GORE - ICA / DREM / AAM.

That same year the mining operation certificate (COM) was obtained and in 2011 it officially begins operations with a production of 100 tons per day, in 2012 the production was increased to 200 tons per day; In 2014, due to the drop in international metal prices and due to economic problems of the company, production was reduced to 50 tons per day, at the end of that same year production increased to 70 tons per day ; But from that year until 2016, production remained between 50 and 70 tons per day, which allowed the company to subsist and pay its debts but did not allow the development of new exploration, development and exploitation projects of new veins.

Due to this, in 2017 a technical-economic analysis was carried out to plan the gradual increase in monthly production; since, the prices of copper, gold and silver, metals that the company produces, had an increase and according to some economists it may be higher in the coming years.

1.2. PROBLEM STATEMENT

The need to exploit larger volumes of ore and the inability to carry them out resulted in the stoppage and closure of some exploration, development, preparation and exploitation projects of the mining company; largely due to the lack of an adequate technical - economic plan in the medium term, in addition to an economic insolvency on the part of the company, partly produced by the reduction of the monthly production of the mine. All this despite the favorable geological and geomechanical characteristics of the mining site where the mine is located.

1.3. DEFINITION OF THE OBJECTIVES

The objectives that are desired to be achieved through the development of this study are detailed below.

1.3.1. General objective

- The general objective of the present work is to develop and establish a model that serves as a guide, and that includes a medium-term technical-economic plan for a medium-sized copper-underground mine with narrow veins.

1.3.2. Specific objectives

- Make known and detail each of the stages that comprise the technical-economic plan, such as the geology of the deposit, estimation of the resources and reserves of ore, geomechanical studies of the rock mass, types of underground mining, ventilation design, description of auxiliary services, the medium-term mining plan and economic evaluation.

- Planning the increase in monthly production in the medium term, it is also intended to obtain and analyze the income from the sale of ore in a specific scenario of copper, gold and silver prices.

- Know the economic variables present in the mining business and the influence that each of them has (Costs, Investment, Metal Price).

1.4. FORMULATION OF HYPOTHESIS

Next, the hypotheses that are to be verified through the development of this thesis are detailed.

1.4.1. General hypothesis

- The implementation of a medium-term mining plan to calculate the economic benefit of the increase in the monthly production of the mine will allow favorable results for the mining company.

1.4.2. Specific hypothesis

- The medium-term technical-economic plan will allow the analysis of sales, costs and investment in various economic scenarios to obtain favorable results for the mining company.

- Having a technical-economic plan that details each of its stages (Geology, Geomechanics, Mining Method, Ventilation, Auxiliary Services and Economic Evaluation) will allow obtaining beneficial results for the mining company.

- Planning the increase in monthly production, in the medium term, in a specific favorable scenario of the price of copper, gold and silver, the main minerals operated by the mining company, will allow obtaining favorable results for the mining company.

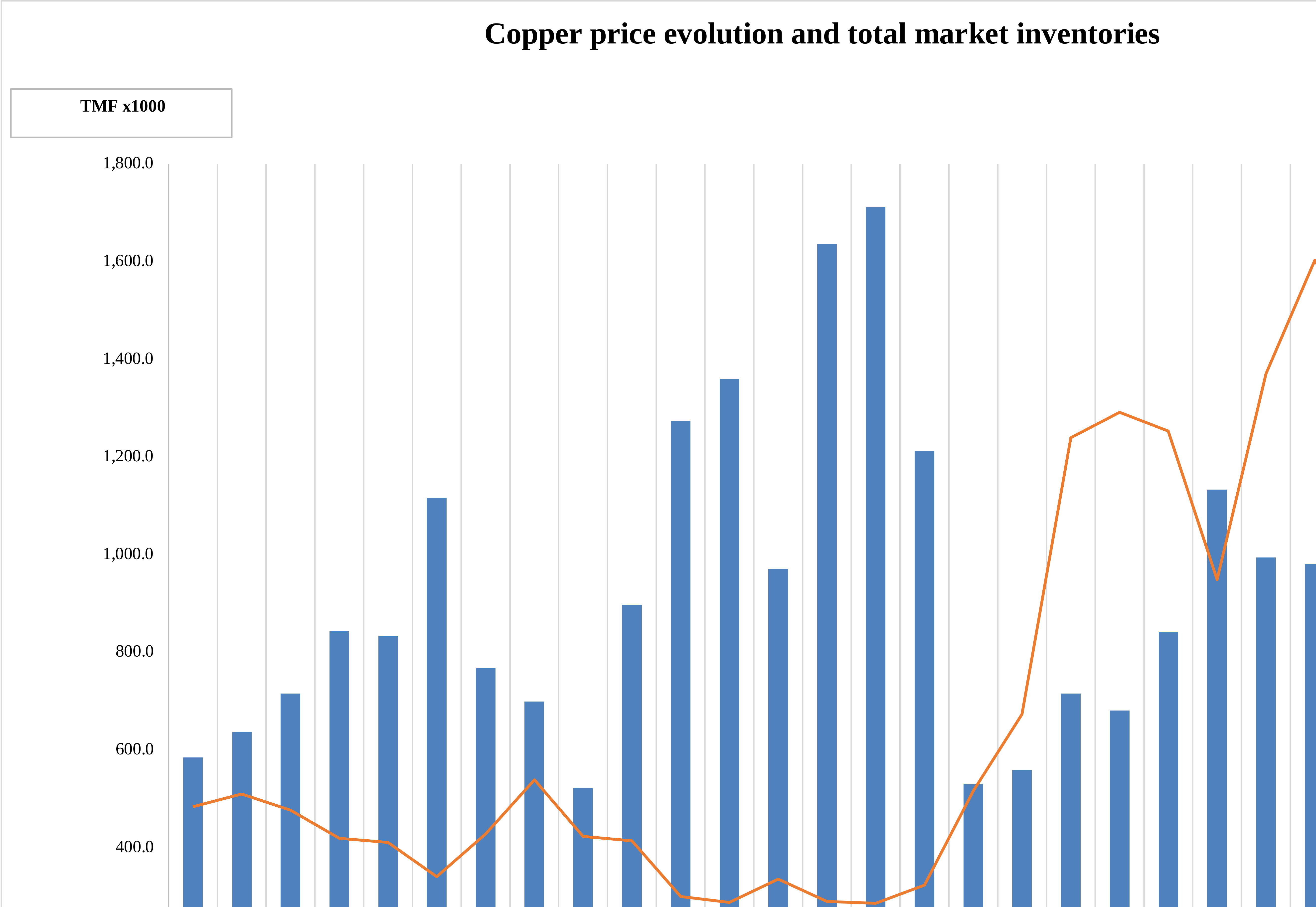
CHAPTER II: PRICE OF COPPER, GOLD AND SILVER

2.1. COPPER PRICE EXPECTATIONS

As in the market of any good, the price is the result of the balance between supply and demand, the same occurs in the metal market. Although the price of copper is determined by the balance of supply and demand, most of the time it is in imbalance, raising and lowering the inventories (Supply) of the metal, as seen in Figure 2, one. Therefore, inventories in the main exchanges are a fundamental determinant in the evolution of the price of copper.

The periods of low prices are a reflection of the excess demand presented by the market; while the price increase is a consequence of the shortage of the offer that the market will present.

In the short term there are internal factors that can affect the price of metal, such as costs and levels of production, consumption, etc., but it is the external factors of the market, such as financial, speculative and balancing of alternative markets that They have a more predominant role. On the contrary, in the long term (greater than five years) it is the internal factors that dominate the equilibrium of the copper price; The long-term price directly influences the copper market, since, through its use, mining projects, budgeting and the establishment of contractual clauses of purchase and sale contracts are evaluated.



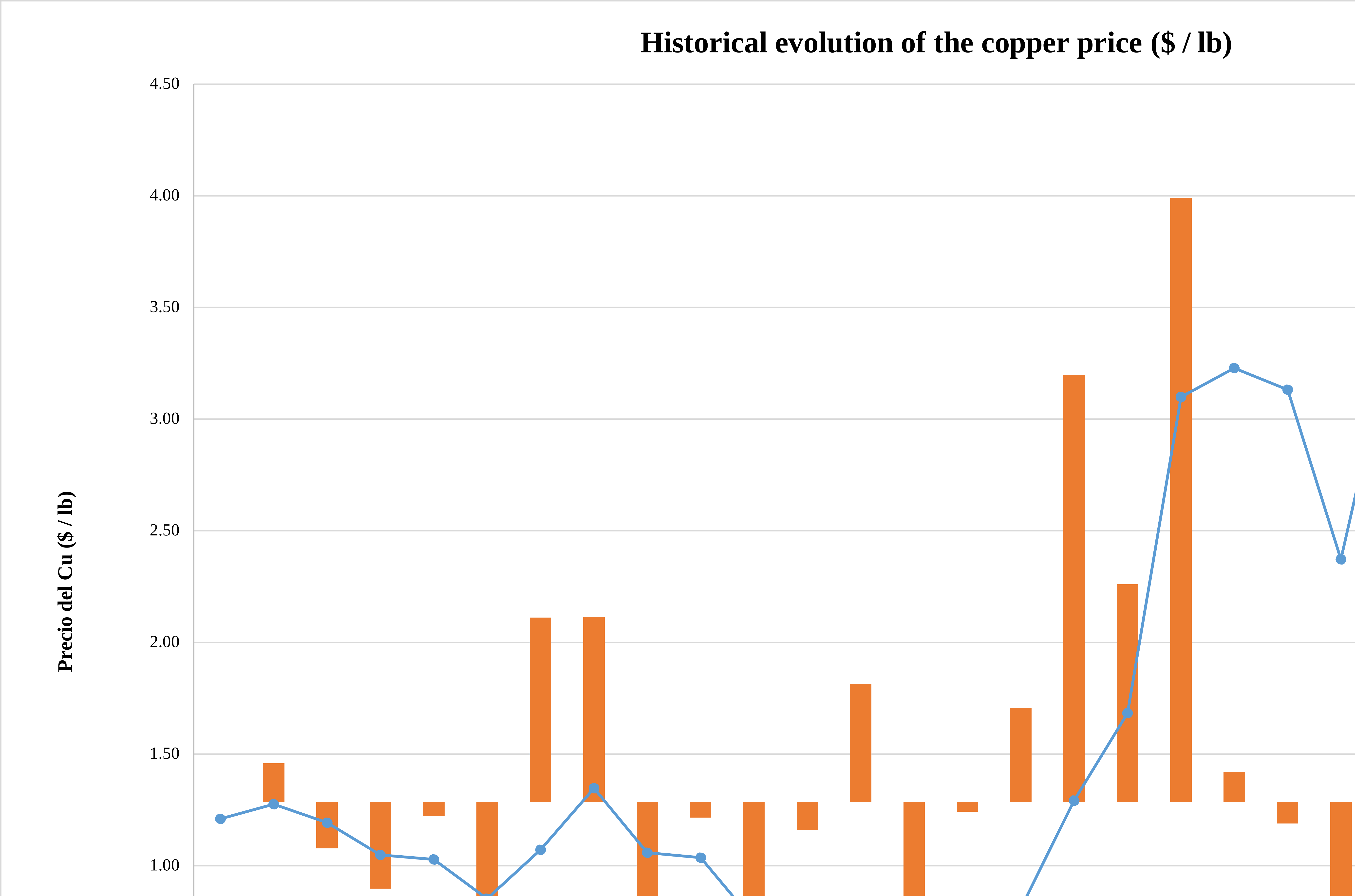
Copper price evolution and total market inventories
TMF x1000
1,800.0
1,600.0
1,400.0
1,200.0
1,000.0
800.0
600.0
400.0

2.1.1. Historical evolution of the price of copper

Studying the evolution of the price of copper is debatable, but it can be said that the price has a cyclical behavior. In addition, while there is uncertainty about the behavior of international demand for copper, this is increasingly reduced due to higher copper consumption in Asian countries, especially China; Therefore, in the coming years, a rebound in the price of metal is expected.

As can be seen in Figure 2.2, the price of copper has historically presented cyclical variations, with price spikes; in the last two decades of the last century, particularly in the years 1989 and 1995, and then fall to a minimum average price of $ 0.72 / lb. In the first decade of the 21st century the price of copper had a constant increase, except during 2009, reaching a peak of $ 4.01 / lb average in 2011; That year begins the US crisis that brings down almost all world stock markets and the downward trend continued until the end of 2016.

At the end of 2016, due to problems outside the market such as one of the biggest labor strikes in one of the largest copper mining companies in the world "Minera Escondida" - Chile, this protest caused significant economic losses to the company and a considerable decrease in the global supply of this metal; In addition, in 2017 the growth of China was higher than expected, so the demand for the metal increased. All this translated into a rise in the price of copper, until the end of May 2018, of $ 3.06 / lb.



Historical evolution of the copper price ($ / lb)
Precio del Cu ($ / lb)
4.50
4.00
3.50
3.00
2.50
2.00
1.50
1.00

To explain the evolution of the supply of copper, it should be understood that throughout the twentieth century the trend was the location of the production of minerals and concentrates in developing countries for the supply of developed countries, this trend has It has been accentuated and currently the dynamism of the production of minerals and concentrates is located in developing countries. The trend for the coming years is a greater concentration of copper production and concentrates in developing countries, particularly Chile and Peru, which contribute 27% and 12%, respectively, of world copper production.

Mayores productores de cobre
(millones de Lb)

País	2016
Chile	12,225
Perú	5,215
China	4,015
Estados Unidos	3,150
Kazakhstan	2,175
Congo	2,170
Australia	2,043
Zambia	1,825
Indonesia	1,631
Rusia	1,560
Otros	9,593
Total	45,602
Perú/Mundo	11.4%

Mayores productores de cobre en Perú
(millones de Lb)

Rank	Company	2016
1	Cerro verde	1,151
2	Antamina	978
3	Las Bambas	726
4	Southern Copper	690
5	Antapaccay	488
	Otros	1,156
	Total	5,215

2°
Nivel
Mundial

Figure 2,3: Analysis and comparison of world and national copper production
Source: Ministry of Energy and Mines - MINEM

While the demand for copper is intrinsically linked to the infrastructure of the countries and their industrial activity, most of it is concentrated in developed countries, traditional consumers of this metal. Copper demand recovery was and is driven by two factors. First, there is the persistence of copper consumption in Asian countries, mainly China, that is, the greater the economic activity, the greater the consumption of copper. Second, there is the intensity of the use of metal in the economy, that is, the coefficient between the copper consumption index and industrial activity.

Figure 2,4: World copper demand

Source: Kallpa securities

2.1.2. Copper offer analysis

According to BHP Billiton in the article "Copper's time has come", there are many limitations on the volume of copper offered. Mainly due to the decreasing degree of quality of mining deposits, the search for deeper mineralized bodies, labor productivity and water scarcity, more frequent socio-environmental problems.

The decline in the quality of copper deposits is expected to be 17%, according to Wood Mackenzie, over the next decade; that is, it will be increasingly difficult to find deposits with high ore grades. In addition, that old mines require greater efforts and higher costs to carry out the exploitation of the deposit.

On the other hand, there is greater difficulty in securing reliable supplies of energy and water to carry out mining operations. Due to the increasingly frequent socio-environmental problems, mining companies can increase the use of desalinated water.

2.1.3. Copper demand analysis

Since the 1990s, the increase in demand for copper was largely due to the persistence of copper consumption in Asian countries, especially China, in addition to other developed countries; To analyze the increase in the consumption of raw materials in China, we must consider “The program of economic reform and openness abroad in the XI CPC Central Committee” that allowed the modernization and economic growth of China; which has made it one of the main consumers of raw materials, but although this economic reform program greatly favored China, but only part of this country favored it, especially the east side. In the present decade the Chinese government has been promoting a series of reforms to increase domestic consumption, decrease the weight of exports and a greater weight of services; to propitiate all this, they will need to develop basic social services, infrastructure, communication, etc. to continue with the development and growth of that country. All this translates into greater consumption of raw materials, copper and more. The difference in GDP per capita by region of China is shown in Figure 2.5. While Figure 2.6 shows the projection of the price of copper according to the growth of China, by Research de Larrain Vial; where it is shown that in 2018 at an economic growth of China of 2%, the estimated copper price is $ 3.2 / lb.

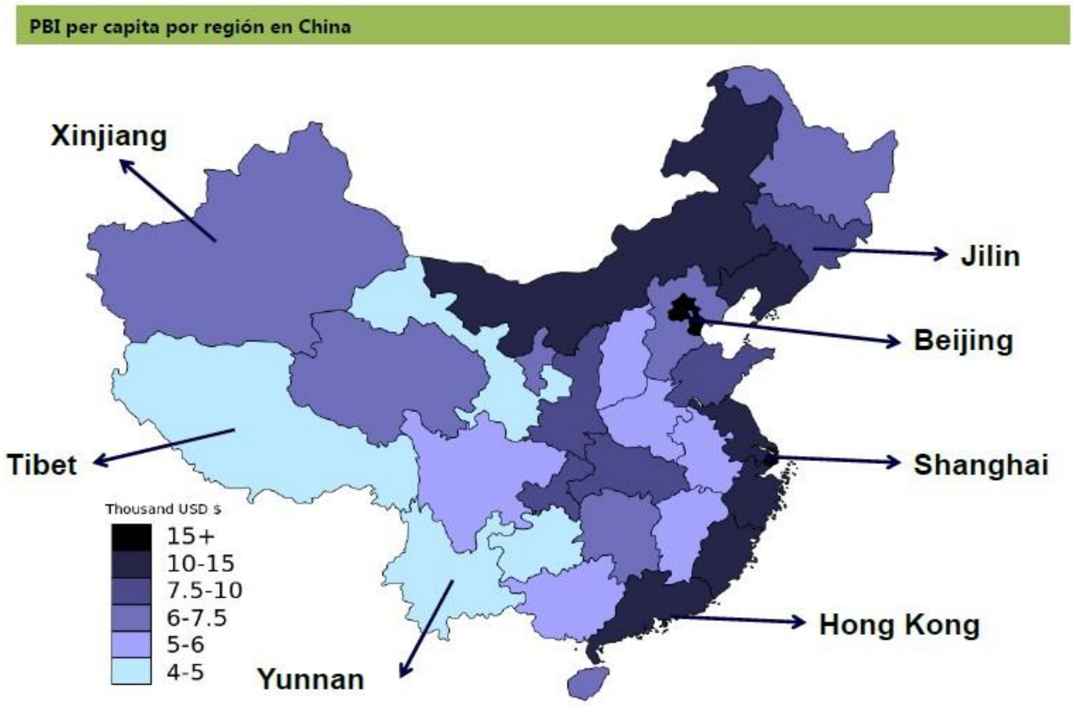


Figure 2,5: Difference between GDP per capita by region of China

Source: Goldman Sachs

Table 1: Global Copper Balance 2013-2020 (Thousands of Tons) & price forecasts

	2013	2014	2015	2016	2017	2018	2019	2020
Global Copper Demand								
Western Europe + UAE	3,048	3,064	3,184	3,220	3,261	3,294	3,376	3,494
Annual Variation (%)	2.1	0.5	3.9	1.1	1.3	1.0	2.5	3.5
Asia-Pacific ex China	4,359	4,491	4,506	4,655	4,738	4,819	4,901	5,048
Annual Variation (%)	0.2	3.0	0.3	3.3	1.8	1.7	1.7	3.0
China	9,411	10,050	10,245	10,575	10,839	11,056	11,277	11,616
Annual Variation (%)	12.5	6.8	1.9	3.2	2.5	2.0	2.0	3.0
NAFTA (USA, Canada & Mexico)	2,317	2,259	2,317	2,287	2,313	2,349	2,393	2,451
Annual Variation (%)	4.4	-2.5	2.5	-1.3	1.2	1.5	1.9	2.4
USA	1,826	1,753	1,798	1,762	1,789	1,824	1,861	1,907
Annual Variation (%)	3.8	-4.0	2.6	-2.0	1.5	2.0	2.0	2.5
Canada & Mexico	491	506	519	525	525	525	533	543
Annual Variation (%)	6.7	3.1	2.5	1.1	0.0	0.0	1.5	2.0
Emerging Europe + Africa + Latin America	2,108	2,163	1,742	1,696	1,722	1,739	1,765	1,800
Annual Variation (%)	0.0	2.6	-19.4	-2.6	1.5	1.0	1.5	2.0
Global Copper Demand	21,241	22,026	21,995	22,432	22,874	23,257	23,713	24,409
Annual Variation (%)	6.1	3.7	-0.1	2.0	2.0	1.7	2.0	2.9
Global Copper Output	21,227	22,102	22,300	22,602	22,634	23,157	23,366	23,614
Annual Variation (%)	5.1	4.1	0.9	1.4	0.1	2.3	0.9	1.1
GLOBAL COPPER BALANCE	-14	76	305	170	-240	-100	-347	-795
Average Copper price. USD¢ / Lb	3.32	3.11	2.60	2.21	2.80	3.20	3.75	4.25
USD / Euro (Average price)	1.33	1.33	1.11	1.11	1.13	1.20	1.25	1.30
Yen / USD (Average Price)	97.53	105.77	121.02	108.82	110.98	107.00	105.00	103.00

Figure 2,6: Copper price projection according to the growth of China

Source: Research Department - Larrain Vial

2.2. GOLD PRICE EXPECTATIONS

Like copper, in the gold market, the price is established based on the balance between supply and demand, this most of the time is in imbalance, which translates into increases and decreases in the international price. While the balance between supply and demand is an important factor in the price of gold, there are external factors that may vary slightly or sharply, such as the value of the US dollar and international geopolitical problems.

The periods of low prices are a reflection of the excess demand that is presented in the market; while high prices are a consequence of the shortage of the present offer.

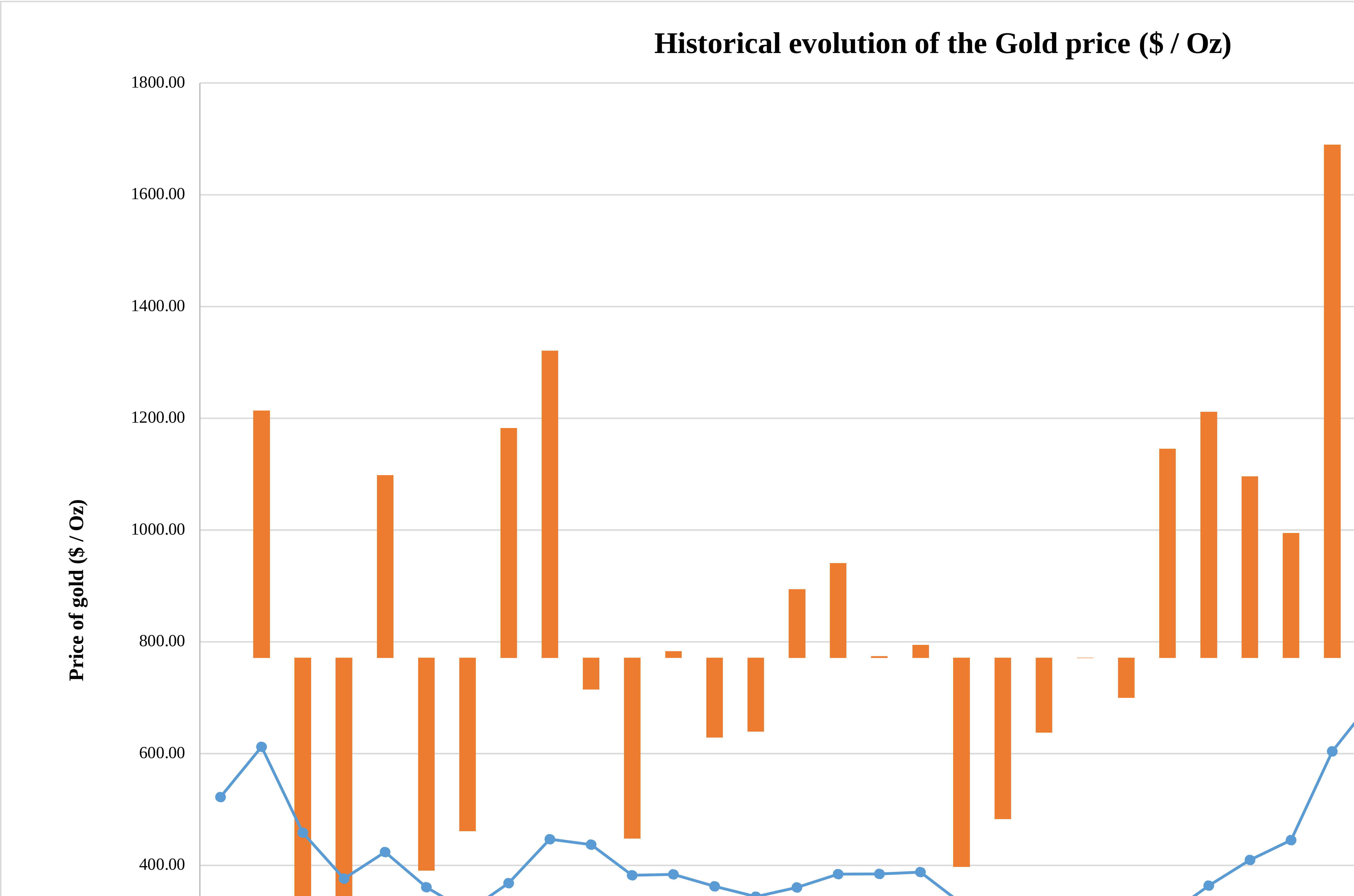
In the short square there are factors that can affect the price of metal, such as operating costs and levels of production, consumption, etc., but it is the factors external to the market, such as financial, speculative and geopolitical factors that have greater influence on price determination. On the contrary, in the long term it is the internal factors that determine the equilibrium in the price of gold, this price directly influences the gold market, since, from this, the gold mining projects, budgeting, are evaluated and the establishment of contractual clauses of purchase and sale contracts.

2.2.1. Historical evolution of the price of gold

Studying the evolution of the price of gold is controversial due to high volatility, but one could say that there is a certain cyclical behavior every 20 years. There is a high uncertainty of the demand due to the fall in gold consumption in jewelry, in addition the current US policy is aimed at strengthening the US dollar, which causes greater confidence in this currency to use it as an asset; but currently the international geopolitical situation between the United States and countries of communist government, such as Russia, Syria and North Korea, causes speculation of asset freezes in world banks; and therefore seek to save those assets taking refuge in the Gold (Main refuge value), so, the demand for this metal would increase considerably.

As seen in Figure 2.7, the price of gold has historically presented cyclical variations over long periods of time; At the beginning of the 80's, the price of gold reached a maximum average value of 611. $ 97 / Oz and then suffered a continuous decline until the middle of said decade where the price was $ 317.46 / Oz, in In 1987, there was a slight increase to $ 446.91 / Oz and after that it remained relatively constant, until the beginning of the new millennium. At the beginning of the first decade of the 21st century, the mining boom began and the price of gold had a rebound to reach an average maximum price of $ 1669.16 / Oz, in 2012. In the present decade the lower demand for gold was due to a reorientation of portfolio preferences, that is, the choice of having assets in US dollars and not in gold; This effect occurs after the crisis in the United States and Europe.

In 2017, the price of gold began to rise, mainly due to the improvement of the global economy, a certain fall in the US dollar and geopolitical tensions; At the end of 2017 the average price of gold was $ 1260.18 / Oz. This upward trend has been maintained due to the causes mentioned above.



Historical evolution of the Gold price ($ / Oz)
Price of gold ($ / Oz)
1800.00
1600.00
1400.00
1200.00
1000.00
800.00
600.00
400.00

2.2.2. Gold offer analysis

According to John Bridges, an analyst at JP Morgan in the "International Gold and Silver Symposium," there are limitations on the volume of gold offered. Mainly due to the decreasing degree of quality of the gold deposits, the search for deeper mineralized bodies increased operating costs and socio-economic problems. In addition, he mentioned that world gold reserves have fallen and it is increasingly difficult to replace, which translates into a decline in world gold inventories.

During the next decade, it will be more difficult to find deposits with high ore grades. In addition, that old mines require greater efforts and higher costs to carry out the exploitation of the deposit.

On the other hand, there is greater difficulty in securing reliable supplies of energy and water to carry out mining operations. Due to the increasingly frequent socio-environmental problems, mining companies can increase the use of desalinated water.

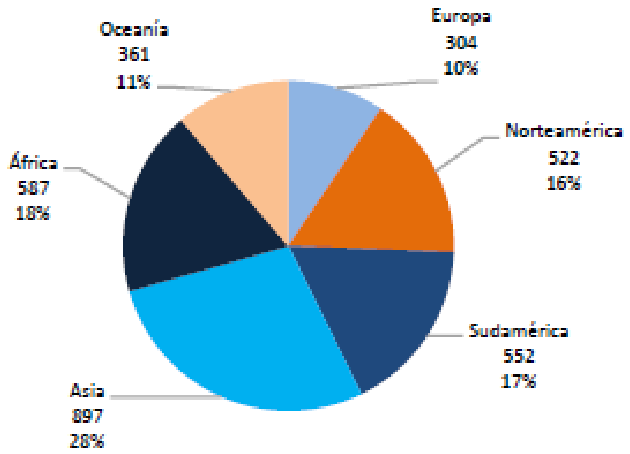


Figure 2,8: Production of regional mine

Source: GFMS Gold Survey 2017

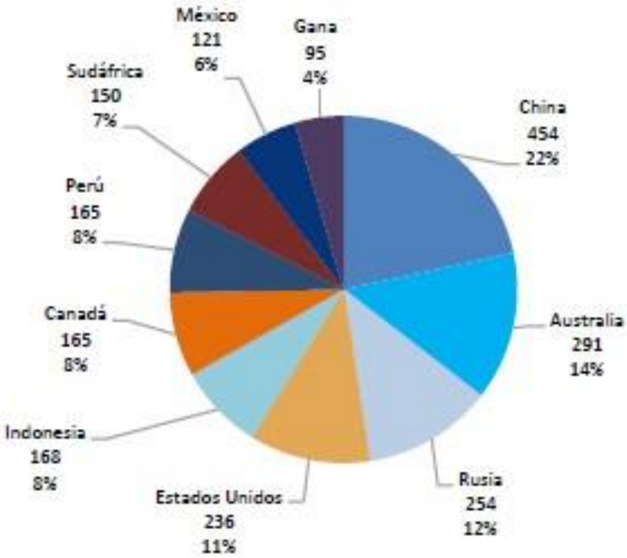


Figure 2,9: Main gold producing countries

Source: GFMS Gold Survey 2017

2.2.3. Gold demand analysis

As of 2017, an improvement in the global economy, a certain weakness of the US dollar and geopolitical tensions between the United States and the European Union against communist countries such as Russia, Syria and North Korea began to be evident; despite the fall in demand in approximately 18% in the jewelry sector.

The increase in assets in gold; It was because, unlike metals such as Copper and Zinc, manufacturing metals, gold is a final asset because it is a refuge asset and therefore has a strong inverse dependence on the US dollar. The following graphs show what was said before:

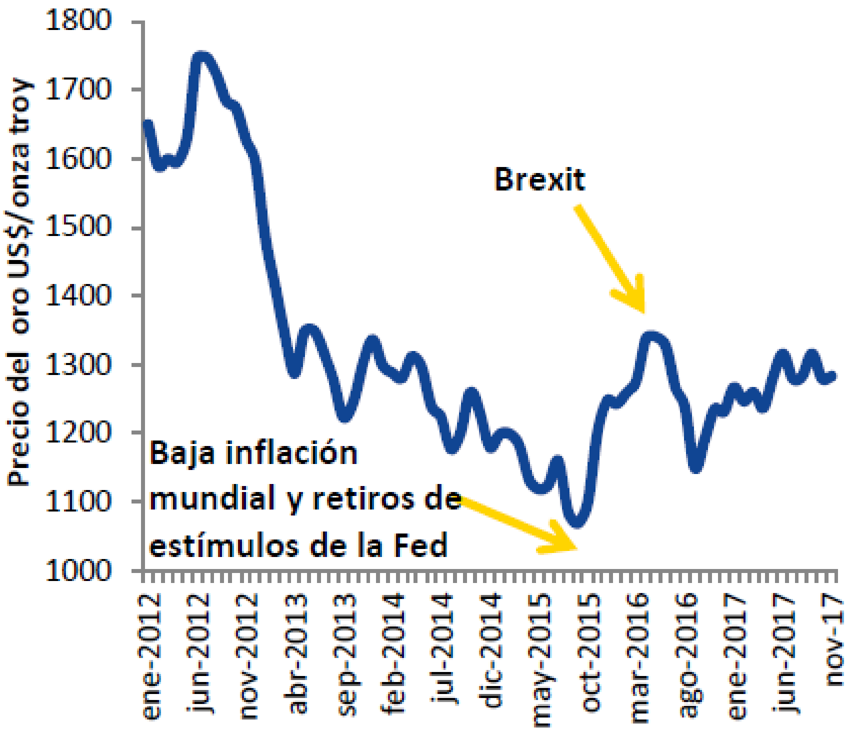


Figure 2,10: Gold Price Evolution (2012 – 2017)

Source: Report of the sectorial economic analysis “Mining sector 2017”– Osinergmin

Año	2011	2012	2013	2014	2015	2016	1S 2016	1S 2017
Fabricación de Joyas	2.091	2.061	2.610	2.469	2.393	1.891	885	1.075
Fabricación Industrial	471	429	421	403	365	355	174	182
Sector oficial (Bancos Centrales)	457	544	409	466	443	258	85	144
Lingotes	1.247	1.056	1.444	886	876	783	364	383
Monedas	369	350	426	276	285	256	114	110
Demanda física	4.635	4.440	5.311	4.499	4.362	3.543	1.622	1.894

Figure 2,11: Gold demand (Ton)

Source: Precious metals “Gold and Silver Market 2017” – Cochilco

2.3. SILVER PRICE EXPECTATIONS

Analyzing the silver market is similar to the study of the gold market since both are active refuge. The price is established based on the balance between supply and demand, this most of the time is in imbalance, which translates into increases and decreases in the international price. While the balance between supply and demand is an important factor in the price of silver, there are external factors that may vary slightly or sharply, such as the value of the US dollar and international geopolitical problems. The main difference with gold is that silver has a greater use in the electronic sector, so that the industrial production of China and other relevant economies are an important factor in determining the price of silver.

As stated in the analysis of copper and gold, periods of low prices are a reflection of the excess demand presented in the market; while high prices are a consequence of the shortage of the present offer.

In the short term there are factors that can affect the price of metal, such as operating costs and production levels, higher consumption, etc., but it is the factors external to the market, such as financial and speculative factors that have the greatest influence. in the price determination. On the contrary, in the long term it is the internal factors that determine the equilibrium in the price of silver, this price directly influences the silver market, since, from this, mining projects are evaluated, development of budgets and the establishment of contractual clauses of purchase and sale contracts.

2.3.1. Historical evolution of the price of silver

Silver being a commodity and the second refuge value, after gold, has some volatility, but less compared to gold. The little information available on the historical evolution of the price of silver does not allow to analyze whether it presents a certain cyclical behavior. But if we analyze this metal as a refuge value,

we can infer that it is affected by the same factors that influence gold, that is, if the improvement in the global economy continues, a certain weakness of the US dollar and the geopolitical tensions between the United States and the European Union against communist countries such as Russia, Syria and North Korea, one could expect an increase in the price of this metal. In addition, this metal, unlike gold, has industrial uses in electronics; as one of the main buyers of silver is known to be China, if the government continues to drive reforms to increase domestic consumption, decrease the weight of exports and a greater weight of services; It will require the development of basic social services, infrastructure, communication, technology, etc. therefore a greater consumption of silver.

As can be seen in Figure 2.12, the price of silver had times remained with low prices between 2000 and 2005, from the year 2007 until the end of 2012 the “mining boom” is produced and the price of Precious metals rose considerably to reach the average price of $ 35.29 / oz. At the end of this stage, silver suffered a sharp drop in price to a minimum of $ 15.69 / oz.

In 2017, the price of silver began to rise, mainly due to the improvement of the global economy, a certain fall in the US dollar and geopolitical tensions, and greater consumption of this metal in China and other important economies; At the end of 2017 the average price of silver was $ 17.05 / oz. This trend has been maintained with small positive and negative variations, but nothing significant.


Historical evolution of the price of Silver ($ / Oz)
Silver Price ($ / Oz)
40.00
35.00
30.00
25.00
20.00
15.00
10.00

2.3.2. Silver offer analysis

Globally, the decreasing degree of the quality of mining deposits is a constant, and silver deposits are no exception. The search for deeper mineralized bodies, the increase in operating costs and socio-environmental problems are the main factors that limit the production of silver; The consequence of this is the decline in world silver inventories.

On the other hand, old mines are increasingly difficult to extract precious metal, since it requires greater efforts and higher costs to achieve the exploitation of the metal.

In addition, reliable energy and water supplies are increasingly difficult to secure. Mainly, due to socio-environmental problems, currently more recurrent; This is why many mining companies are using alternative methods of obtaining these supplies and thus increasing their costs.

OFERTA FISICA	2010	2011	2012	2013	2014	2015	2016	Variación 2016/2015
Producción de mina	23.418	23.583	24.622	25.617	27.013	27.704	27.548	-0,6%
Ventas netas de gobiernos	1.375	373	230	246	0	0	0	0,0%
Reciclaje de plata	7.041	8.089	7.893	5.940	5.141	4.388	4.345	-1%
Coberturas	1.567	379	-1.465	-1.082	522	243	-572	-335,9%
Total	33.401	32.425	31.280	30.721	32.677	32.335	31.321	-3,1%

Figure 2,13: World Silver Offer (Ton)

Source: Precious metals “Gold and Silver Market 2017” – Cochilco

Ranking	País	2016
1	México	5.791
2	Perú	4.593
3	China	3.496
4	Chile	1.501
5	Rusia	1.449
6	Australia	1.356
7	Bolivia	1.353
8	Polonia	1.197
9	Estados Unidos	1.101
10	Argentina	933

Ranking	Compañía	2016
1	Fresnillo plc.	1.421
2	Glencore plc.	1.216
3	KGHM Polska Miedź	1.207
4	Polymetal International	908
5	Goldcorp Inc.	874
6	Pan American Silver	790
7	Cia. De Minas Buenaventura	768
8	Volcan Cia. Minera	684
9	Tahoe Resources Inc.	662
10	Codelco	650

Figure 2,14: Ten countries and companies with the highest silver production by 2016 Ton)
Source: Precious metals “Gold and Silver Market 2017” – Cochilco

2.3.3. Demand analysis of silver

Like any commodity and refuge value, its demand is influenced, mainly, by external factors such as the improvement in the global economy, a certain weakness of the US dollar and geopolitical tensions between the United States and the European Union against communist countries such as Russia, Syria and North Korea; but also because of its demand that between 2015 and 2016 there was a 9.3% drop in the jewelry sector.

As you can see there are factors that favor the rise in the price of silver and those that are counterproductive to the price of this metal. But in general terms, the supply of this metal, compared to demand, still presents a deficit that can positively favor the price of silver.

Año	2010	2011	2012	2013	2014	2015	2016	Variación 2016/2015
Joyería	5.909	5.956	5.828	6.898	7.088	7.100	6.438	-9,3%
Lingotes y monedas	4.593	6.481	4.951	7.483	7.277	9.041	6.431	-28,9%
Platería	1.605	1.468	1.359	1.829	1.888	1.956	1.620	-17,2%
Aplicaciones Industriales	19.711	20.570	18.660	18.800	18.526	17.715	17.475	-1,4%
Demanda física total	31.818	34.475	30.798	35.010	34.779	35.812	31.964	-10,7%

Figure 2,15: Silver demand between 2009 - 2015 (Ton)

Source: Precious metals "Gold and Silver Market 2017"– Cochilco

Año	2010	2011	2012	2013	2014	2015	2016
Oferta total	33.401	32.425	31.280	30.721	32.677	32.335	31.321
Demanda física total	31.818	34.474	30.798	35.009	34.779	35.812	31.965
Superávit/Déficit	1.583	-2.049	482	-4.288	-2.102	-3.477	-644
Inversión en ETF	4.027	-746	1.720	78	47	-550	1.462
Inventarios en Bolsas	-230	379	1.934	274	-165	392	2.482
Balance Neto	-2.214	-1.682	-3.172	-4.641	-1.984	-3.319	-4.588

Figure 2,16: Comparison between the offer and demand of silver (Ton)

Source: Precious metals "Gold and Silver Market 2017" - Cochilco

CHAPTER III: GENERAL DESCRIPTION OF THE MINE

3.1. LOCATION

The El Sol Naciente Tercero mining concession of the mining company S.M.R.L. Gotas de Oro, is located at the head of the San Antonio gorge, with an average altitude of 800 m.s.n.m .; politically it is located in the place of the Huayurí Hill, to the Southeast of the district of Santiago, province of Ica, department of Ica.

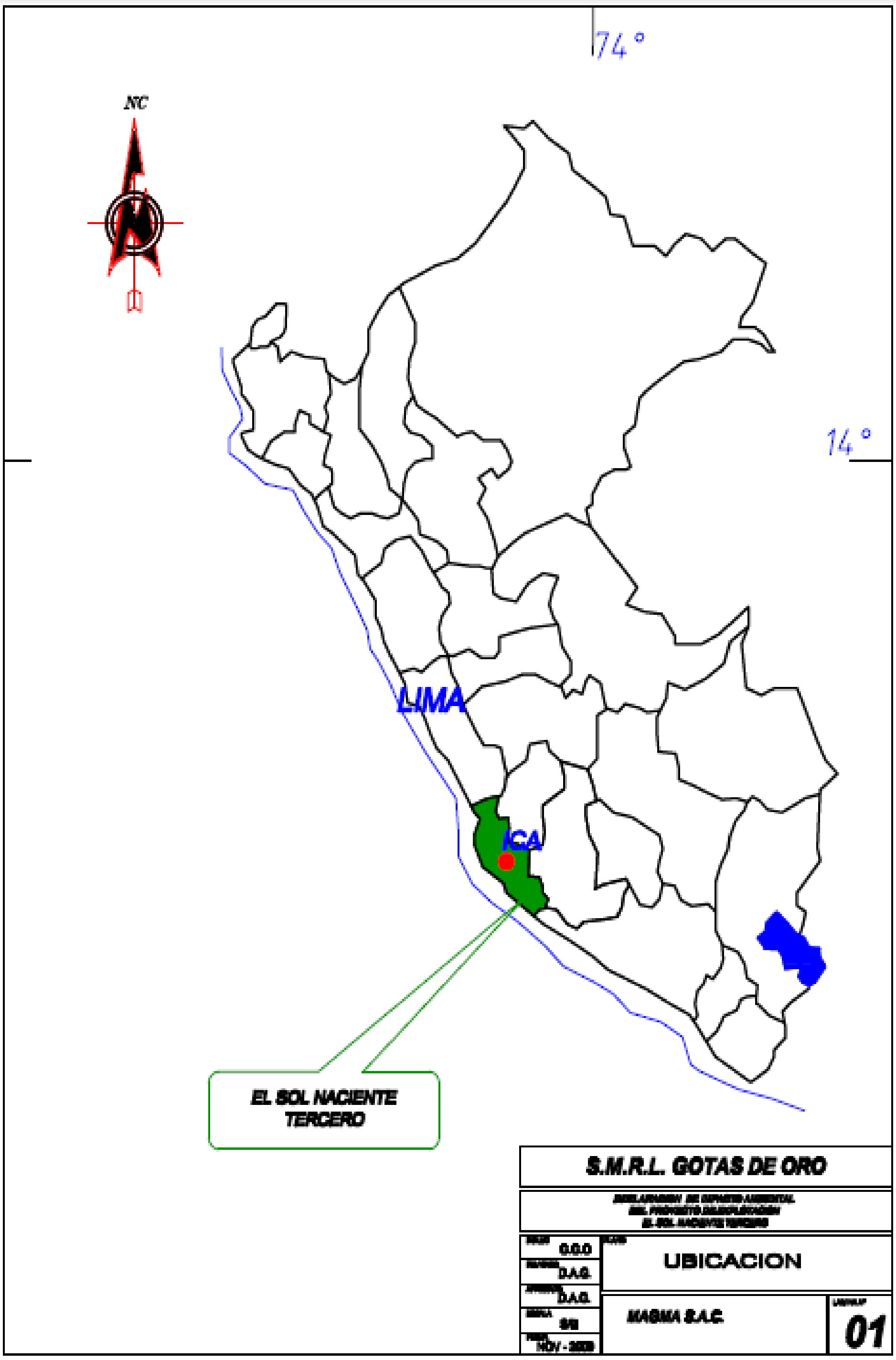


Figure 3,1: Location map of the El Sol Naciente Tercero mining concession

Source: Department of Geology - S.M.R.L. Gotas de Oro

Figure 3,2: Geographical location and access to the mining concession El Sol Naciente Tercero

Source: Department of Geology – S.M.R.L. Gotas de Oro

3.2. ACCESSIBILITY

To access the mining concession of the S.M.R.L. Drops of Gold from the city of Lima, the South Pan-American Highway is used, passing through the city of Ica, district of Santiago until reaching kilometer 354, from that place you take a detour with a Northeast direction of 9 kilometers until you reach the place of Cerro Huayurí where the mine is located, the times are shown below:

Table 3,1: Access Route to the El Sol Naciente Tercero mining concession

ROUTES OF ACCESS TO THE CONCESSION AREA			
TRIP	**ROAD TYPE**	**LENGHT (Km.)**	**TIME (Hr.)**
Lima – Ica	Paved road	300	4
Ica – Desvío (Km. 354)	Paved road	54	1
Desvío (Km. 354) – Mina	Carriage trail	9	0.7
TOTAL		363	5.7

Source: Department of Geology - S.M.R.L. Gotas de Oro

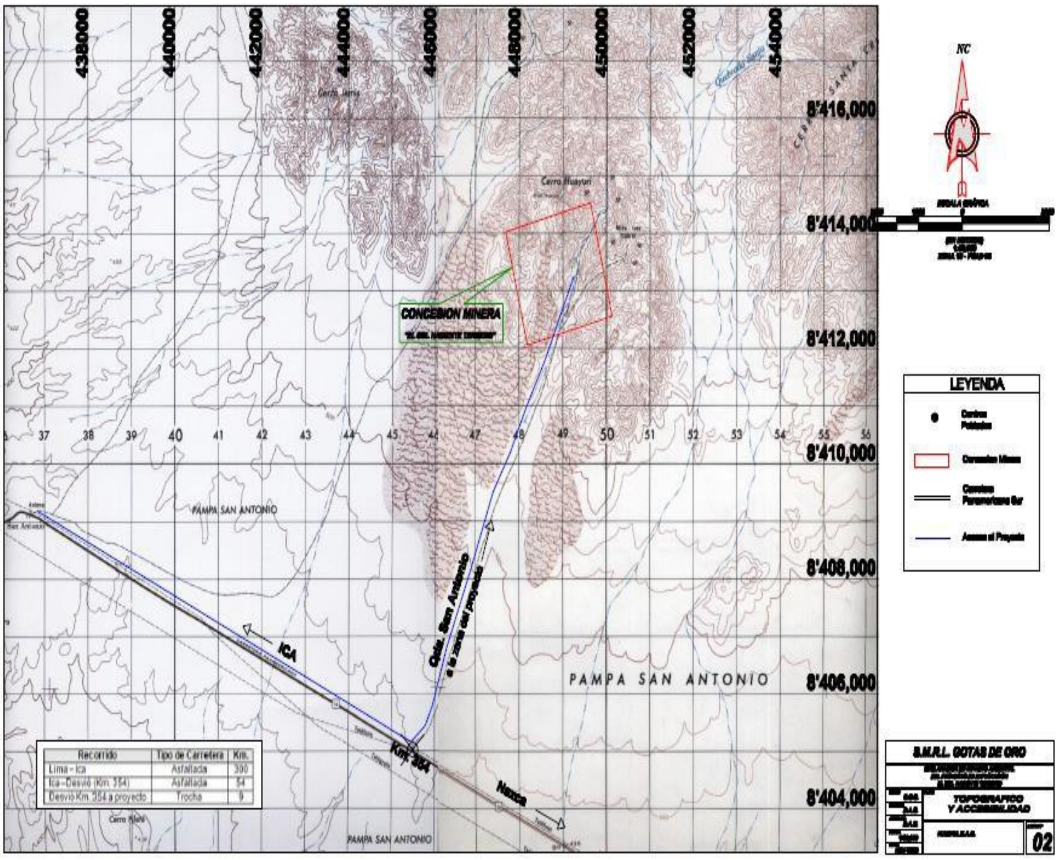


Figure 3,3: Access to the mining unit El Sol Naciente Tercero

Source: Department of Geology – S.M.R.L. Gotas de Oro

3.3. MINING PROPERTY

The mine is located at the head of the San Antonio gorge, made up of 400 hectares. The UTM coordinates of the El Sol Naciente Tercero mining concession are as follows:

Table 3,2: Coordinates of the Mining Concession El Sol Naciente Tercero

LOCATION		
VERTEX	**NORTH**	**EAST**
1	8´424,544.76	449,640.26
2	8´412,607.09	450,135.67
3	8´412,111.68	448,198.00
4	8´414,049.36	447,702.59

Fuente: Departamento de Geología – S.M.R.L. Gotas de Oro

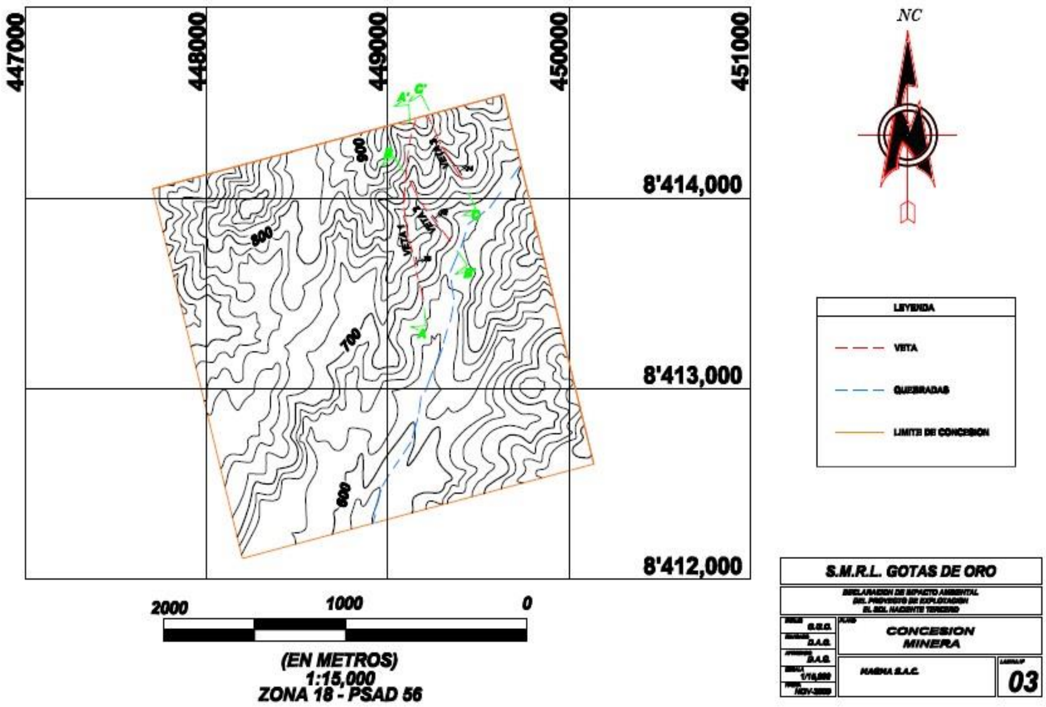


Figure 3,4: Extension of the mining concession El Sol Naciente Tercero

Source: Department of Geology - S.M.R.L. Gotas de Oro

3.4. PHYSIOGRAPHY

The mine area corresponds to the pre-assembled ecological deserted floor, characterized by presenting sectors with wavy relief, plain type and coastal foothills that reach up to 1000 meters. It is located in the Southeast of the province of Ica, in the department of Ica and is constituted by two main physiographic units: La Costa and Yunga Marítima.

3.4.1. La Costa

La Costa is characterized by its flat topography with gentle undulations, it begins on the sea coast until the height of 500 m.a.s.l., it presents esplanades that reach with the Maritime Yunga.

3.4.2. Marítime Yunga

The Maritime Yunga starts at 500 m.a.s.l. to the foothills of the coastal batolith, approximately 1000 m.a.s.l.; It is formed by wind - alluvial deposits, which was previously seabed.

3.5. Weather

The weather of the area where the mine is located, since it is located in the coastal area and forming part of a pre-assembled desert, it presents a moderate warm climate, slightly humid, with little seasonal summer rainfall, also characterized by the presence of sun for most of the year.

Constant winds in certain seasons, due to the concentrated heat, cause Paracas winds that occur from time to time. River precipitation is scarce, with evaporation being greater than river precipitation.

3.5.1. Temperature

The temperature in the area of the mine corresponds to that of a semi-warm climate, where temperatures are registered annually between a minimum of 16 0C (During the months of June, July, August and September) and a maximum of 28 0C (During the months of January, February and March); the other months the temperature fluctuates within the aforementioned range.

3.5.2. Humidity

The relative humidity of the area, because it is in a desert area, is low. The annual average relative humidity average recorded, according to the Ocucaje weather station of SENAHMI, is 73.42%. Reaching a maximum of 84% in the months of June and July, and a minimum of 70% in the months of December, January, February and March.

3.5.3. Rainfall

Las precipitaciones fluviales en el área son muy escasas, debido a su ubicación desértica, por lo general no existen precipitaciones importantes, por lo que, el peligro de inundaciones o catástrofes ocasionadas por las condiciones climatológicas, es mínimo. Las pocas precipitaciones, por lo general se presentan entre los meses de enero a abril.

3.5.4. Evaporation

The recorded evaporation, according to the Ocucaje weather station of SENAHMI, varies between 2.4 and 57 millimeters, the annual average being 9.35 millimeters. The lowest values are recorded in the months of June and July. As the evaporation is greater than the maximum precipitation due to river precipitation, this allows a decrease in the ambient temperature in the mine area.

3.6. VEGETATION

La vegetación, en la zona de la mina, es incipiente; con la presencia esporádica de cactus y algunas plantas de arbustos pequeños en partes de la quebrada San Antonio, el resto es terreno seco y árido.

3.7. HYDROGRAPHY

The San Antonio gorge is dry and arid without surface and underground water resources, this being a small micro basin that is born on the south side of the Huayurí hill. The micro basin has an extension of 1.5 kilometers from birth to the place where the project is located.

3.7.1. Microbasin: San Antonio Ravine

The total area of the microbasin of the San Antonio ravine is approximately 0.45 km2. The total length of the dry riverbed is 15 km, the average slope is 8.3% and flows into the San Antonio pampas. No discharge regime is dry and arid during the year.

The San Antonio ravine is born near the summit line of the Batolito of La Costa; it is broken, in its route it is intercepted by small ravines, forming a dendritic drainage oriented towards the Pacific Ocean. In addition, due to the short length of the water basin, the contributors that are small streams do not have much flow due to the few routes they have.

For the reasons stated and because there are no effluents from the mine for water monitoring according to environmental standards, the water monitoring points within the basin are not established.

3.8. TOPOGRAPHY

The topography that occurs in the area where the mine is located is of coastal plain, desert-like, with flat surfaces in the lower parts of the area and hills of moderate slope in the upper parts. As shown in Figure 3.3 of "Access to the El Sol Naciente Tercero mining unit".

3.9. RESOURCES

3.9.1. Water resources

The area where the mine is located does not have underground or surface water resources, so the water is taken from a well located in the town of La Venta (20 kilometers from the mine), from which the mine is supplied through 11000 gallon tank trucks, which are discharged into a tank located 50 meters north of the camp, from where it is driven by gravity to the drinking water system. In addition, this water is used inside mine for rock drilling and irrigation of broken ore.

3.9.2. Compressed air

The mine currently has 05 diesel compressors: An INGERSOLL RAND 600 of 600 CFM, a SULLAIR 375 of 375 CFM, a DEMAG 350 of 350 CFM and an INGERSOLL RAND 825 of 825 CFM and an INGERSOLL RAND 1400 of 1400 CFM (Inoperative). In total, the compressed air capacity allows 12 drilling machines to be operated simultaneously, which have a total air consumption of 1850 CFM.

3.9.3. Energy resource

Currently there are 04 generators: Volvo of 300 KW, Perkins of 130 KW and two GENPACK of 50 KW and 60 KW, all this power allows to operate the winches, lamp house, camp, others; in total they add an electrical energy requirement of 370 KW.

3.9.4. Human resource

For a production of 2000 tons per month, the number of staff employed is 88 people; but with the increase in production, more personnel were required, distributed as follows:

Table 3,3: Distribution of personnel of the El Sol Nascent Third Mining Concession

CHARGE	AMOUNT	CHARGE	AMOUNT
General Manager	1	Performer	14
General superintendent	1	Performer Assistant	14
Mine operations chief	1	Timber	4
Security officer	2	Timber Helper	4
Administrator	1	Compressors	4
Chief of guard	2	Storage	2
Surveyor	1	Grocer	2
Surveyor Assistant	2	Drivers mine service	4
Heavy machinery operators	8	Pallaqueros	8
Mine secretary	1	General Mine Services	23
Mechanics	5		
TOTAL			103

Source: Engineering Department - S.M.R.L. Gotas de Oro

3.9.5. Cargo and transport equipment

En el área de carguío y acarreo, actualmente la mina cuenta con los siguientes equipos para movimiento de tierras en labores subterráneas y acumulación en superficie.

Table 3,4: Equipment for loading and transporting ore and clearing

TYPE	BRAND	CAPACITY	MODEL
Front loader	Kobelco	2.5 Yd^3	350
Front loader	Caterpillar	4 Yd^3	988
Scoop trumps	Eimco Jarvis Clark	3.5 Yd^3	EJC 130
Scoop trumps	Wagner	3.5 Yd^3	ST 3.5
Scoop trumps	Eimco Jarvis Clark	1.5 Yd^3	EJC 650
Mini charger	Bobcat	0.5 Yd^3	838 G
Dumper	Mercedez benz	8 Tn	N^0 1100
Dumper	Huatong	10 Tn	JN5815PAD1A
Dumper	Mercedez benz	8 Tn	N^0 1100
Mining cars	-	0.8 Tn	-

Source: Engineering Department - S.M.R.L. Gotas de Oro

3.9.6. Supplies

The mining company has an EIA - sd and the COM (Certificate of mining operation), required for the purchase of explosives nationwide.

CHAPTER IV: GEOLOGY

4.1. HISTORICAL GEOLOGY

The historical geological events, where the mine is located, date back from the Precambrian, with the formation of the metamorphic rocks of the basal complex of the coast, as a product of the catazonal to metazonal regional metamorphism, originating from numerous orogenic movements.

In the Upper Cretaceous, the first Andean deformation occurred with the Peruvian movement, folding and slightly raising the region while the hipabisal rocks were located, followed by the site of the Batolito de la Costa.

Subsequently, an extensive area of erosion was developed in the Miocene, marine transgression reached the area, reaching the current coastal strip and depositing the sediments of the Guaneros Formation.

At the end of the Miocene there was the Quichuano movement that slightly folded the mountain region while the coastal part was subject to failure.

4.1.1. External geodynamics

The geodynamic processes that take place in the area of the mine, are closely related to the rainfall that occurred during the rainy seasons. These geodynamic processes translate, mainly, in river erosion phenomena, which affected the rocky outcrops of the area, forming their incipient streams. It is considered that the activity of these geodynamic phenomena, such as wind, heat and temperature changes, reach their maximum degree of affectation in the lower part, given the presence of seabed and eluvial deposits, with accumulations of fine sand in the hills.

4.2. REGIONAL GEOLOGY

Regionally, the litho-stratigraphic units of the mine, as well as the surrounding ones, cover a wide chronology, from the Recent Quaternary to the Jurassic.

Sedimentary rocks and volcanic rocks and quaternary deposits emerge, these deposits correspond to eluvial soils composed of thick fragments (silty gravels with sand); of somewhat excessive drainage and high water requirements.

4.2.1. Guaneros Formation

Guaneros formation is made up of vulcan - sedimentary rocks. The lithology consists of volcanic rocks of green-brown color with fragments of andesitic composition, andesites-profyritic, gray-brown; interspersed with fine to medium vein sandstones and also conglomeric sandstones, shales and marls.

Regionally this formation has a power that varies from 200 to 1000 meters and is of the age of the Upper Jurassic.

4.2.2. Yura group

According to Jenks, W. (1948), the Yura group is a sedimentary sequence made up of quartzites, slate and sandstone.

This group is made up of two stratigraphic sequences, one inferior called Yauca and the other superior called Hualhuani formation.

The Yauca formation has an approximate power of 2000 meters and the Hualhuani formation 200 meters, is of the Neocomiano Superior - Titoniano age of the Lower Triassic.

4.2.3. Alluvial Deposits

These deposits are widely distributed in the San Antonio pampas, composed of detritic material, resulting from the alteration of the rocks that remain in situ.

The dynamics of the area is mainly related to the tectonic movements of the Andean cycle. The structural evidences of the oldest orogenes are indicated, in the first place, by the regional metamorphism that affects the rocks of the Batolito complex of the coast and by angular disagreements, recognizing the hercinic phases.

The block tectonics is linked to the orogenic and epirogenic movements, typical of the rise of the Andes.

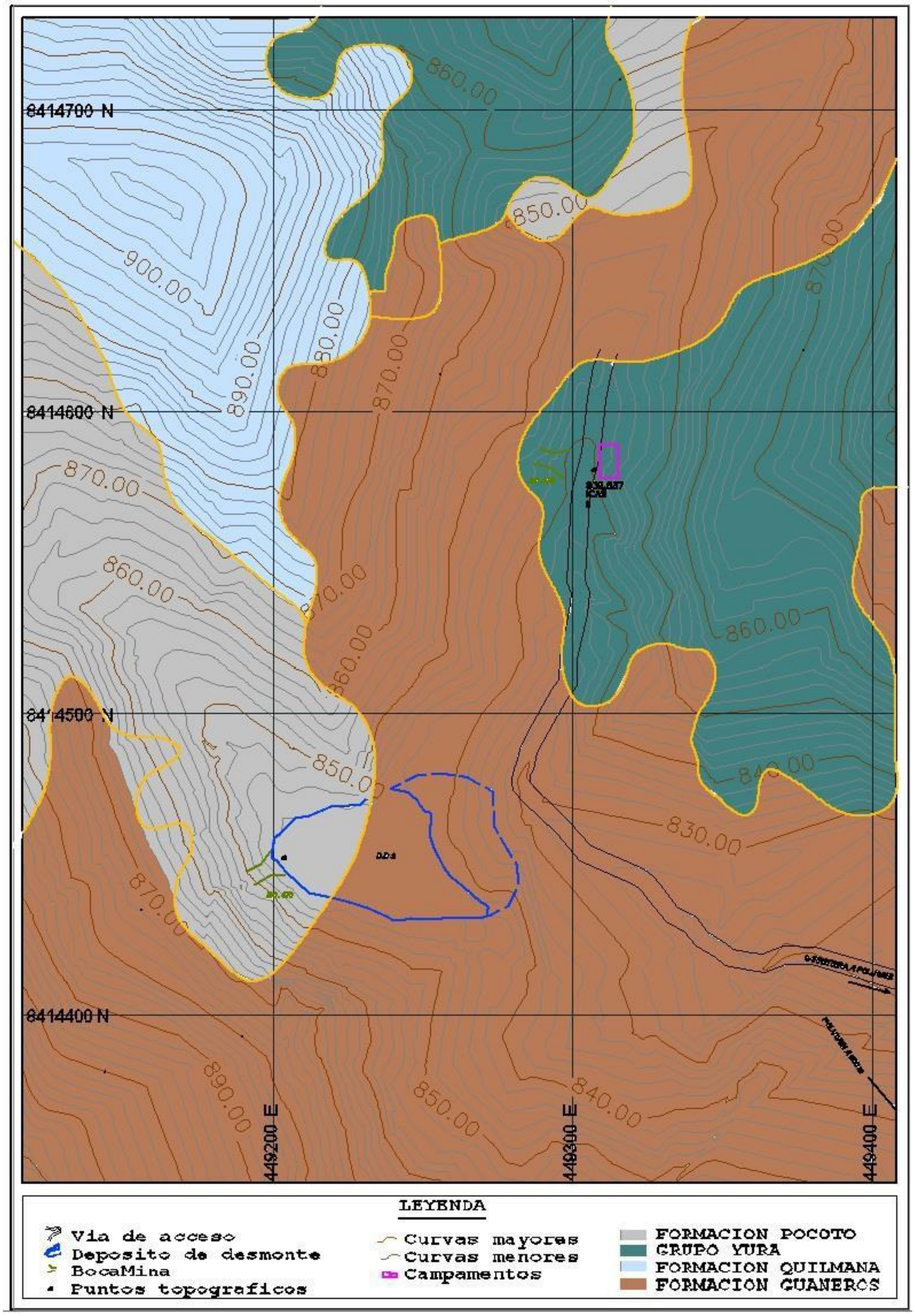


Figure 4,1: Local Geology of the Mining Concession El Sol Naciente Tercero – S.M.R.L. Gotas de oro

Source: Geological, Mining and Metallurgical Institute - Ingemmet

4.3. LOCAL GEOLOGY

The El Sol Naciente Tercero mining concession of the mining company S.M.R.L. Gotas de Oro is located 354 kilometers from the city of Lima, to the Southeast of the district of Santiago, at the head of the San Antonio gorge, place of the Huayurí Hill, province of Ica, department of Ica, at an average height of 800 masl

The local area geology is composed of quaternary material, the result of both alluvial and colluvial meteorism, which over time has been able to change the initial physiography generating wavy surfaces, as well as occupies volcanic slopes represented by rocky outcrops that have enabled the formation of the mineral deposit of the mine, establishing different periods of deposits, generating a surface that does not present important vegetation, with a slope above 350.

The following table 4.1 shows the stratigraphic column of the local geology where the mine is located:

Table 4,1: Stratigraphic column of the area where the Mining Concession El Sol Naciente Tercero is located

AGE	SISTEM	SERIE	LITHESTRA TIGRAPHIC UNIT	INTRUSIVE ROCKS PLUTONIC
CENOZOIC	QUATERNARY	HOLOGEN	ALUVIAL DEPOSITS	
	TERTIARY	PLIOCENE	POCOTO FORMATION	ANDESITE
				TONALITE
			YURA GROUP	TONALITE
MESOZOIC	CRETACEOUS	EARLY	QUILMANA FORMATION	GRANODIORITE
				DIORITE
		LATE	GUANEROS	
	JURÁSSIC	EARLY	FORMATION	ANDESITE

Source: Department of Geology – S.M.R.L. Gotas de Oro

4.4. STRUCTURAL GEOLOGY

As a result of compression efforts at the regional level, a series of shear fractures and heading tension N100E to N500W have originated, which is a general tectonic characteristic of the district and served for the placement of mineralized fluids.

- **Systems fractures $N64^0$ – 88^0E and diving 70^0 – 80^0SE**

They are fractures that are longer, with inflections, cymoids and branches in different sections throughout their length. The veins belong to this system: ICAS I, ICAS II and RECUPERADA.

- **Systems fractures N50^0 – 60^{0}W and diving 65^0 – 80^{0}NW**

They are tension structures with mineralized filling of great importance, mainly comprising the veins: GINO I, ESCONDIDA AND ROSITA, but the latter with a heading of N10^{0}E.

- **Systems fractures N40^0 – 50^{0}W and diving 60^0 – 75^{0}NE**

This mineralized structure contains a filling of the same importance as those mentioned above and is in turn comprised of a series of branches in which some have a SW diving direction, mainly comprising the vein: GINO II.

4.5. ECONOMIC GEOLOGY

The deposit of the El Sol Naciente Tercero concession is of the philonic type, with fractures filled by hydrothermal solutions, whose mineralization has been placed under moderate conditions of pressure and temperature.

4.5.1. Mineralogy

Economic mineralization occurs in irregular nails in length, depth and power, separated from each other by areas of thinning and / or impoverishment (Rosario type vein).

The economic minerals present in the deposit are: Chalcopyrite ($CuFeS_2$), Covellite (CuS), Bornite (Cu_5FeS_4), Chalcocite (Cu_2S), Fluorite (CaF_2), Galena Argentiferous (PbS). Gold is in its native state and as inclusions in Quartz (SiO_2) and Pyrite (FeS_2). The bargain minerals are Quartz (SiO_2), Pyrite ($Fe\ S_2$), Calcite ($Ca\ CO_3$) and Hematite (Fe_2O_3).

Figure 4,2: Chalcopyrite ($CuFeS_2$), the most abundant copper sulfide in the mining concession El Sol Naciente Tercero, in addition there is presence of Chalcocite (Cu_2S).

Source: Author

Figure 4,3: Chalcocite (Cu_2S), a sulfide with a higher copper content than Chalcopyrite ($CuFeS_2$).

Source: Author

Figure 4,4: Bornite (Cu_5FeS_4), a copper sulphide commonly called "Pigeon Chest" due to its characteristic color, is found in smaller amounts in the mining unit.

Source: Author

Figure 4,5: Gold (Au), it is present in inclusions within the Quartz (Si_2O).
Source: Author

On the surface the veins have a high content of iron and copper oxide, as the deepening increases the presence of sulphides increases, in general terms it could be said that mineralization in mining is mixed, a combination in similar proportions of oxides and sulphides.

4.5.2. Mineralized structures

There are currently 07 mineralized structures:

- **Vein GINO I**

  It is the largest of the tabular structures, the most uniform and continuous, with vein powers that vary from 1.5 to 3 meters. It is a vein of Cu, Au and Ag, it has a mineralized filling of the rosary type in a recognized length of 300 meters, it has a heading of N15°W and a diving of 72°SW, in its branch it has a heading of N40°W and diving of 70°SW.

Mineralogically it consists of concentrations of chalcopyrite, chalcocite, chrysocolla, covellite, bornite, galena and gold is associated with the minerals of quartz and pyrite, it has as an andesitic type rock.

- **Vein ROSITA**

This vein in a branch of the Gino I structure, its heading is N180W and diving is 75°NE and is recognized in about 200 meters in length, with vein powers that vary between 1.5 to 2 meters.

Mineralogically it consists of concentrations of chalcopyrite, covellite, bornite, Argentinean galena and gold is associated with the minerals of quartz and pyrite.

- **Vein ICAS I**

It is a vein that emerges and is recognized in a section of 400 meters, in the Nv. 730 its heading is N70°E and diving is 75°SW, with an average power of 3 meters. It is a very long vein with slight changes of course, among its branches are the Gino II, Soledad and Icas II veins.

Mineralogically it consists of concentrations of chalcopyrite, covellite and gold, the latter is associated with the minerals of quartz and pyrite.

- **Vein GINO II**

It constitutes one of the branches of the Icas I vein, it has an almost homogeneous heading and diving, but in the Nv. 840 its heading is N45°W and diving is 75°NE, it is recognized in a length of 240 meters, with vein powers that vary from 1.5 to 3 meters.

Mineralogically it consists of concentrations of chalcopyrite, chalcocite, chrysocolla, covellite, bornite, galena and gold associated with the minerals of quartz and pyrite, has as andesitic type rock.

- **Vein ICAS II**

On the east side, the Icas II vein in an important branch of the Icas I vein, with more than 200 meters in length, has a N35°W heading and 80°SW dip; its mineralogy consists of abundant concentrations of covellite and chalcopyrite with a vein power that varies from 1 to 2.5 meters.

- **Vein ESCONDIDA**

It is located 300 meters north of the Gino I vein and its outcrop is visible in 200 meters, has an N25°W heading and 80°SW diving, has an average vein power of 3 meters.

The mineralization is composed of quartz, pyrite, chalcopyrite, covellite; In addition, the gold law is greater than 1 Oz / Ton. Geologically it has the possibility of deepening and continuing west, so it is convenient to explore it in the short term.

- **Vein RECUPERADA**

It is a Rosario type vein, which varies constantly and slightly in direction, from which the trail was lost, but with subsequent development work it was found that it has a N100E heading and 720NW dip, with a power of vein that varies from 1.5 at 3 meters, in its structure there are distributions of copper and gold.

The following table shows a summary of the above mentioned on the veins that the mine has, so far.

Table 4,2: Vein Inventory

Vein Inventory								
VEIN	**HEAD. DIP (m)**	**RUMBO / BUZ.**	**AVERAGE POWER (m)**	**MINERAL**	**LAW**			**STATE**
					Au^+ (Oz / Tn)	**Cu^+ (%)**	**Ag^+ (Oz / Tn)**	
GINO I	300	$N15^0W$ / 72^0SW	2	Au^+, Cu^+, Ag^+	0.8 – 1.2	1.5 – 1.9	0.8 – 1.2	Exploitation
ROSITA	200	$N18^0W$ / 75^0NE	1.5	Au^+, Cu^+, Ag^+	0.7 – 1	1.4 – 1.7	0.6 – 0.9	Exploitation
ICAS I	400	$N70^0E$ / 75^0SW	3	Au^+, Cu^+	0.6 – 0.9	1.3 – 2		Exploitation
GINO II	240	$N45^0W$ / 75^0NE	2	Au^+, Cu^+, Ag^+	0.8 – 1.3	1.3 – 2.1	0.6 – 1.1	Exploitation
ICAS II	200	$N35^0W$ / 80^0SW	1.5	Au^+, Cu^+	0.5 – 0.8	1.5 – 2.7		Exploitation
ESCONDIDA	300	$N25^0W$ / 80^0SW	3	Au^+, Cu^+, Ag^+	1 – 1.4	1.4 – 1.7	0.4 – 0.8	Exploitation
RECUPERADA		$N10^0E$ / 72^0NW	2	Au^+, Cu^+	0.8 – 1.2	1.4 – 1.8		Exploitation

Source: Department of Geology - S.M.R.L. Gotas de Oro

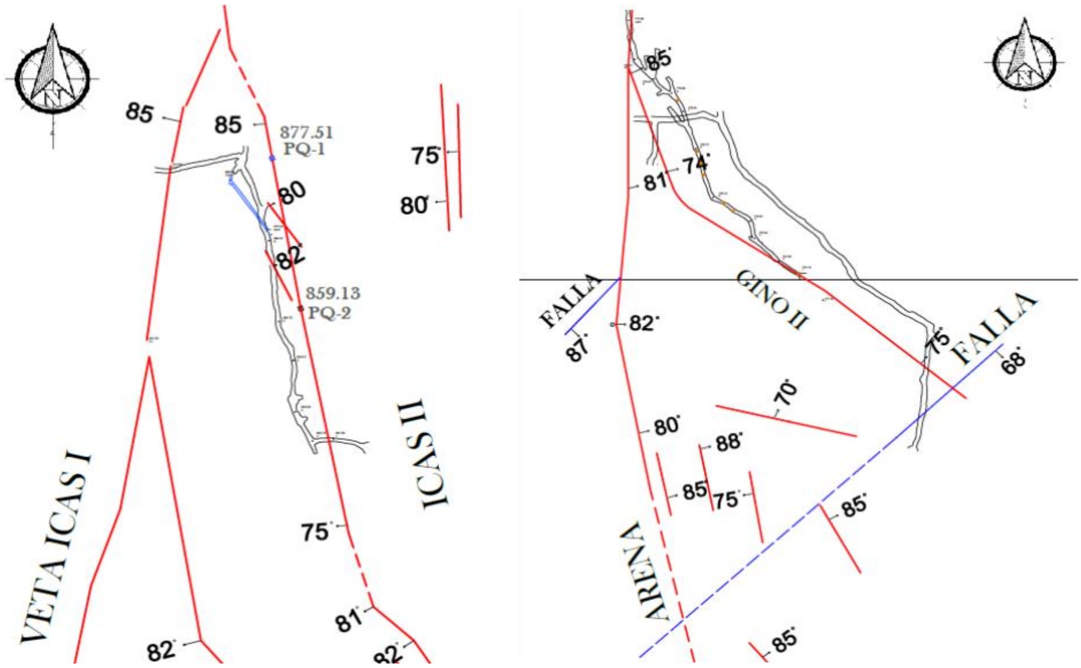


Figure 4,6: Vein Icas I and its branch Icas II *(fig. left)*, Vein Icas I and its branch Gino II *(fig. right)*. Vein Icas II is farther north than the vein Gino II.

Source: Department of Geology - S.M.R.L. Gotas de Oro

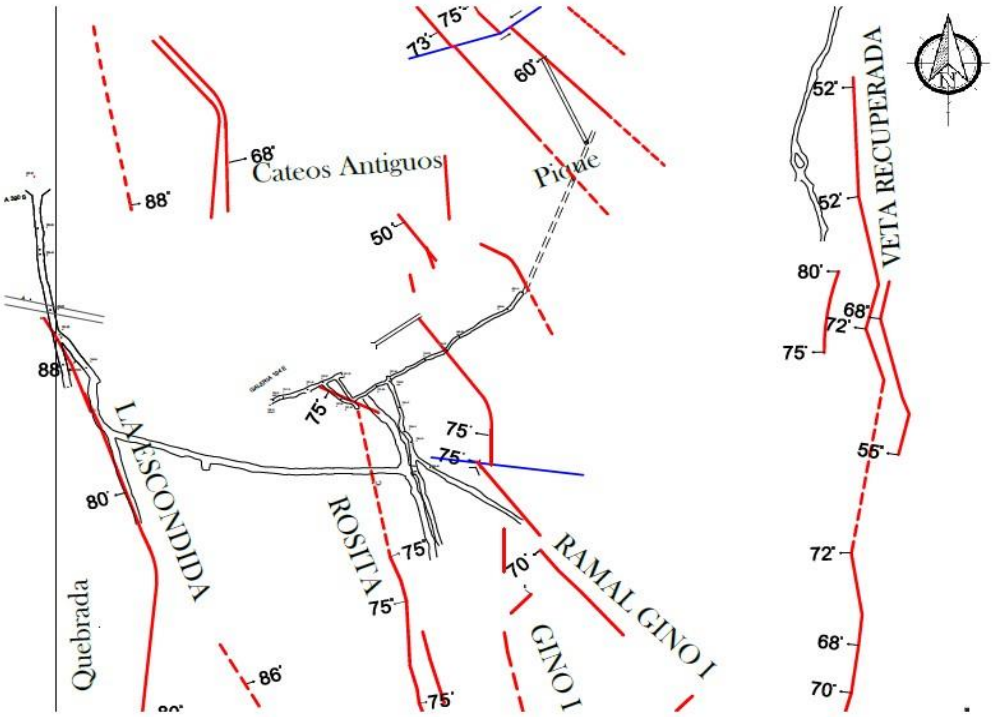


Figure 4,7: Vein Escondida, Rosita, Gino I and Recuperada. All of them are located east of the vein Icas I.

Source: Department of Geology - S.M.R.L. Gotas de Oro

CHAPTER V: ESTIMATION OF RESOURCES AND RESERVES, PRODUCTION AND LIFE OF THE MINE

5.1. ESTIMATION OF RESOURCES AND RESERVES

To perform the estimation of Mineral Resources and Mena Reserves; In the first place, it has been reviewed the available information of the geological and sampling plans of the different mineralized bodies, which the mine has (Gino I vein, Icas I vein, Gino II vein, Icas II vein, Rosita vein). Secondly, the estimation of Resources and Reserves was carried out, according to the JORC code; Table 5.1 shows the most recent reserve estimate available.

Table 5,1: Recent estimate of mine reserves - El Sol Naciente Tercero

To September 30th, 2016

ZONES	MINABLE RESERVATIONS Accessible Mineral				POTENTIAL MINERAL			
	TMS	Au Oz / Tn	Ag Oz / Tn	Cu %	TMS	Au Oz / Tn	Ag Oz / Tn	Cu %
Vein Gino I	22902.00	1.00	1.00	1.70	31615.00	0.98	1.00	1.75
Vein Icas I	12570.00	0.80	-	1.90	29417.00	0.72	-	1.79
Vein Gino II	7000.00	1.09	1.00	2.00	11169.00	1.03	1.00	1.95
Vein Icas II	4498.00	0.75	-	2.34	6219.00	0.71	-	2.20
Vein Rosita	26450.00	0.87	0.82	1.57	25523.00	0.90	0.83	1.60
TOTAL	**73420.00**	**0.91**	**0.92**	**1.76**	**103943.00**	**0.88**	**0.94**	**1.77**

Source: Department of Geology - S.M.R.L. Gotas de Oro

To make a current estimate of Ore Reserves and Mineral Resources, the mineralized areas were re-sampled and corroborated the cubed blocks of ore that appear in the old reports; in addition the blocks of ore that are not corroborated are being considered within the Mineral Resources Indicated; and the projection towards the lower levels of the veins in operation, which will have to be verified through exploration work, are being considered as Inferred Mineral Resources.

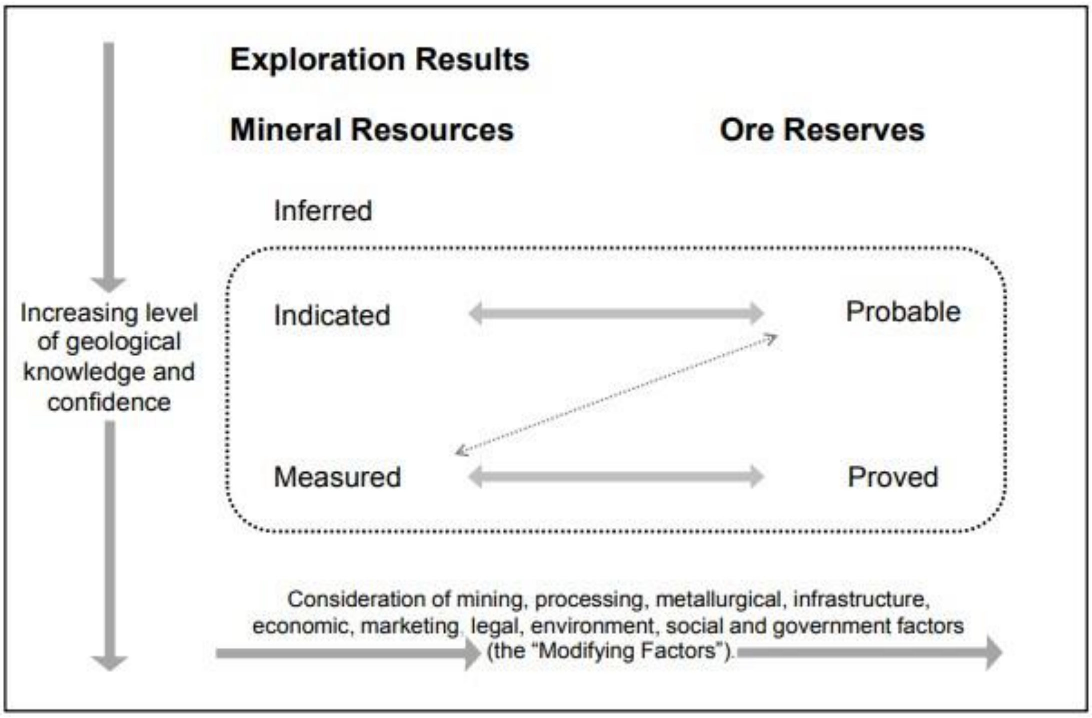


Figure 5,1: Terminology and relationship between exploration information, Mineral Resources and Ore Reserves

Source: Australasian code for reporting of identified mineral resources and ore reserves, "The Jorc Code (2012)"

The sequential relationship between exploration information, Mineral Resources and Ore Reserves is shown in Figure 5.1. The classification of the estimates takes this theoretical framework as a reference, so that we can reflect the different levels of geological confidence and the degrees of technical and economic evaluation. Therefore, based on this theoretical framework and the guidelines mentioned in the previous paragraph, a new estimate of mineral resources will be carried out.

5.2. MINERAL RESOURCES

They are concentrations of solid, liquid or gaseous materials that exist naturally in the earth's crust, in quantity and quality, so that their economic extraction, from the concentration, is current and potentially feasible. The location, quantity, law, geological characteristics and continuity of a mineral resource are known or estimated or interpreted from information, evidence and specific geological knowledge, with some contributions from other disciplines.

Mineral Resources declarations are generally documented outdated that are affected by technology, infrastructure, metal prices and other factors. If any of these factors vary, the material may enter or leave the mineral resource estimate. The parts of a deposit that do not present reasonable prospects for eventual economic extraction should not be included in a mineral resource.

According to the JORC code (21012), mineral resources are subdivided into three Inferred, Indicated and Measured categories; according to the order of increasing geological trust.

5.2.1. Inferred Mineral Resource

Part of a mineral resource for which the tonnage, laws and mineral content can be estimated with a low level of reliability. It is inferred from geological evidence and / or assumed laws, but not verified in depth. The estimate is based on information gathered through appropriate exploration techniques at points such as outcrop, ditches, wells and surveys; which is limited or of reduced quality and reliability, but that allow to estimate the tonnage, quality, mineral content with a high degree of uncertainty.

The reliability in the estimate is insufficient to apply technical and economic parameters; or conduct a pre-feasibility economic evaluation that deserves to be made known to the public.

5.2.2. Mineral resource indicated

Part of a mineral resource for which tonnage, density, shape, physical characteristics, grade and mineral content can be estimated with reasonable level of confidence. Its estimate is supported by detailed and reliable exploration, sampling and testing information, obtained through appropriate data collection techniques for outcrops, trenches, underground workings and drilling; nevertheless, the sampling points are very spaced or inappropriately spaced from each other, as to confirm the geological and / or law continuity, but close enough to assume continuity.

The reliability in the estimate, despite being lower than in the case of the measured resources, is sufficient to apply the technical and economic parameters for a possible economic pre-feasibility assessment.

5.2.3. Measured Mineral Resource

Part of a mineral resource for which tonnage, density, shape, physical characteristics, grade and mineral content can be estimated with a high level of reliability. Its estimation is based on detailed and reliable information on exploration, sampling and testing, obtained through appropriate techniques for capturing data on outcrops, ditches, underground workings and drilling; The sampling points are spaced sufficiently to confirm the geological and law continuity.

In this category, a high level of reliability is required in the understanding of the geology and controls of the deposit, the high degree of reliability in the estimation allows the adequate application of technical and economic parameters to enable an economic feasibility assessment.

5.3. ORE RESERVES

It is the economical and viable part of a Measured or Indicated Mineral Resource, it includes dilution materials and discounts for the losses that may occur during the mining process. To determine ore reserves it is necessary to have carried out evaluations that may include pre-feasibility studies considering mining, processing, metallurgy, economy, marketing, legal, environmental, social and governmental factors assumed in a real context.

When we refer to economic factors, it implies the establishment or analytical demonstration that profitable production is possible, under defined investment assumptions. These hypotheses must be reasonable, they must include assumptions related to the prices and costs that will prevail during the life of the project. In legal terms, it implies no uncertainty regarding the necessary permits to carry out the operation of extraction and processing of minerals, nor the resolution of pending legal matters.

Like the estimates of the Mena Reserves, they are predictions of what will happen in the future (Based on an incomplete knowledge of the present), these may have a certain degree of inaccuracy. In addition, it is known that interpretations and conclusions, which have different technicians, on reservation data may be discrepant, but not necessarily incorrect; since, an estimate of reserves may be influenced by the available information or economic conditions, at that time. Therefore, the information related to the estimation of ore reserves must have a sustainable basis and must be done in good faith.

There are circumstances, when the previously reported Mena Reserves could revert to Mineral Resources. Due to the fall in the international price of metal for a short time, temporary emergency in the mine, transport strike, etc.

According to the JORC code (2012), ore reserves are subdivided into two Probable and Probable categories; according to the order of increasing geological trust.

5.3.1. Probable ore reserve

It is the removable economic part of Indicated Mineral Resource and in some circumstances of a Measured Mineral Resource. This type of reserve includes dilution materials and loss tolerances that may occur during the mining process. At this stage, appropriate evaluations have been carried out that may include feasibility studies and include considerations and modifications for assumed factors of mining, metallurgy, economic, market, legal, environmental, social and governmental; These factors demonstrate that mineral extraction can be justified on the date the report is submitted.

A Probable Mena Reserve has a lower level of confidence than a Proven Mena Reserve and its estimate must be of sufficient quality to serve as a basis for making decisions on capital investment commitments and the final development of the deposit. However, it requires more information to demonstrate geological and law continuity.

5.3.2. Proven ore reserve

It is the economically exploitable part of a Measured Mineral Resource, including dilution materials and loss tolerances during the mineral extraction process. The application of this type of reserve implies the highest degree of confidence in the estimate of ore reserves and it is assumed that the information available to demonstrate geological continuity and laws is sufficient and reliable.

This type of reservation involves carrying out feasibility evaluations in which modifications are considered by realistic mining, metallurgical, economic, market, legal, environmental, social and governmental factors. These evaluations will demonstrate that the extraction of the mineral is viable, for which there must be a detailed mining plan.

In no case may the indicated Mineral Resources be converted directly to Proven Ore Reserves.

To obtain the complete information of the Mineral Resources and Reserves of Ore, according to the JORC code, we will first establish the following parameters:

- **Metallurgical Recoveries and Estimated Prices**

Gold (Au):

- Metallurgical Recoveries: 88.64%
- Estimated Prices: 1100 $ / Oz

Copper (Cu):

- Metallurgical Recoveries: 79.89%
- Estimated Prices: 2.6 $ / lb

Silver (Ag)

- Metallurgical Recoveries: 78.23%
- Estimated Prices: 14 $ / Oz

- **CUT OFF**

According to the balance of the El Sol Naciente Tercero mine, there is a Cut off of 0.68 Oz / Tn, which allowed the estimation of ore reserves, according to the JORC code.

The amount of Mineral Resources that did not become Mena Reserves is 98920.20 tons, according to said code (See Table 5.3).

➢ **Dilution of the ore**

The dilution of the ore is the reduction of the ore grade by mixing with material below the sterile or cutting grade with the economical ore. Dilution is one of the most important parameters in mining, since, by reducing its effects we obtain greater profits and a reduction in costs, that is why its value and control is necessary.

For the present study we understand the dilution of the mineral as the result of the sum of the primary dilution of the mineral and the secondary dilution of the mineral.

- The primary dilution (Planned dilution) is the product of the design by the exploitation method, that is to say it includes parameters that determine the minimum mining width, such as the vein 's own geometry, the type of equipment used, etc.
- The secondary dilution (Unplanned dilution) is the product of the instabilities of the rock mass, that is, it refers to the effects of over-breaking after a blast, it depends on the method of exploitation, amount of explosive, geomechanical conditions of boxes.

Mineral Dilution = Planned Dilution + Unplanned Dilution

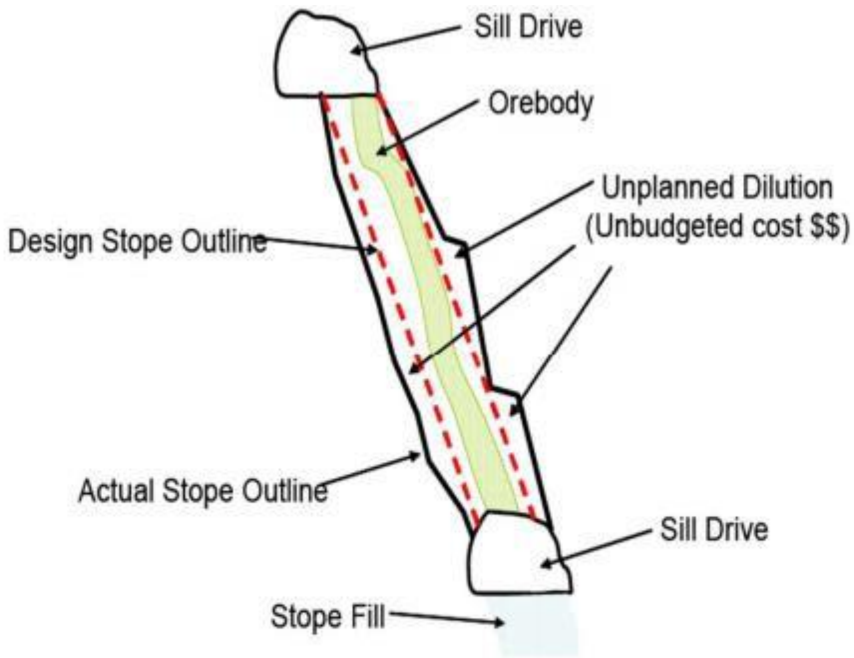


Figure 5,2: Scheme of planned and unplanned dilution in a vein

Source: Minimising dilution in narrow vein mines. PhD Thesis, The University of Queensland - Stewart, P.

Through the postulate of O'Hara (1980) for the calculation of the dilution, which includes the dilution of design, cleaning, etc. (Planned or primary dilution) and dilution from the consequences of blasting, unfavorable geomechanical factors, etc. (Unplanned or secondary dilution).

For the method of exploitation that uses the mine, which is Cut and Fill Up As O'Hara proposes the following equation:

$$\% \text{ Dil.} = 25 / (W^{0.5} \times \text{Sen}(\beta))$$

Where:

% Dil.: Dilution percentage (%)

W: Vein Power (m)

β: Vein dip

Table 5,2: Average ore dilution

MINERAL DILUTION		
VEIN POWER (m)	**VEIN DIP**	**% DILUTION**
1.50	75.00	21.13

Source: Author

Second, we will proceed to estimate the Mineral Resources, the Gold Equivalent Law (Oz / Ton) and the Gold Equivalent Ounces, for this we need the following equations:

$$L_{Eq-Au} = L_{Au} + FC_{Cu} \times L_{Cu} + FC_{Ag} \times L_{Ag} \ldots\ldots (1)$$

Where:

L_{Eq-Au}: Equivalent law regarding gold (Oz / Ton)

L_{Au}: Gold law (Oz / Ton)

FC_{Cu}: Copper correction factor

L_{Cu}: Copper Law (Oz / Ton)

FC_{Ag}: Silver correction factor

L_{Ag}: Silver Law (Oz / Ton)

$$FC_{Cu} = P_{Cu} \times R_{Cu} \times 0.06842 / P_{Au} \times R_{Au} \ldots\ldots (2)$$

Where:

P_{Cu}: Copper price ($ / lb)

R_{Cu}: Copper Metallurgical Recovery (%)

P_{Au}: Gold price ($ / Oz)

R_{Au}: Gold Metallurgical Recovery (%)

$$\mathbf{L_{Cu}\ (Oz / Tn) = L_{Cu}\ (\%)\ x\ 10000 / 31.1\ \ldots..\ (3)}$$

Where:

L_{Cu} (%): Copper Law (%)

$$\mathbf{FC_{Ag} = P_{Ag}\ x\ R_{Ag} / P_{Au}\ x\ R_{Au}\ \ldots..\ (4)}$$

Where:

P_{Ag}: Silver price ($ / Oz)

R_{Ag}: Silver Metallurgical Recovery (%)

P_{Au}: Gold price ($ / Oz)

R_{Au}: Gold Metallurgical Recovery (%)

From equations (1), (2), (3) and (4) we can obtain the following formula:

$$\mathbf{L_{Eq-Au} = L_{Au} + (P_{Cu}\ x\ R_{Cu}\ x\ L_{Cu}\ (\%)\ x\ 22 / P_{Au}\ x\ R_{Au}) + (P_{Ag}\ x\ R_{Ag}\ x\ L_{Ag} / P_{Au}\ x\ R_{Au})}$$

In addition, to calculate the total amount of equivalent ounces of gold (Eq - Au), we use the following equation:

$$\textbf{Onzas}_{Eq-Au} = \textbf{Ton x L}_{Eq-Au}$$

Where:

Ounces $_{Eq-Au}$: Gold equivalent ounces

Ton: Tons of mineral resource

Table 5,3: Estimation of mineral resources

ESTIMATION OF MINERAL RESOURCES							
CLASSIFICATION	**TONS**	**Au (Oz / Tn)**	**Cu (%)**	**Ag (Oz / Tn)**	**Eq - Au (Oz / Tn)**	**POWER (m)**	**Ounces Eq – Au**
Measured	21962.50	0.95	2.12	0.92	1.06	1.40	23273.48
Indicated	36099.50	0.84	2.06	0.82	0.95	1.35	34141.34
TOTAL RESOURCES(*)	**58062.00**	**0.88**	**2.08**	**0.86**	**0.98**	**1.37**	**57414.82**

(*) They are additional resources to Ore Reserves

Inferred	40858.20	0.59	1.39	0.58	0.66	1.20	27034.23

Source: Author

Third, we will proceed to estimate the ore reserves, diluted tonnage, diluted gold law, diluted copper law, diluted equivalent law and equivalent ounces of gold.

Table 5,4: Estimation of ore reserves with the dilution percentage included

To November 30th, 2016

ESTIMATION OF MENA RESERVATIONS							
CLASSIFICATION	**DIl. TONS**	**Au DIL. (Oz /Tn)**	**Cu DIL. (%)**	**Ag DIL. (Oz / Tn)**	**Eq - Au DIL. (Oz / Tn)**	**POWER (m)**	**Ounces Eq – Au**
Proven	34485.93	0.91	1.26	0.88	0.98	1.50	33656.56
Probable	21275.98	0.83	1.21	0.80	0.89	1.50	19020.29
TOTAL RESERVES	**55761.92**	**0.88**	**1.24**	**0.85**	**0.94**	**1.50**	**52676.84**

Source: Author

5.4. MINE PRODUCTION AND LIFE

To calculate an approximation of the life of the mine, from Table 5.1, the estimated volume of Mineable Reserves and the Potential Mineral (Estimated through the use of the JORC code in the El Sol Naciente Tercero mining unit) was taken.

Mineable Reserves = 73420.00 Tons

Potential Mineral = 103943.00 Tons

Total = 177363.00 Tons

The Recovery in Mine is 95%, therefore, the tonnage of ore to be obtained will be:

0.95 x 177363.00 = 168494.85 Tons

The mine's ore is treated by a cyanidation process, transported approximately 02 kilometers to the Tinguiña district, department of Ica; where the ore processing plant is located; The approximate transport time from the mine to the plant is 01 hour.

This plant has an installed capacity to process 6000 Ton / month; Therefore, the monthly mineral volume raised in this study is covered, and the apparent life of the deposit is as follows:

168494.85 Ton / 4000 Ton / month = 42.12 ≈ 42 month (3 years and a half)

It should be noted that as the Gino I and Rosita vein is advanced and deepened; the tonnage of potential ore could increase due to the lengths and lack of deepening of these veins. In the previous chapter (Geology), it was commented that there are currently 07 veins, of which 05 veins are in exploration, exploitation and extraction, 02 veins are in the exploration stage and other mineralized bodies accounted for among Mineral Resources; Therefore, there are resources and reserves that in the future can become potentially extractable ore and extend the apparent life of the mine.

This apparent short mine life is a constant in gold mining of narrow veins, since having reserves of more than 04 years would imply an investment greater than necessary. What has been said before makes mining exploration and planning activities relevant to keep the mining business going.

CHAPTER VI: GEOMECHANICAL STUDIES

6.1. GENERAL CONSIDERATIONS

To determine the geomechanical behavior of the rock mass, in the underground work a structural mapping is carried out that allows identifying the possible structural failures of this.

The size and shape of the potential wedges that can be formed in the surrounding rock mass depend primarily on the size, shape and orientation of the openings, in addition to the orientation of the main fracture systems.

To analyze the type of support required by mining work, the calculation and classification parameters of the rock mass will be taken into account to determine, technically, if the openings made on the rock mass are going to require some type of support.

In order to develop the geomechanical studies of the rock mass in the El Sol Naciente Tercero mining unit, the following activities are carried out:

- Systematic recognition of the study area and the current area of operation.
- Obtaining and reviewing geological information.
- Insitu measurement of the geomechanical characteristics of the rock (Geomechanical classification).
- Regular work meetings with the professional and technical staff of the company to coordinate the work to be carried out.

It is necessary to consider that when underground mining works are designed for the purpose of exploitation of a mining deposit, a series of geomechanical conditions and problems that affect the mechanical behavior of the rock mass are presented; These factors must be taken into account in order to make the mining activity reasonable.

Through the geomechanics, points that are to be considered to avoid or diminish as much as possible the result of the alteration of efforts that occur when modifying the balance of the rock mass in which they carry out the mining work are made relevant.

From the disposition and use of the technology that geomechanics has available, a proven affirmation can be obtained: Optimize the design, provide security in the execution of mining work, facilitate the control of the performance of mining work and, therefore, the increase in productivity.

6.2. GEOLOGICAL MODEL

Regionally, the mine is located on the coastal batolith, where litho-stratigraphic units can be found that, chronologically, range from the Recent Quaternary to the Jurassic. There are outcrops of sedimentary rocks and volcanic rocks, in addition to quaternary deposits of alluvial nature composed of silty gravels with sand.

Mineralization occurs in narrow veins with powers that vary between 1.5 and 3 meters, with gold, copper and average silver values. So far seven veins have been identified, of which five veins were in operation, but due to adverse geological and economic conditions, the exploitation of two veins was paralyzed. The mineralogy of the veins is made up of copper ores, such as: Chalcopyrite ($CuFeS2$), Covellite (CuS), Bornite (Cu_5FeS_4), Chalcocite (Cu_2S); Gold is in its native state and as inclusions in Pyrite (FeS_2) and Quartz (SiO_2).

Locally the geological formations where the mine is located are composed of quaternary material, the result of alluvial weathering, which over time changed the initial physiography generating wavy surfaces; In addition, there are slopes of volcanic origin represented by rocky outcrops that enabled the formation of the mine's mineral deposit.

The predominant formation is the "Guaneros Formation", which is made up of volcanic - sedimentary rocks; the lithology is constituted by volcanic rocks of green - brown color with fragments of andesitic composition, andesites - porphyritics interspersed with fine to medium vein sandstones, in addition to conglomeric sandstones.

6.3. GEOMECHANICAL MODEL

In order to determine the direction in the mining design, requirements and type of support, it was required to develop an underground valuation of the study of rock mechanics.

From the data that were obtained in the rock massif's geomechanical study, they try to establish the direction of the design of the pits, requirements and type of support based on the following elements:

- Geological mapping of the levels.
- Determination of physical and mechanical properties.
- Classification of the rock mass.
- Geomechanical data: RQD, type of rock, discontinuities, spacing of discontinuities, filling of discontinuities, etc.

- Rock witness analysis.
- Presence of water.
- Geological description.

6.3.1. Determination of physical and mechanical properties

6.3.1.1. Physical properties

The determination of physical properties was based on the establishment of dry weight, saturated weight and external volume of rock samples.

By drying the samples in a ventilated oven at an approximate temperature of 105 ° C; then saturate the samples by immersing them in water, after repeating the above-mentioned procedures several times, and obtaining a variation between dry and saturated weights of less than 0.1 grams. The density, apparent specific gravity, apparent porosity and absorption are calculated.

Table 6,1: Formulas for calculating the physical characteristics of the rock mass

DENSITY	Dry Weight / Volume (g/cm^3)
APPEARING SPECIFIC WEIGHT (P.E.A)	(Dry Weight / Volume) x 9.81 (KN/m^3)
APPARENT POROSITY (P.A)	(Saturated Weight - Dry Weight) x 100% / (Water density x
ABSORPTION (by weight)	(Saturated Weight - Dry Weight) x 100% / Dry Weight

Source: Rock Mechanics Laboratory - National Engineering University

6.3.1.2. Mechanical properties

The determination of mechanical properties was based on resistance tests on Point Load on rock and / or mineral samples. In the case of the mine, samples of rock witnesses were considered; In addition, the ISRM (International Society for Rock

Mechanics and Roc Engineering) standard was considered for the execution of the trial.

- **Slenderness ratio**

The specimen to be tested must have the following relationship:

$$L / D = 1.4$$

Where:

L: Test tube length (cm)
D: Test tube diameter (cm)

- **Mathematical formula**

$$I_s = P / D^2$$

Where:

Is: Franklin point load index (Kg / cm^2)

P: Ultimate Breaking Load (Kg)

D: Test tube diameter (cm)

To determine the compressive strength of the rock "σ_c", using the point load, the following formula is used:

$$\sigma_c = (14 + 0.175 \text{ x } D) \text{ x } I_s$$

Where:

σ_c: Rock compressive strength (Kg / cm^2)

D: Test tube diameter (cm)

- **Results**

Samples:

M - 1: Andesite

M - 2: Mineral

Table 6,2: Results of dry and saturated weights of rock and mineral samples

ROCK SAMPLE		NATURAL WEIGHT (gr)	DRY WEIGHT (gr)	SATURATED WEIGHT (gr)	VOLUME (cm^3)
M – 1	1	166.0	163.4	166.2	88
	2	207.0	202.5	206.7	74
M – 2	1	315.1	312.8	316.8	94
	2	138.0	138.1	138.8	48

Source: Engineering department - S.M.R.L. Gotas de Oro

Table 6,3: Dimensions and results of punctual loading of rock and mineral simples

ROCK SAMPLE	DIAMETER (cm)	LENGTH (cm)	LOAD (Kg)
Andesite	5.4	7.70	1820
Mineral	5.4	7.82	885

Source: Engineering department - S.M.R.L. Gotas de Oro

Table 6,4: Results of physical properties tests of rock and mineral samples

ROCK SAMPLE	PHYSICAL PROPERTIES				MECHANICAL PROPERTY
	DENSITY (gr/cm^3)	P.E.A. (KN/m^3)	P.A. (%)	ABSORTION (%)	PUNCTUAL LOAD (MPa)
Andesite	2.61	25.57	4.96	1.89	143.52
Mineral	3.15	30.83	5.07	1.63	69.79

Source: Engineering department - S.M.R.L. Gotas de Oro

According to the resistance classification of Deere and Miller, the following results are obtained for rock and mineral samples:

- Andesite: High resistance
- Mineral: Medium resistance

6.3.2. Classification of the rock mass

The classification of the rock mass is an indispensable tool to describe and categorize the different types of rock, with the aim of evaluating the structural characteristics and efforts generated at the time of underground work, determining the type of support, the maximum time of self - support, in order to place the necessary support within the security period.

The most common rock mass classification systems for engineering applications are the Modified GSI (Geological Strength Index) and the RMR (Rock Mass Rating).

Currently the mining company S.M.R.L. Golden Drops uses the rock classification method of Bieniawski (1973), whose calculation establishes the mass evaluation (RMR), based on the following parameters.

- Uniaxial compression resistance of intact rock.
- Modified token recovery rate or RQD.
- Spacing between discontinuities or fractures.
- Condition of discontinuities or fractures.
- Groundwater effects

For the application of Bieniawski's rock classification method, the mapping of rock conditions was performed, according to Bieniawski.

- **Uniaxial compression resistance of intact rock**

The mine has an andesitic rock type with an average uniaxial compressive strength of 143.52 MPa.

- **Modified witness recovery rate or RQD**

To determine the RQD (Rock Quality Designation), we use the method of Palsmtrom (1974), that is, the method of volumetric fissure counting (Jv: Joint Volumétric number) by means of the lithological - structural survey of the walls of the mining works. From the lithological survey it is indicated that on average there are 5,267 discontinuities per cubic meter.

$$\mathbf{RQD = 115 - 3.3 \times Jv}$$

Where:

RQD: Rock Quality Designation - Deere

Jv: Joint Volumétric number

RQD calculation:

$$RQD = 115 - 3.3 \times 5.267$$

RQD = 97.62% (Very good)

- **Spacing of discontinuities or fractures**

The mineralized deposit of the El Sol Naciente Tercero mining concession is a philonean type deposit, where most of the fractures present have a spacing that can vary from 0.2 to 0.8 meters between discontinuities.

➢ **Condition of discontinuities or fractures**

The mineralized deposit where the mine is located is constituted by intrusive rocks, of the andesitic type, which are characterized by being stable and competent.

Therefore, in order to perform the mapping of a certain area, the following aspects are taken into account: length, opening, roughness, filling and weathering of discontinuities.

➢ **Effects of groundwater**

In the area where the mine is located, no water flows have been registered, since it is in an arid zone, but according to the drilling of the work, water flows could be found, for which corrective measures were taken in the Geomechanical study

➢ **Orientation of discontinuities or fractures**

The rocky massif where the mine is located generally presents fractures with an almost vertical dip; They are also favorable to the sense of underground excavations.

Table 6.5 shows, in summary form, the above:

Table 6,5: Valuation of rock massif parameters according to Bieniawski (1973)

PARAMETERS	VALUES	SCORE
UNIAXIAL COMPRESSION RESISTANCE OF THE INTACT ROCK		
Uniaxial Compression Resistance	143.62 MPa	12
MODIFIED WITNESS RECOVERY INDEX		
RQD	97.62 %	20
SPACING THE DISCONTINUITIES OR FRACTURES		
Spacing	0.2 – 0.8 m	10
CONDITION OF DISCONTINUITIES OR FRACTURES		
Length	1 – 3 m	4
Opening	0.1 – 1 mm	4
Roughness	Rough	5
Filling	None	6
Meteorization	Healthy	6
EFFECTS OF GROUNDWATER		
Groundwater flow	Completely dry	15
TOTAL (RMR)		82

Source: Engineering Department - S.M.R.L. Gotas de Oro De

according to the classification of the rock massif of Bieniawski (1973):

Design Parameters and Engineering Properties of Rock Mass

S. No.	Parameter/ properties of rock mass	RMR (rock class)				
		100–81 (I)	*80–61 (II)*	*60–41 (III)*	*40–21 (IV)*	*<20 (V)*
1	Classification of rock mass	Very good	Good	Fair	Poor	Very poor
2	Average stand-up time	20 years for 15 m span	1 year for 10 m span	1 week for 5 m span	10 hours for 2.5 m span	30 minutes for 1 m span
3	Cohesion of rock mass (MPa)*	>0.4	0.3–0.4	0.2–0.3	0.1–0.2	<0.1
4	Angle of internal friction of rock mass	>45°	35–45°	25–35°	15–25°	<15°
5	Allowable bearing pressure (T/m^2)	600–440	440–280	280–135	135–45	45–30
6	Safe cut slope (°) (Waltham, 2002)	>70	65	55	45	<40

Figure 6,1: Geomechanical classification of Bieniawski

Source: Engineering Rock Mass Classification "A Practical Approach in Civil Engineering" - Bhawani Singh y R.K. Goel

In the mining concession El Sol Naciente Tercero of the mining company S.M.R.L. Gotas de Oro basically works with type I rock. Eventually and under the influence of external aspects (particularly the effect of water from the drilling of higher levels) you could have work with type II rock.

- **Rock type I (RMR: 81 – 100)**

  In the case of rock type I, the quality is very good whose main characteristic in the presence of very hard rock with very few discontinuities, where you can advance to full section without the need for immediate support.

6.3.3. Self-sustaining time

For horizontal openings such as galleries, sub-levels, cruises and ramps, considering a section without support of 3.5 meters and an RMR of 82, according to Bieniawski, it is observed that no support is required; that is, the rock in the mine is very competent that it supports itself.

On the other hand, for the work of exploitation (cuts and sub-levels) it is considered that to avoid problems due to the closing of the boxes or “ironing”, it is considered that a period of 25 days is an adequate self-sustaining time, that is to say In the exploitation work, the volume extracted must be filled and the next cut before the nominal self-sustaining time is fulfilled.

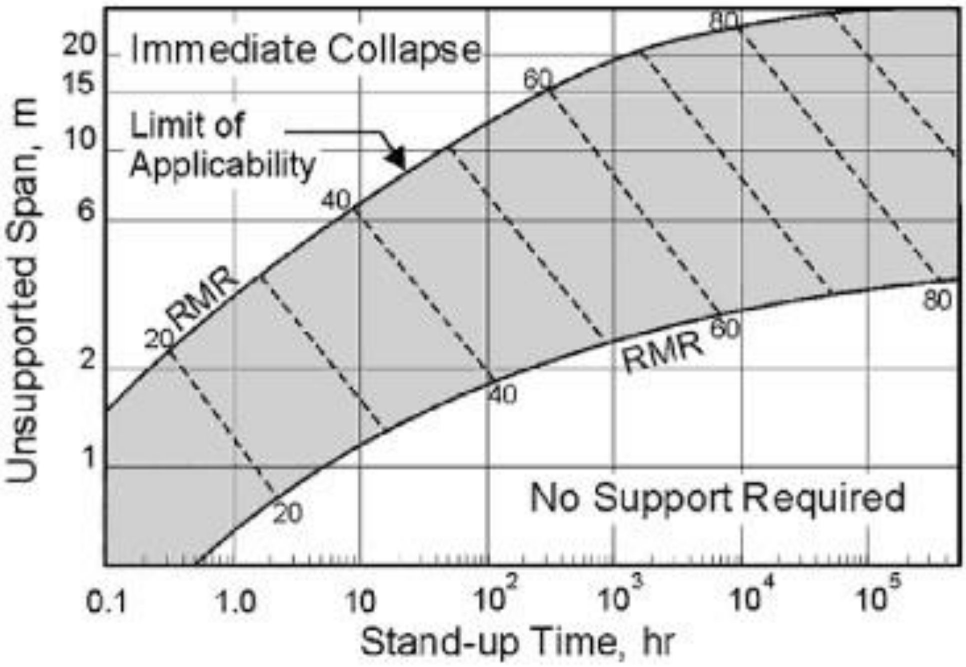


Figure 6,2: Self-support time according to Bieniawski

Source: Engineering Rock Mass Classification "A Practical Approach in Civil Engineering" - Bhawani Singh y R.K. Goel

6.3.4. Maximum opening without support

To determine the maximum opening without support, first, we will use the Q (Rock Mass Quality). From the RMR (Rock Mass Rating) of Bieniawski, calculated in Table 6.5, we obtain Barton's Q using the following equation:

$$\mathbf{RMR = 9 \times Ln\ Q + 44 \ldots.. (4)}$$

Where:

RMR: Rock Mass Rating – Bieniawski

Q: Rock Mass Quality – Barton

From equation (4) we obtain the following equation:

$$\mathbf{Q = e^{(RMR - 44)/9}}$$

Q calculation:

$$Q = e^{(82 - 44)/9}$$

$$\mathbf{Q = 68.18}$$

Second, we will determine the value of the ESR (Excavation Support Ratio) from the following figure.

TABLE 8.11 Values of Excavation Support Ratio

	Type of excavation	ESR
A	Temporary mine openings, etc.	2–5
B	Permanent mine openings, water tunnels for hydro power (excluding high pressure penstocks), pilot tunnels, drifts and headings for large openings, surge chambers	1.6–2.0
C	Storage caverns, water treatment plants, minor road and railway tunnels, access tunnels	1.2–1.3
D	Power stations, major road and railway tunnels, civil defense chambers, portals, intersections	0.9–1.1
E	Underground nuclear power stations, railway stations, sports and public facilities, factories, major gas pipeline tunnels	0.5–0.8

ESR should be increased by 1.5 times, Q by 5, and Q_w by 5, for temporary supports.
Source: Barton, 2008.

Figure 6,3: Reason values of the excavation support according to Barton
Source: Engineering Rock Mass Classification "Tunneling, Foundations, and Landslides" - Bhawani Singh y R.K. Goel

Therefore, the maximum opening without support would be defined by the following equation:

$$\mathbf{Máxima\ abertura = 2 \times ESR \times Q^{0.4}}$$

Where:

ESR: Excavation Support Ratio

Q: Rock Mass Quality – Barton

Maximum opening calculation without support:

$$\text{Máxima abertura} = 2 \times 1.6 \times 68.18^{0.4}$$

Máxima abertura = 17.32 metros

6.3.5. Geomechanical parameters of the rock mass

To determine the geomechanical parameters of the rock massif, the RocData 3.0 Software was used.

- **Parameters mb and s of the rock mass**

The parameters mb and s are constant of the rocky material, which depend on the properties of the rock and the degree of fracturing of the rock before being subjected to a variation of stresses. Both parameters can be obtained from the RMR (Rock Mass Rating) of Bieniawski.

First, the GSI (Geological Strength Index) must be determined from the RMR (Rock Mass Rating).

$RMR_{89} > 23 \rightarrow GSI = RMR_{89} - 5$

$RMR_{89} < 23 \rightarrow$ The RMR_{89} cannot be used to calculate the GSI

Where:

RMR: Rock Mass Rating – Bieniawski

GSI: Geological Strength Index – Hoek

GSI calculation:

$$RMR = 82$$

$$GSI = 82 – 5$$

$$\mathbf{GSI = 77}$$

Second, using the relationship between the material constant “mb / mi” and the Geological Resistance Index “GSI”; in addition to the constant of the material of the original rock mass "mi" for andesitic type rocks, according to Hoeck and Brown (1980).

$$\mathbf{m_b / m_i = e^{(GSI - 100) / 28}}$$

Where:

m_i: Material constant of the original massif (Table 10 of Hoeck, Brown, ET 1980 Page 214 and 215)

m_b: Material constant of the rock mass

To calculate the material constant "s", we use the following equation:

$$\mathbf{s = e^{(GSI - 100) / 9}}$$

Where:

s: Material constant

Calculation of parameters m_b and s:

m_i = 16 (Table 10 of Hoeck, Brown, ET 1980 Page 214 and 215)

$$m_b = 16 \times e^{(77 - 100) / 28}$$

$$\mathbf{m_b = 7.03}$$

$$s = e^{(77 - 100) / 9}$$

$$\mathbf{s = 0.077}$$

Corroborating with RocData 3.0 Software:

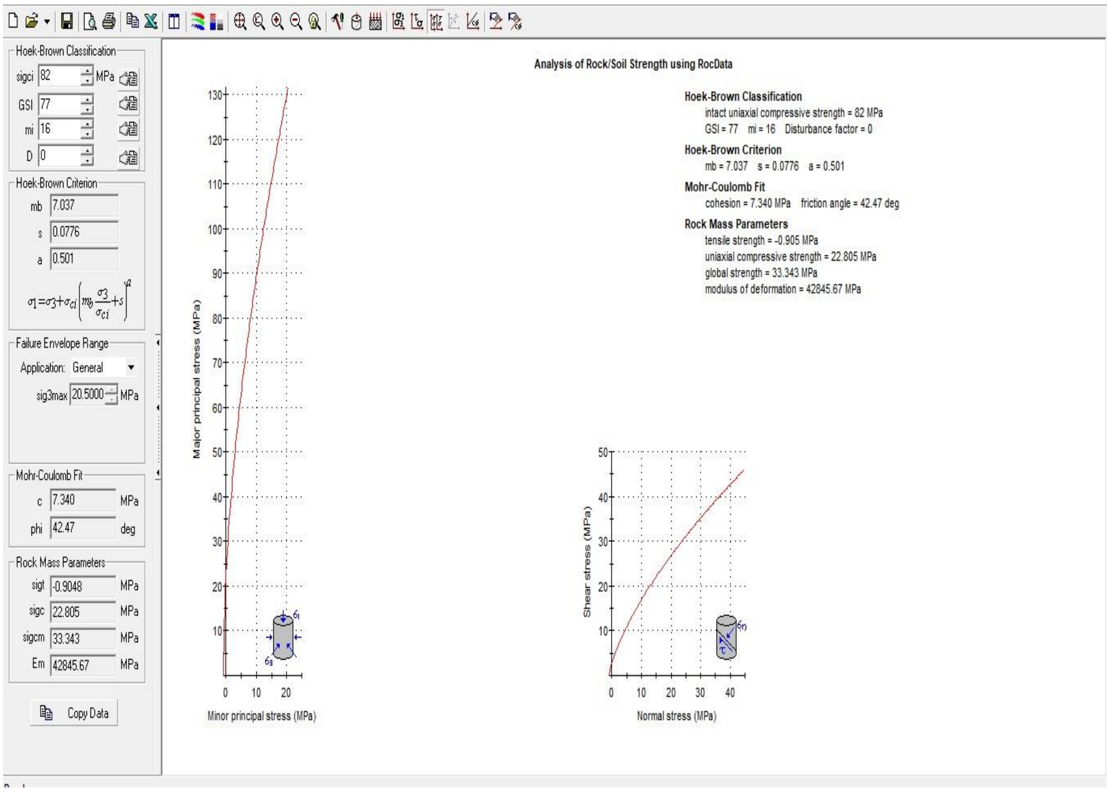


Figure 6,4: Calculation of m_b and s of the rock massif with the help of Rock Data

Source: Author

- **Proportionality constant K**

To determine the proportionality constant "K", we use the criteria of Shorey (1994):

$$\mathbf{K = 0.25 + 7 \times E_h \times (0.001 + 1 / Z)}$$

Where:

K: Proportionality Constant

Z: Depth below surface (m)

E_h: Average horizontal deformation modulus of surface rock mass (Gpa)

Calculation of the proportionality constant “K”:

$$Z = 100 \text{ meters}$$

$$E_h = 42.845 \text{ Gpa (Obtained with Software RocData 3.0)}$$

$$K = 0.25 + 7 \times 42.845 \times (0.001 + 1 / 100)$$

$$\mathbf{K = 3.54}$$

- **Estimation of vertical and horizontal efforts**

According to Goodman (1980), it is safe to assume that the normal vertical effort is equal to the unit weight of the overlying rock by the depth in the rock.

$$\mathbf{S_v = \delta * Z}$$

Where:

S_v = Average vertical effort (Mpa)

δ = Unit weight (MN / m^3)

Z = Depth below surface (m)

To calculate the magnitude of horizontal stresses, it is convenient to consider the ratio of horizontal and vertical stresses.

$$\mathbf{K = S_h / S_v}$$

Where:

S_h: Horizontal effort (Mpa)

S_v: Vertical effort (Mpa)

K: Proportionality constant of S_h and S_v

Calculation of vertical and horizontal stresses:

δ = 0.027 MN / m^3

Z = 100 meters

Sv = 0.027 x 100

Sv = 2.70 Mpa

K = 3.54

Sh = 3.54 x 2.70

Sh = 9.56 Mpa

6.3.6. Preferential direction of excavation progress

Due to the average depths of the mining company's exploitation, it is important to consider that the behavior of the rock mass is going to depend on the dominant structural arrangement.

Depending on the structural arrangement of the rock mass, there are favorable directions, which, as far as possible, the progress of the mining excavations should be aligned, in order to avoid altering the stability conditions of the rock mass during the life of the mine. The most unfavorable stability conditions occur when the excavations move parallel to the dominant system of discontinuities or heading of the strata, main faults and cutting areas; because the efforts are concentrated in the area between the fault and the excavation, and if these exceed the resistance of the rock, it can fail.

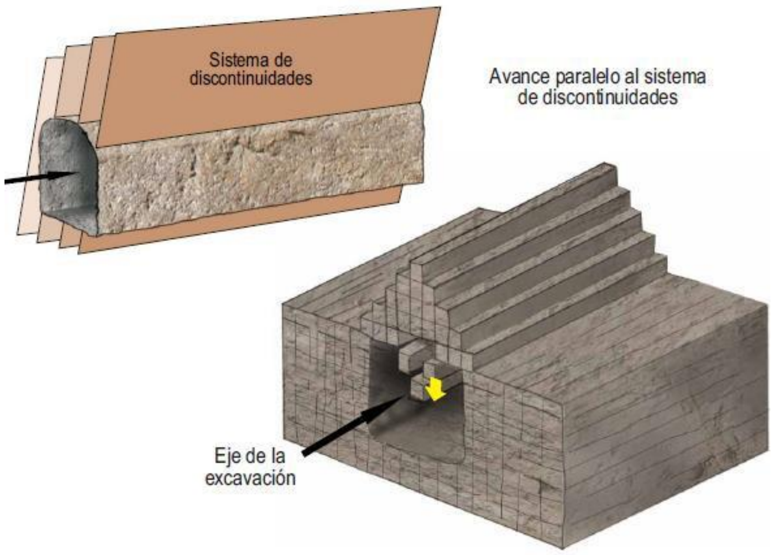


Figure 6,5: Advancement conditions very unfavorable for stability.
Source: Geomechanics manual applied to the prevention of accidents caused by falling rocks in underground mining – SNMPE

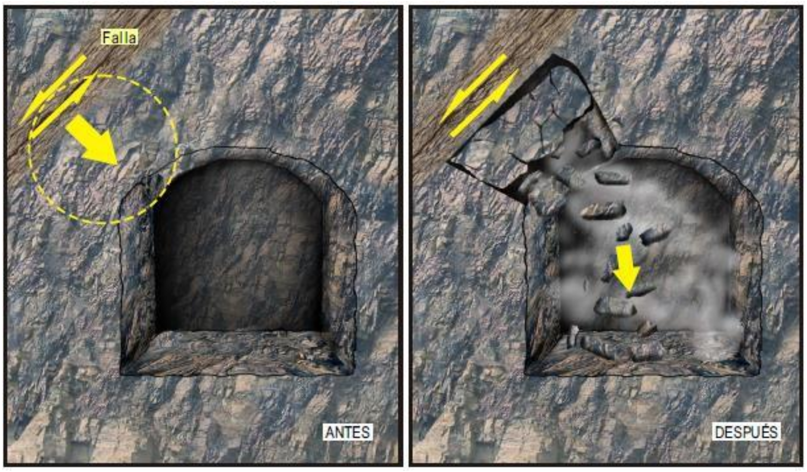


Figure 6,6: Problems of instability when the excavation advances in parallel and very close to a geological fault.

Source: Geomechanics manual applied to the prevention of accidents caused by falling rocks in underground mining – SNMPE

While, to have favorable stability conditions of the rock mass in an excavation, it is advisable to advance perpendicularly to the main system of discontinuities or heading of the strata, main faults and cutting areas, that is to say the dominant structural arrangement.

Figure 6,7: Advancement conditions very favorable for stability.

Source: Geomechanics manual applied to the prevention of accidents caused by falling rocks in underground mining – SNMPE

In the case of the mine, the main family of discontinuities has a heading of N50°W; Therefore, the excavation has been given a course of N60°E, trying to meet the criteria expressed above.

6.4. SELECTION OF THE EXPLOITATION METHOD

Applying the methodology of Nicholas (1981) for the selection of the mining method that takes into account the geometry of the deposit, distribution of laws and the quality of both the vein and the rock (floor and ceiling box), the following values were found:

6.4.1. Valorization of the geometry and distribution of laws for exploitation methods

- **General form of the deposit:** The mine has a tabular deposit (TAB).
- **Power of the vein:** The vein has an average power of 2 meters, so, according to Nicholas's methodology, it is considered a very narrow vein (M/A).
- **Dip:** The vein has a dip greater than 550, so, according to Nicholas it is considered a standing diver (PAR).
- **Distribution of laws:** Laws have zonal characteristics, and gradually change from one place to another (GRA).

Table 6,6: Valorization of the geometry and distribution of the deposit type

EXPLOITATION METHOD	GENERAL FORM	VEIN POWER	DIP	LAW DISTRIBUTION	TOTAL
	TAB	M/A	PAR	GRA	
OPEN PIT	2	-49	4	3	-40
BLOCK CAVNG	2	-49	4	2	-41
SUBLEVEL STOPING	2	1	4	3	10
SUBLEVEL CAVING	4	-49	4	2	-39
LONGWALL MNING	4	4	-49	2	-39
ROOM AND PILLAR	4	0	0	3	7
SHRINKAGE STOPING	2	1	4	2	9
CUT AND FIL STOPING	4	4	4	3	15
TOP SLICING	3	-49	2	2	-42
SQUARE SET	2	2	3	3	10

Source: Author

6.4.2. Valorization of the mechanical characteristics of the vein for the exploitation methods

- **Resistance:** The vein has a resistance that varies between 8 and 15 MPa on average, according to Nicholas's methodology it is considered a moderate resistance (MOD).

- **Fracture spacing:** In the geomechanical mapping, an average of five fractures per meter could be obtained, which is considered thick fracture spacing (GRU).

- **Shearing:** Discontinuities filled with strength material greater than intact rock which is considered as strong shear (FRT).

Table 6,7: Valorization of the mechanical characteristics of the vein

EXPLOITATION METHOD	RESISTANCE	SPACING BETWEEN FRACTURES	SHEARING	TOTAL
	MOD	GRU	FRT	
OPEN PIT	4	4	4	12
BLOCK CAVNG	2	3	0	5
SUBLEVEL STOPING	3	1	4	8
SUBLEVEL CAVING	2	3	0	5
LONGWALL MNING	2	3	0	5
ROOM AND PILLAR	3	2	4	9
SHRINKAGE STOPING	2	3	4	9
CUT AND FIL STOPING	2	2	4	8
TOP SLICING	2	3	0	5
SQUARE SET	2	2	2	6

Source: Author

6.4.3. Valorization of the mechanical characteristics of the roof box for exploitation methods

- **Resistance:** The roof box has a resistance greater than 15 MPa on average, so, according to Nicholas's methodology, it is considered a strong resistance (FRT).
- **Fracture spacing:** In the geomechanical mapping an average of five fractures per meter could be obtained, which is within thick fracture spacing (GRU).
- **Shearing:** The shear in this mine is moderate, because it has clean discontinuities with rough surfaces and in those that have filling this is equal to that of the rock (MOD).

Table 6,8: Valorization of the mechanical characteristics of the roof box

EXPLOITATION METHOD	RESISTANCE	SPACING BETWEEN FRACTURES	SHEARING	TOTAL
	FRT	GRU	MOD	
OPEN PIT	4	4	3	11
BLOCK CAVNG	1	3	3	7
SUBLEVEL STOPING	4	1	2	7
SUBLEVEL CAVING	3	4	2	9
LONGWALL MNING	0	0	3	3
ROOM AND PILLAR	4	2	2	8
SHRINKAGE STOPING	4	3	2	9
CUT AND FIL STOPING	2	2	3	7
TOP SLICING	3	2	2	7
SQUARE SET	1	2	3	6

Source: Author

6.4.4. Valorization of the mechanical characteristics of the floor box for exploitation methods

- **Resistance:** The floor box has a resistance greater than 15 MPa on average, so according to Nicholas's methodology it is considered as a strong resistance (FRT).
- **Fracture spacing:** In the geomechanical mapping, an average of five fractures per meter could be obtained, which is within the range of thick fracture spacing (GRU).
- **Shearing:** There are clean discontinuities with rough surfaces and in those that have a filling that is equal to that of the rock, so that in the mine the shear is moderate (MOD).

Tabla 6,9: Valorization of the mechanical characteristics of the floor box

EXPLOITATION METHOD	RESISTANCE	SPACING BETWEEN FRACTURES	SHEARING	TOTAL
	FRT	GRU	MOD	
OPEN PIT	4	4	3	11
BLOCK CAVNG	3	3	3	9
SUBLEVEL STOPING	4	2	1	7
SUBLEVEL CAVING	4	3	2	9
LONGWALL MNING	3	4	3	10
ROOM AND PILLAR	3	3	2	8
SHRINKAGE STOPING	3	3	2	8
CUT AND FIL STOPING	2	2	4	8
TOP SLICING	3	3	2	8
SQUARE SET	2	2	4	8

Source: Author

Table 6.10 shows the results of recovery of rock structures according to Nicholas (1981).

Table 6,10: Valorization of the most feasible exploitation methods

EXPLOITATION METHOD	DEPOSIT	MINERAL	ROOF BOX	FLOOR BOX	TOTAL
OPEN PIT	-40	12	11	11	-6
BLOCK CAVNG	-41	5	7	9	-20
SUBLEVEL STOPING	10	8	7	7	32
SUBLEVEL CAVING	-39	5	9	9	-16
LONGWALL MNING	-39	5	3	10	-21
ROOM AND PILLAR	7	9	8	8	32
SHRINKAGE STOPING	9	9	9	8	35
CUT AND FIL STOPING	15	8	7	8	38
TOP SLICING	-42	5	7	8	-22
SQUARE SET	10	6	6	8	30

Source: Author

As shown in the table above, the recommended exploitation methods are those that yield the highest values:

- Cut and Fill Stoping
- Shrinkage Stoping
- Sublevel Stoping

➢ **Sublevel Stoping**

Disadvantages:

The high investment capital due to the need to carry out many development tasks and the low selectivity between ore and clearing, make this method of exploitation not feasible to apply.

➢ **Shrinkage Stoping**

Disadvantages:

In this method of exploitation the dilution is high, since, during the emptying phase of the mansions, the mineral is commonly mixed with the dismantling of the sterile areas that collapse from the walls. Therefore, it is common that at the end of the emptying it is necessary to separate certain volumes of ore with very low grades, reducing the recovery of the deposit.

➢ **Cut and Fill**

Advantages:

- It is a very safe method.
- It is a method with a recovery rate, practically, of 100%.
- It is highly selective, so you can exploit sections with a high grade and

leave those low-grade areas untapped; This type of mineralogical context is common in deposits of narrow veins.

- It can be mechanized, to increase the production and productivity of the mine.

Therefore, the exploitation method to be used in the operations of the El Sol Naciente Tercero gold mining unit is the Cut and Fill method.

The necessary filling for this method of exploitation is obtained from the abundant debris that covers the high surfaces of the hills and the interior mine; as the deepening of mining work increases, the use of detritic filling from a hydraulic filling plant is planned.

CHAPTER VII: MINING

7.1. DESCRIPTION OF THE STAGES IN THE MINING OPERATION

- **Exploration work**: During this stage of the mining operation, horizontal and vertical tasks are carried out (Cruises, ramps and chimneys), which must be adapted to the type of deposit, the main objectives of these are to reach the projection of the veins, determine the quality and quantity of the mineral; and so start with the development work.
- **Development work**: After the exploration work has reached the mineralized bodies (Veins), horizontal and vertical work is carried out (Galleries and chimneys), following the vein structure, to establish access to the mineral reserves, recognize and confirm the laws and powers along the route; the objective of these tasks is to cover the reserves.
- **Preparation work**: They are tasks that carry out, in parallel, to the development tasks; they are horizontal and vertical tasks (chimneys and sub-levels) that must conform to the exploitation method. They allow to prepare the blocks of ore, that is, the way of extracting the ore is designed on the ground.
- **Exploitation work**: The set of tasks that aim to extract the mineral resource, prepared and cubed, in a systematic way; from work areas (Pit).

7.2. TYPES OF UNDERGROUND MINING WORK

7.2.1. Cruises and galleries

They are horizontal tasks of 3.5 x 3 meters section, whose primary objectives are exploration, give access to the exploitation areas. The main galleries serve as the main level where the ore of pits and sub-levels arrives through chimneys; these are spaced 50 meters and are carried out in a conventional manner with the use of the following equipment:

- Jackleg type drills.
- Front loaders type Scoop trumps of 3.5 Yd^3.
- Dumper Trucks of 08 and 10 Ton.

The stages during the work cycle are as follows:

- Drilling: They are made by using Jacklegs drills and holes of 02, 04, 06 and 08 feet in length and their drilling mesh is between 40 and 43 holes, according to the geomechanical characteristics of the rock.
- Blasting: The explosive used is the Anfo and dynamite Semexa 65, as a blasting accessory safety wick and fulminant N0 8 is used to start the explosive column together with the dynamite.
- Cleaning: It is done through the use of 3.5 Yd3 Scoop trumps, which load the broken material, to the 08 and 10 Ton Dumper trucks and then extract them to those of ore or dismantlers.
- Support: Due to the type of rock, the support is only given in the sections where, according to the engineering department, there may be structural damage and cause accidents to the workers or equipment of the mine. It is done by using wooden frames.

Table 7,1: Distribution of times in cruise ships and galleries

ACTIVITIES	HOURS	CYCLE
Entry to work	0:20:00	
Labor Inspection	0:20:00	
Watering the rock	0:15:00	
Unleashed rocks	0:20:00	
Sustenance	2:00:00	
Cleaning	1:50:00	
Drilling	3:00:00	
Loading and blasting	0:35:00	
Exit	0:20:00	
TOTAL	**9:00:00**	

Source: Engineering Department - S.M.R.L. Gotas de Oro

7.2.2. Chimneys

They are vertical and / or inclined tasks that depending on use can be 1.2 x 1.2 meters in section for simple chimneys, whose function is to explore; and of 2.4 x 1.2 meters of section for double chimneys, which has the objectives to serve as extraction of pit to sub-levels and access. These tasks are carried out in a conventional manner with the use of the following equipment:

- Stopper Drills.
- Front loaders type Scoop trumps of 3.5 Yd^3 and “Buggy” type trucks.
- 08 and 10 Ton Dumpers trucks and 0.8 Ton mining cars.

The stages during the work cycle are as follows:

- Drilling: They are made through the use of Stopper drills and holes of 02, 04 and 05 feet in length and their drilling mesh has between 12 and 18 holes for single chimneys and between 18 and 22 holes for double chimneys, according to the geomechanical characteristics of the rock.

- Blasting: The explosive used is the Anfo and dynamite Semexa 65, as a blasting accessory safety wick and fulminant N° 8 is used to start the explosive column together with the dynamite.
- Cleaning: The chimney top is cleaned by gravity, the broken material falls towards the main work where the Scoop and Dumper awaits, to proceed to remove the material towards the outside of the mine. There are cases where old main works that do not have the dimensions for a Scoop to enter, but have mining cars; In these cases, this level is connected to another level, where if you can enter a front loader, using single and double chimneys to extract the ore or disassemble.
- Sustainability: The support is carried out according to the geomechanical characteristics of the rock, through the use of wooden frames and advancing struts; while double chimneys are lined with boards to separate the path of the dump (Mineral and / or dismount) from the access road.

Table 7,2: Time distribution in chimneys

ACTIVITIES	HOURS	CYCLE
Entry to work	0:20:00	
Labor Inspection	0:20:00	
Watering the rock	0:15:00	
Unleashed rocks	0:20:00	
Sustenance	1:20:00	
Cleaning	2:00:00	
Drilling	3:30:00	
Loading and blasting	0:35:00	
Exit	0:20:00	
TOTAL	**9:00:00**	

Source: Engineering department - S.M.R.L. Gotas de Oro

7.2.3. Sub-levels

They are works of 1.8 x 2.4 meters section, which are carried out during the stage of preparation of work from a double chimney spaced every 100 meters and serve to delimit the beginning of the area of exploitation; Between a main level and a sub-level, a 3-meter-wide mineral bridge is left, to support the filling of the work. These tasks are carried out in a conventional manner with the use of the following equipment:

- Jackleg type drills.
- "Buggy" type trucks.
- Trailed winches of 7.5 HP and capacity between 08 and 12 ft^3.

The stages during the work cycle are as follows:

- Drilling: They are made by using Jacklegs drills and holes of 02, 04 and 06 feet in length and their drilling mesh is between 20 and 24 holes, according to the geomechanical characteristics of the rock.
- Blasting: The explosive used is the Anfo and dynamite Semexa 65, as a blasting accessory safety wick and fulminant N0 8 is used to start the explosive column together with the dynamite.
- Cleaning: It is carried out by means of drag winches whose capacity can vary between 08 and 12 ft3, moving the broken ore to the hopper of the sub-level, to then be extracted to the surface by means of Scoop and Dumper, or it can also be pulled into mining cars from a level old to one where the two transport teams, mentioned above, wait.
- Sustainment: In this type of work no support is used, due to the small section

dimensions, in addition to the type of rock present in the reservoir.

Table 7,3: Time distribution in sub-levels

ACTIVITIES	HOURS	CYCLE
Entry to work	0:20:00	
Labor Inspection	0:20:00	
Watering the rock	0:15:00	
Unleashed rocks	0:20:00	
Sustenance	1:30:00	
Cleaning	2:30:00	
Drilling	2:50:00	
Loading and blasting	0:35:00	
Exit	0:20:00	
TOTAL	**9:00:00**	

Source: Engineering Department - S.M.R.L. Gotas de Oro

7.2.4. Cut and fill up

The Ascending Filling and Cutting method allows to have a high selectivity, stability and adequate recovery, it consists in extracting the mineral by means of horizontal slices (Cuts) of a height of 1.5 meters, which are drilled following the vein dip, according to the drilling mesh

In case the vein narrows too much and is very irregular in power, the circus is used, which is very selective. To do this, only the box is fired, and then this broken material is laid and used as a filler.

The work where the exploitation of the mineral is carried out is composed of several blocks, generally the dimensions of the blocks are 50 meters in length by

50 meters high. All exploitation of these tasks is carried out in a conventional manner with the use of the following equipment:

- Jacklegs and / or Stoppers type drills.

- "Buggy" type trucks.
- 7.5 HP drag winches and capacity between 8 and 12 ft^3.
- Front loaders type Scoop trumps of 3.5 Yd^3 and Dumpers trucks of 08 and 10 Ton, in some cases mining cars of 0.8 Ton.

The stages during the work cycle are as follows:

- Drilling: They are made by using Jacklegs and / or Stoppers drills with holes of 02, 04, 06 and 08 feet in length and drill bits of 36, 38 and 41 millimeters in diameter. The drilling mesh is 0.30 x 0.30 meters square and in some cases when the rock is very compact 0.25 x 0.30 meters.
- Blasting: The explosive used is the Anfo and dynamite Semexa 65, as a blasting accessory safety wick and fulminant No. 8 is used to start the explosive column together with the dynamite. Blasting is always done taking care not to damage the boxes; The load factor varies between 1.5 and 1.8 Kg / m^3.
- Sustainability: Due to the favorable characteristics of the rock, it generally does not use support, only in some when the boxes are unstable, temporary support is used by means of struts; all this to have a safe work for the worker, so that he can clean the ore and then proceed with the filling of the pit that serves as a definitive support.
- Cleaning: It is carried out by means of drag winches whose capacity can vary between 08 and 12 ft^3, moving the broken ore towards the hopper of the sub-level, to then be extracted to the surface by means of Scoop and Dumper, or

it can also be pulled in mining cars from an old level to one where the two transport teams, mentioned above, are waiting.

- Filling: Once the broken ore has been extracted, the extracted section is filled to a height of 2.4 meters from the new floor to the ceiling. The filling material comes mainly from the same work, low grade ore, dog holes (Glory hole) and surface, for the latter chimneys are made that connect the sublevel to the surface and making use of shovels, winches and rakes is taken to the pits.

Table 7,4: Time distribution in pit

ACTIVITIES	HOURS	CYCLE
Entry to work	0:20:00	
Labor Inspection	0:20:00	
Watering the rock	0:15:00	
Unleashed rocks	0:20:00	
Sustenance	1:30:00	
Cleaning	3:00:00	
Drilling	2:20:00	
Loading and blasting	0:35:00	
Exit	0:20:00	
TOTAL	**9:00:00**	

Source: Engineering Department - S.M.R.L. Gotas de Oro

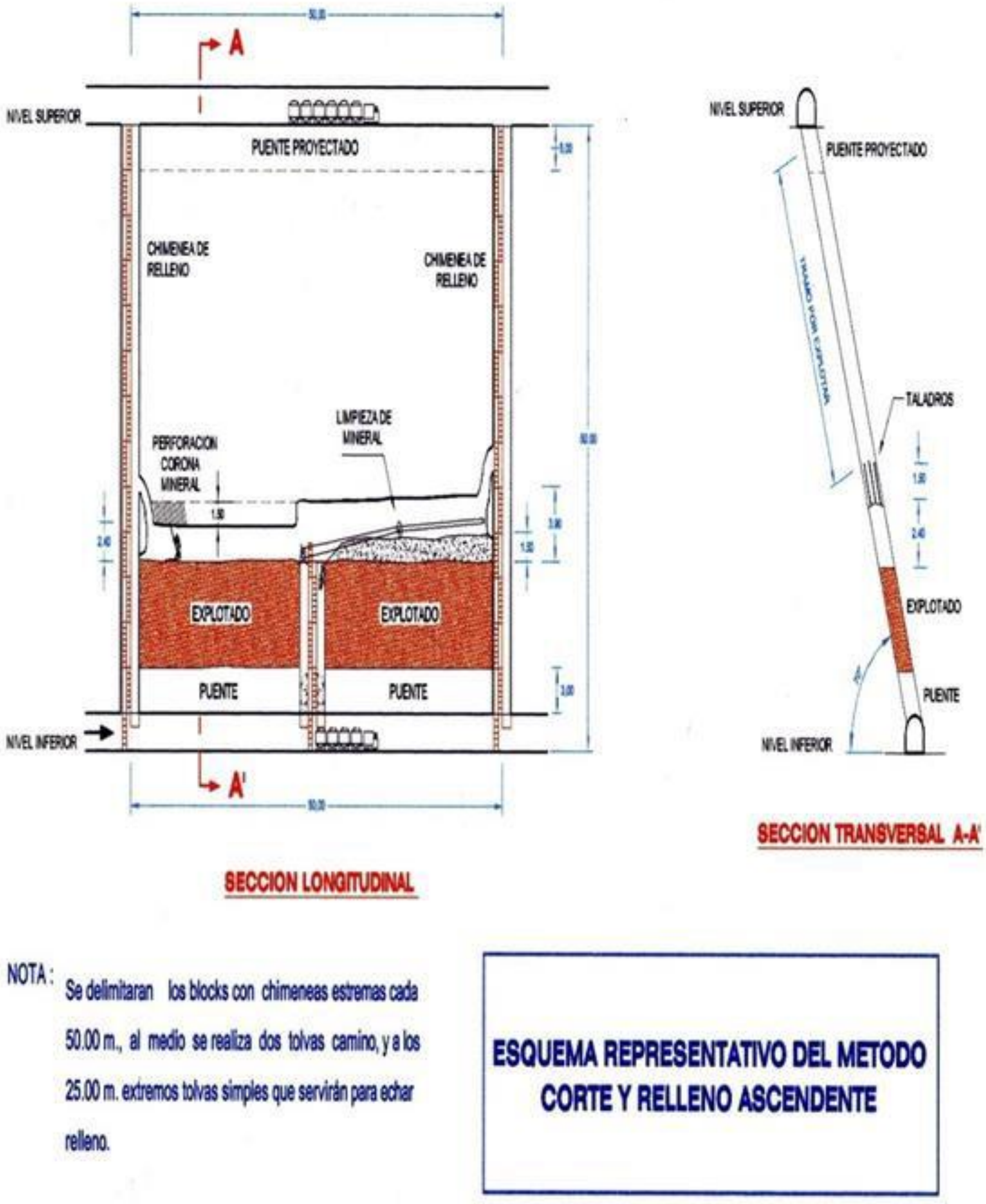


Figure 7,1: Representative scheme of the method of exploitation of Cut and Ascending Filling

Source: Pre-professional internship report “Mining company Gotas de oro S.M.R.L.” – Nestor Enrique Rodriguez Jesus

CHAPTER VIII: VENTILATION

8.1. VENTILATION NETWORK DESIGN

The need to have a pleasant working environment with good standards in ventilation is of the utmost importance to perform a proper job in this type of mining. Currently in the mine the work that is carried out, is naturally ventilated and in main work it is complemented with mechanical ventilation, depending on the required need. As they move forward with more development, preparation and deepening work, a mechanical ventilation network must be designed suitable for mining, by installing fans and sleeves in series by lower levels, with the objective of supplying enough oxygen for the personnel inside the mine.

To determine the total air flow required, we will rely on the number of personnel that will work per day guard, the machinery that works inside the mine, type of explosive and temperature throughout the day, in such a way that it allows the work to be found. properly ventilated throughout the guard.

8.1.1. Ventilation of galleries, chimneys and cruises

As the galleries and cruises are blind and confined tasks, so they require insufflation of a large volume of air, so that, in these types of work, mechanical ventilation is used so that the work environment in these tasks is adequate according to the safety regulation DS N° 024 - 2016 - EM. In the galleries there is a natural ventilation that supplies 34255.23CFM of natural air.

8.1.2. Ventilation of operating pit

The design of ventilation in the exploitation work is considered the execution of chimneys every 50 meters in order to have an adequate natural air flow; in addition, having this design has three basic objectives: vertical exploration, ventilation of work and services (roads, pipes, etc.)

In order to have a good fresh air circuit in the pits, by means of natural ventilation, it has been designed to operate a set of pits simultaneously so that there is a connection between 03 existing pits between the ventilation chimneys. To detail what was said before, the following figure is presented; where you can see the design of the chimneys and the flow of natural air in the work of the mining unit.

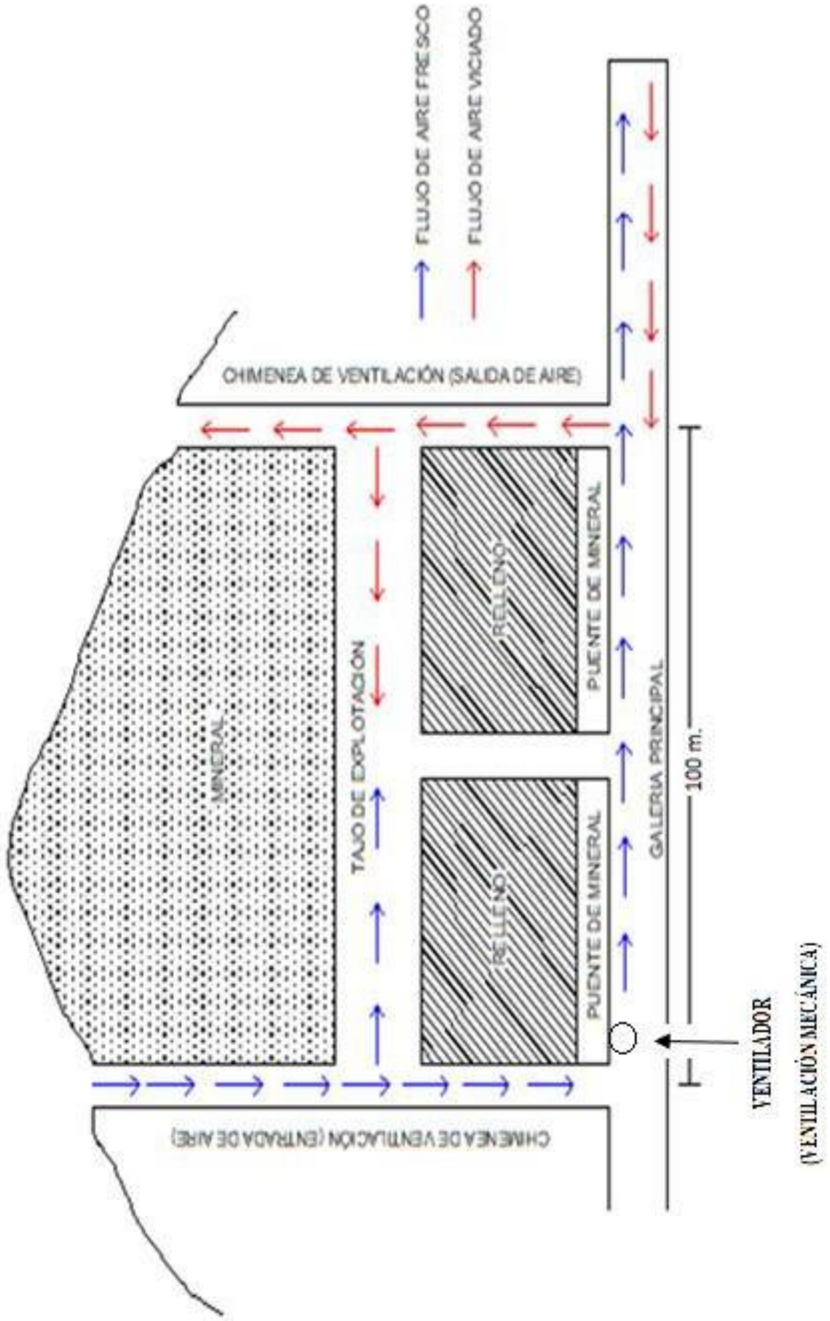


Figure 8,1: Scheme of ventilation design

Source: Author

8.2. REQUIRED AIR FLOW CALCULATION

Table 8,1: Fresh air requirement for work in mine interior (First part)

MINING UNIT: SOL NACIENTE TERCERO FRESH AIR REQUIREMENT FOR MINING WORK		
AMOUNT OF STAFF ENTERING MINE PER GUARD		
Area	**N^0 workers**	
Mine operation	8	
Geology	2	
Engineering	2	
Security	1	
Sampling	2	
General Mine Services	3	
Total staff required	**18**	
FRESH AIR REQUIREMENTS IN THE MINE INTERIOR FOR VENTILATION		
Preliminary data	**Units**	**Quant.**
Average air speed (Measured)	m / min	100
Average area of main gallery in interior mine (A_p)	m^2	9.7
Average sub-level area in the mine interior (A_s)	m^2	3.9
Work levels	unid.	1
Minimum air speed (Anfo)	m / min	25
Altitude of mining work	m.s.n.m	700
Scoop number per main gallery	unid.	1
Dumper number per main gallery	unid.	1
Scoop power per main gallery	HP	150
Dumper power per main gallery	HP	100
Preliminary calculations	**Units**	**Quant.**
Amount of circulating air per work inside mine	m^3 / min	970
Total power per scoop	HP	150
Total power per dumper	HP	100

Source: Author

Table 8,2: Fresh air requirement for work inside mine (Second part)

Air flow for personnel (0 - 1500 m.a.s.l.)	**m^3 / min**	**CFM**
Q_1 = (N^0 workers / guard) x 3	54	1906.99
Air flow for equipment	**m^3 / min**	**CFM**
Q_2 = N^0 total HP x 3	750	26486.00
Air flow to dilute blasting gases	**m^3 / min**	**CFM**
Q_3 = Air velocity x A_s x Work levels	390	13772.72
Total air flow required	**m^3 / min**	**CFM**
	804	28392.99
AIR BALANCE TO VENTILATE THE MINE INTERIOR		
	m^3 / min	**CFM**
Fresh air intake by pithead (Artificial ventilation)	141	4979.27
Fresh air intake by pithead (Natural ventilation)	970	34255.23
Air required inside mine	804	28392.99
Balance	307	10841.60
% Coverage	**138**	

Source: Author

When the total required air flow was calculated, the air flow was not considered to dilute blasting gases, since when a blast is performed, the personnel and machinery are evacuated from the interior mine; For this reason, after blasting, only the air flow to dilute gases is considered as a requirement to calculate the total air flow.

As can be seen in Table 8.2, the total required air flow is lower than the mine air flow, therefore, the use of artificial ventilation in blind work and natural ventilation in the pits allows for an adequate environment. labor; However, the use of axial fans in all operational tasks will become indispensable as the development, preparation and deepening of these tasks increase.

Air flow in the mine interior > Total air flow required

$$1111 \text{ m}^3 / \text{min} > 804 \text{ m}^3 / \text{min}$$

CHAPTER IX: AUXILIARY SERVICES

9.1. DESCRIPTION OF THE AIR, WATER, ENERGY AND OIL REQUIREMENT

Auxiliary services are activities of the utmost importance; since, they allow the mining cycle to be carried out with normality, development and continuity. In the case of the El Sol Naciente Tercero mining unit, the following air, water and energy consumption is considered:

Table 9,1: Daily consumption of air, water, electricity and oil in the mining unit El Sol Naciente Tercero (Day guard)

MINING UNIT EL SOL NACIENTE TERCERO DAILY REQUIREMENT OF AIR, WATER, ELECTRICITY AND OIL		
COMPRESSED AIR CONSUMPTION (CFM)		
Drilling machines (Jacklegs and Stoppers)	1850	CFM
TOTAL	**1850**	**CFM**

ELECTRICAL POWER CONSUMPTION (KW)		
Electric Winches (Drag)	220	KW
Street lighting and housing	60	KW
Fans	40	KW
Others	25	KW
TOTAL	**345**	**KW**

WATER CONSUMPTION (m^3)		
Drilling machines (Jacklegs y Stoppers)	5.32	m^3
Staff Consumption	4.8	m^3
Others	0.5	m^3
TOTAL	**10.62**	**m^3**

PETROLEUM CONSUMPTION (Gln)		
Compressors	594	Gln
Generator sets	28.8	Gln
Loading and hauling machinery (Scoops, Dumpers and Front Loader)	40	Gln
Pickup trucks	4.32	Gln
Others	7	Gln
TOTAL	**674.12**	**Gln**

Source: Author

9.2. DESCRIPTION OF THE EQUIPMENT USED

9.2.1. Drag winches

They are mechanical equipment used in the cleaning of the pits, either to pull the stuffing or haul the ore with a drag of 180 and a capacity between 8 to 12 cubic feet; They are powered by a 7.5 HP electric motor.

In the mining unit there are 10 drag winches of 7.5 HP, located in the pit.

9.2.2. Generator sets

They are electric power generating equipment powered by diesel engine, which moves the oil-powered power generators.

The mine has 04 generator sets of different powers that are used depending on the energy demand required in the mining unit; the generator sets are as follows:

- Generator set Volvo of 300 KW.
- Generator set Perkins of 130 KW.
- Generator set GENPACK of 50 KW.
- Generator set GENPACK of 60 KW.

9.2.3. Compressors

They are pneumatic equipment that provide compressed air, are powered by a diesel engine, coupled to a screw-powered oil compressor.

These equipment are connected by means of pipes that are introduced to the interior of the mine by means of 4-inch polyethylene pipes, distributed to development and exploitation tasks by means of 2-inch pipes and reach the drilling equipment by 1-inch pipes.

The mine has 04 operational and 01 inoperative compressors, all of them of different capacities that are used depending on the demand for compressed air in the mining unit, the compressors are as follows:

- Compressor INGERSOLL RAND 600 of 600 CFM.
- Compressor SULLAIR 375 of 375 CFM.
- Compressor DEMAG 350 of 350 CFM.
- Compressor INGERSOLL RAND 825 of 825 CFM.
- Compressor INGERSOLL RAND 1400 of 1400 CFM (Inoperativa).

9.2.4. Fans

Axial fans are activated by an electric cage motor (squirrel type), which provide the fresh air necessary for blind work (chimneys and cruises).

In the mining unit there are 10 fans with the following characteristics:

- Ventiladores de 5000 CFM / 3500 RPM de 10 HP.

9.2.5. Others

Here are considered mining cars with a capacity of 0.8 tons that move on rails and are pushed by the workers, to transfer the ore to lower levels through extraction chimneys.

CHAPTER X: MINING PLANNING

10.1. DESCRIPTION OF THE MINING PLAN

The ore processing plant, located in the Tinguiña district, has a capacity to process 6000 tons of ore per month. The tonnage of ore provided by the El Sol Naciente Tercero mining unit, currently, is 4000 tons per month; therefore, the capacity of the processing plant is sufficient to process the tonnage of ore supplied by the mine.

The objective of this thesis was to develop a mining plan for a term of three and a half years, taking into account the volume of available reserves and the beginning of operation of the ROSITA vein. The relevant aspects of this plan are the linear advance program (Exploration, development and preparation), production program by zones (Veins) and summary of ore laws. In this way it is sought to increase the production of the mine and increase the profit obtained from the sale of the greater volume of concentrate; taking advantage of the favorable geological characteristics of the deposit, the various veins that are available and the increase and high expectations of rising metals prices.

The exploration work, expressed in meters of progress, has not had a drastic change throughout the year 2017 and 2018; since increasing these tasks too much would imply a considerable increase in investment, but a greater volume of reserves to support the operation.

The development and preparation work have had a gradual increase; expressed in tons, mainly due to the start of operation of the Rosita vein.

The main variation within the production program occurs during 2017; At the beginning of the mining plan, there is a production of 2000 tons per month, as the development and preparation work advances in the Rosita vein, the contribution of ore, which it provides, increases until the approximate regular monthly quota is 1500 tons. ; the remaining 500 tons, to reach 4000 tons per month, are contributed by the other 04 veins in operation. Therefore, at the end of the first year of the mining plan, the monthly production was the one proposed in the "Technical - economic plan" and this will remain constant throughout the objective period of time.

An important aspect to consider is that so far only Millable Reserves and Potential Mineral are being exploited (See Table 5.1); The estimate of Mena Reserves (See Table 5.4) provides a favorable horizon to continue or increase the proposed production, as required.

To have an approximate idea of the income obtained from the sale of the mineral, there is a summary of laws registered monthly and annually; The above lines are explained in more detail in Tables 10.1 and 10.2.

10.2. SUMMARY OF THE OPERATION PROGRAM OF THE YEAR 2017

Table 10,1: Operational program of the year 2017 of the mining unit El Sol Naciente Tercero

OPERATION PROGRAM OF THE YEAR 2017 - MINING UNIT EL SOL NACIENTE TERC

EXPLORATION										
	Enero	Febrero	Marzo	Abril	Mayo	Junio	Julio	Agosto	Setiembre	Oc
TOTAL (m)	350	350	340	350	350	350	350	350	320	

DEVELOPMENT AND PREPARATION										
	Enero	Febrero	Marzo	Abril	Mayo	Junio	Julio	Agosto	Setiembre	Oc
TOTAL (Tn)	200	200	240	240	200	220	220	180	180	

VEIN PRODUCTION										
ZONAS	Enero	Febrero	Marzo	Abril	Mayo	Junio	Julio	Agosto	Setiembre	Oc
Vein GINO I	820	810	980	970	980	880	870	1200	1000	1
Vein ICAS I	700	690	920	890	810	850	840	1020	930	1
Vein GINO II	300	320	320	320	350	350	350	300	350	
Vein ICAS II	180	180	200	200	190	200	200	200	200	
Vein ROSITA	0	0	280	320	370	420	440	480	720	
TOTAL (Tn)	2000	2000	2700	2700	2700	2700	2700	3200	3200	3

MINERAL LAWS										
	Enero	Febrero	Marzo	Abril	Mayo	Junio	Julio	Agosto	Setiembre	Oc
Au (Oz / Tn)	0.921	0.923	0.911	0.911	0.916	0.910	0.910	0.910	0.907	0
Ag (Oz / Tn)	0.560	0.565	0.567	0.575	0.605	0.583	0.585	0.592	0.606	0
Cu (%)	1.873	1.875	1.838	1.833	1.826	1.829	1.827	1.812	1.802	1

10.3. SUMMARY OF THE OPERATION PROGRAM OF THE YEAR 2018 (JANUARY - NOVEMBER)

Table 10,2: Operation program of the year 2018 of the mining unit El Sol Naciente Tercero

OPERATION PROGRAM OF THE YEAR 2018 - EL SOL NACIENTE MINERA MINING UN

EXPLORATION									
	Enero	Febrero	Marzo	Abril	Mayo	Junio	Julio	Agosto	Setier
TOTAL (m)	395.7	395.7	395	395	395	395	395	395	39

DEVELOPMENT AND PREPARATION									
	Enero	Febrero	Marzo	Abril	Mayo	Junio	Julio	Agosto	Setier
TOTAL (Tn)	186	186	184	186	186	185	186	185	18

VEIN PRODUCTION									
ZONAS	Enero	Febrero	Marzo	Abril	Mayo	Junio	Julio	Agosto	Setier
Vein GINO I	1000	990	1010	1030	1000	1010	1000	1020	10
Vein ICAS I	950	960	960	940	950	940	940	940	95
Vein GINO II	350	350	330	330	350	350	360	340	35
Vein ICAS II	200	200	200	200	200	200	200	200	20
Vein ROSITA	1500	1500	1500	1500	1500	1500	1500	1500	15
TOTAL (Tn)	4000	4000	4000	4000	4000	4000	4000	4000	40

ORE LAWS									
	Enero	Febrero	Marzo	Abril	Mayo	Junio	Julio	Agosto	Setier
Au (Oz / Tn)	0.899	0.899	0.898	0.899	0.899	0.900	0.900	0.899	0.8
Ag (Oz / Tn)	0.645	0.643	0.643	0.648	0.645	0.648	0.648	0.648	0.6
Cu (%)	1.757	1.758	1.756	1.755	1.757	1.757	1.757	1.756	1.7

10.4. PROJECTION OF THE OPERATION PROGRAM UNTIL THE END OF THE YEAR 2018

Table 10,3: Projection of the operating program for the year 2018 of the mining unit El Sol Naciente

OPERATION PROGRAM OF THE YEAR 2018 - MINING UNIT EL SOL NACIENTE TERC

EXPLORATION										
	Enero	Febrero	Marzo	Abril	Mayo	Junio	Julio	Agosto	Setiembre	Oc
TOTAL (m)	395.7	395.7	395	395	395	395	395	395	395	

DEVELOPMENT AND PREPARATION										
	Enero	Febrero	Marzo	Abril	Mayo	Junio	Julio	Agosto	Setiembre	Oc
TOTAL (Tn)	186	186	184	186	186	185	186	185	185	

VEIN PRODUCTION										
ZONAS	Enero	Febrero	Marzo	Abril	Mayo	Junio	Julio	Agosto	Setiembre	Oc
Veta GINO I	1000	990	1010	1030	1000	1010	1000	1020	1000	1
Veta ICAS I	950	960	960	940	950	940	940	940	950	
Veta GINO II	350	350	330	330	350	350	360	340	350	
Veta ICAS II	200	200	200	200	200	200	200	200	200	
Veta ROSITA	1500	1500	1500	1500	1500	1500	1500	1500	1500	1
TOTAL (Tn)	4000	4000	4000	4000	4000	4000	4000	4000	4000	4

ORE LAWS										
	Enero	Febrero	Marzo	Abril	Mayo	Junio	Julio	Agosto	Setiembre	Oc
Au (Oz / Tn)	0.899	0.899	0.898	0.899	0.899	0.900	0.900	0.899	0.899	0
Ag (Oz / Tn)	0.645	0.643	0.643	0.648	0.645	0.648	0.648	0.648	0.645	0
Cu (%)	1.757	1.758	1.756	1.755	1.757	1.757	1.757	1.756	1.757	1

10.5. PROJECTION OF THE OPERATION PROGRAM UNTIL THE END OF THE YEAR 2019

Table 10,4: Projection of the operating program for the year 2019 of the mining unit El Sol Naciente

OPERATION PROGRAM OF THE YEAR 2019 - MINING UNIT EL SOL NACIENTE TERC

EXPLORATION										
	Enero	Febrero	Marzo	Abril	Mayo	Junio	Julio	Agosto	Setiembre	Octubre
TOTAL (m)	395	395	395	395	395	395	395	395	395	395

DEVELOPMENT AND PREPARATION										
	Enero	Febrero	Marzo	Abril	Mayo	Junio	Julio	Agosto	Setiembre	Octubre
TOTAL (Tn)	186	186	186	186	186	186	186	186	186	186

VEIN PRODUCTION										
ZONAS	Enero	Febrero	Marzo	Abril	Mayo	Junio	Julio	Agosto	Setiembre	Octubre
Veta GINO I	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
Veta ICAS I	950	950	950	950	950	950	950	950	950	950
Veta GINO II	350	350	350	350	350	350	350	350	350	350
Veta ICAS II	200	200	200	200	200	200	200	200	200	200
Veta ROSITA	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500
TOTAL (Tn)	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000

ORE LAWS										
	Enero	Febrero	Marzo	Abril	Mayo	Junio	Julio	Agosto	Setiembre	Octubre
Au (Oz / Tn)	0.899	0.899	0.899	0.899	0.899	0.899	0.899	0.899	0.899	0.899
Ag (Oz / Tn)	0.645	0.645	0.645	0.645	0.645	0.645	0.645	0.645	0.645	0.645
Cu (%)	1.757	1.757	1.757	1.757	1.757	1.757	1.757	1.757	1.757	1.757

CHAPTER XI: MINERAL PROCESSING

11.1. MINERAL PROCESSING PLANT

Once the total tonnage of the five veins was obtained (Gino I, Gino II, Icas I, Icas II and Rosita) as a result of the mining operations, the next stage of the process is proceeded; the treatment in the ore processing plant.

The plant is owned by the Peruvian Metals company and is located 54 kilometers from the mining unit, in the district of Tinguiña, department of Ica. The ore is transported from the mine to the plant in dump trucks with a capacity of 50 tons, 02 to 03 daily trips during the project.

In the plant two flotation and cyanidation processes are carried out; that is, the plant uses methods based on physical - chemical processes that explain the affinity of some particles for air, in addition to the affinity of other mineral particles for water (Flotation) and in percolation treatments, sand agitation, concentration of values of a cyanide solution (Cyanuration). This plant has an installed capacity to process 6000 tons of ore per month.

Minerals from the El Sol Naciente Tercero mining unit are treated by flotation process, due to the mineralogical characteristics of the mine ore (Sulfides) of this process, a Cu / Au / Ag concentrate and tailings are obtained. It is deposited on the tailings field while the concentrate is transported to the port of Callao for commercialization and export. The cost of mineral treatment, according to a contract between the mining company S.M.R.L. Gotas de Oro and Peruvian Metals is $ 32.5 / ton.

The following schemes help to better understand the mineral treatment process.

11.2. COMPREHENSIVE PRODUCTIVE PROCESS SCHEME

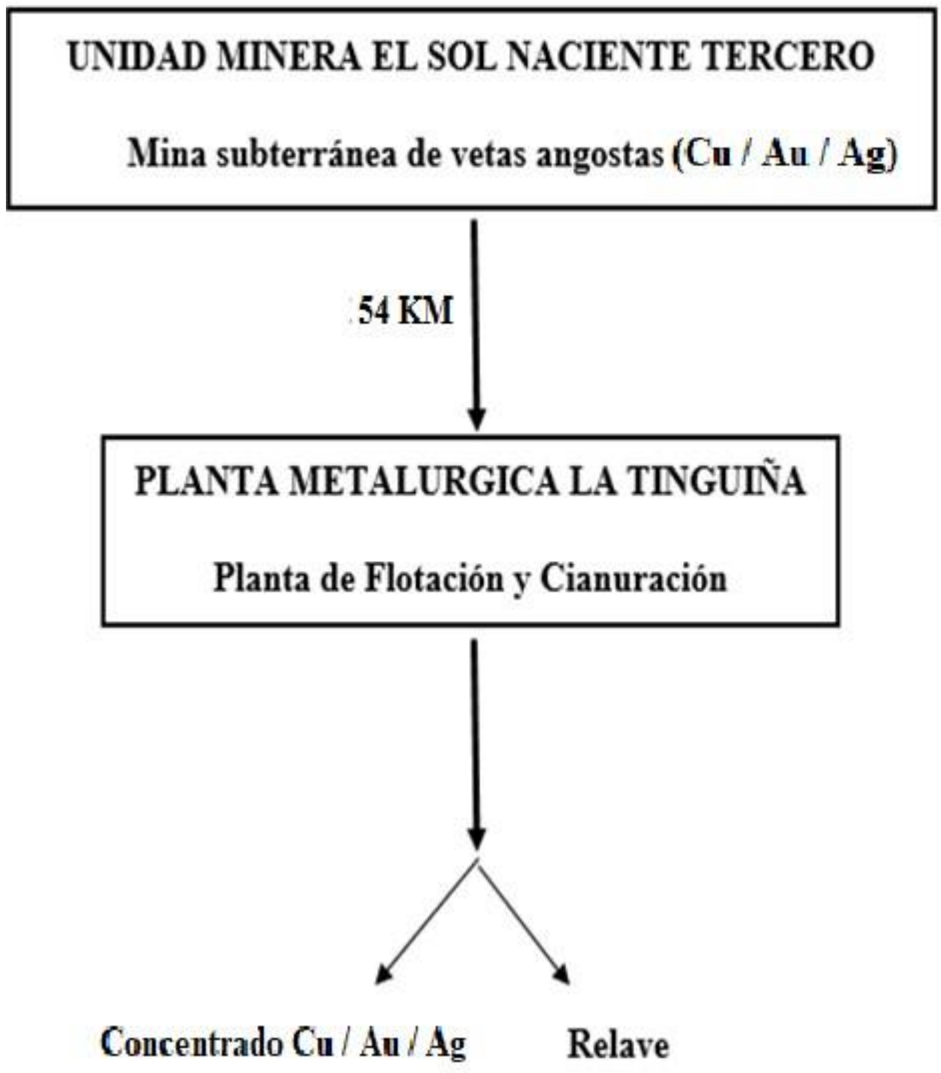


Figure 11,1: Scheme of the integral productive process

Source: Author

11.3. LA TINGUIÑA PROCESSING PLANT PROCESS SCHEME

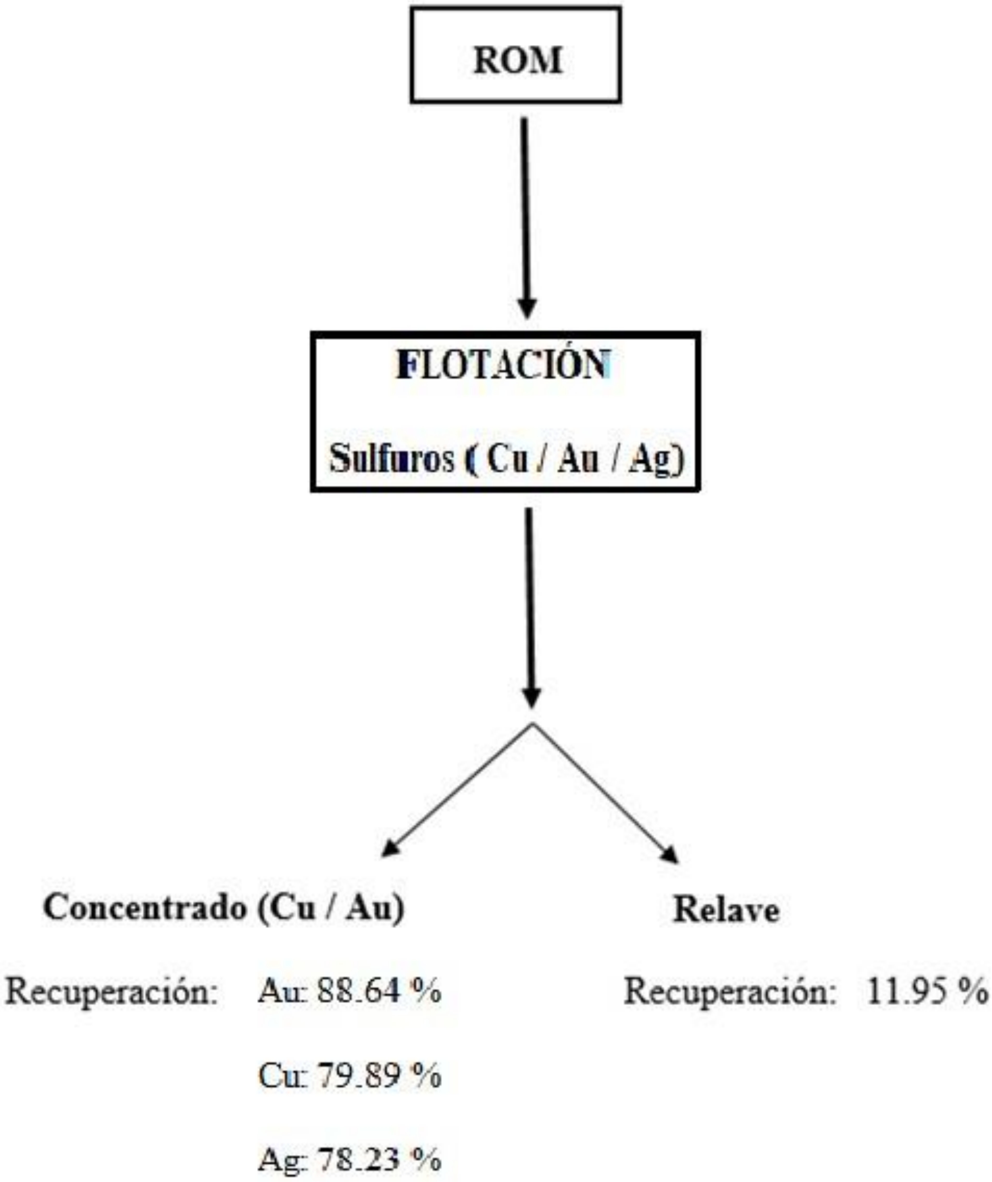


Figure 11,2: Process scheme in the processing plant (La Tinguiña Plant)

Source: Author

CHAPTER XII: ECONOMIC EVALUATION

12.1. ECONOMIC ANALYSIS OF THE MINING PLAN

To have a more concise idea of the effects of the economic variables involved in the mining business; In this study, an economic evaluation has been carried out for a period of three years, based on the expenses incurred during the mining process and the profits obtained during 2017 and the end of 2018.

Once the recovery process at the treatment plant is completed, the income obtained from the sale of the Cu / Au / Ag concentrate can be estimated. These revenues are easily affected by the price of the metals involved in the study (Copper, Gold and Silver).

The expenses incurred by the El Sol Naciente Tercero mining unit within the production chain of the integral production process are considered within the operating costs necessary to carry out the mineral extraction process.

Regarding the participation of workers, 08% and an income tax of 27% are being considered; In addition, the costs incurred in the investments and the administrative expenses of the headquarters of the mining company are considered.

The following tables summarize all the above lines, a classification is presented, according to the type of costs; but mainly it is possible to build an economic flow for each year, resulting in the final operating margins. The discount rate considered is 10% per year.

Table 12,1: Classification of types of costs according to their behavior

TIPOS DE COSTOS	
FIXED COSTS	**VARIABLE COSTS**
Preparation, exploitation and AA.SS.	Ore transport
Common auxiliary services	Equipment operation and maintenance
Benefit Plant Cost	Prospecting
Depreciation	Exploration and Development
Marketing cost	Worker Participation
Royal Government Royalties	Mining Unit Management
Income tax	
Ica administrative expenses	

Source: Author

12.2. ECONOMIC FLOW AFTER THE 2017 INVESTMENT (INCOME, COSTS, INVE MARGIN)

Table 12,2: Income, costs, investment and profit margin for 2017 - Increase from 2000 t

ECONOMIC FLOW OF THE YEAR 2017		
		Año 2017
BALANCE METALÚRGICO	UND.	
TONELAJE	Ton	35,400.00
Ley Au	Oz / Ton	0.909
Ley Ag	Oz / Ton	0.600
Ley Cu	%	1.812
RECUP. Au	%	88.64
RECUP. Ag	%	78.23
RECUP. Cu	%	79.89
TOTAL DE ONZAS Eq – Au		35,435.17
VALORIZACIÓN PROGRAMADA (US$)		**34,550,703.79**
DETALLE DE COSTOS POR ÁREA		
PREPARACIÓN, EXPLOTACIÓN Y SS.AA		2,136,036.00
SERVICIOS AUXILIARES COMUNES		313,644.00
GESTIÓN DE UNIDAD MINERA		1,694,244.00
TRANSPORTE DE MINERAL		842,520.00
OPERACIÓN Y MANTENIMIENTO DE EQUIPOS		387,276.00
COSTOS DE PLANTA DE BENEFICIO		1,150,500.00
DEPRECIACIÓN		141,450.00
COSTOS DE OPERACIÓN (C_1)		**6,665,670.00**
COSTOS DE COMERCIALIZACIÓN		265,500.00
REGALIAS GOBIERNO CENTRAL (1%)		345,507.04
COSTO TOTAL		**7,276,677.04**
MARGEN OPERATIVO		27,274,026.75
COSTO TOTAL US$ / Oz Eq – Au		205.35
PARTICIPACIÓN DE TRABAJADORES (8%)		2,181,922.14
IMPUESTO A LA RENTA (I.R. = 27%)		6,774,868.24

12.3. ECONOMIC FLOW AFTER THE INVESTMENT OF 2018 (INCOME, COSTS, IN MARGIN)

Table 12,3: Income, costs, investment and profit margin for the year 2018 - Increase fro

ECONOMIC FLOW OF THE YEAR 2018		
		Año 2018
BALANCE METALÚRGICO	UND.	
TONELAJE	Ton	48,000.00
Ley Au	Oz / Ton	0.899
Ley Ag	Oz / Ton	0.646
Ley Cu	%	1.757
RECUP. Au	%	88.64
RECUP. Ag	%	78.23
RECUP. Cu	%	79.89
TOTAL DE ONZAS Eq – Au		47,460.52
VALORIZACIÓN PROGRAMADA (US$)		**46,275,900.98**
DETALLE DE COSTOS POR ÁREA		
PREPARACIÓN, EXPLOTACIÓN Y SS.AA		2,858,880.00
SERVICIOS AUXILIARES COMUNES		430,080.00
GESTIÓN DE UNIDAD MINERA		2,254,080.00
TRANSPORTE DE MINERAL		1,142,400.00
OPERACIÓN Y MANTENIMIENTO DE EQUIPOS		520,320.00
COSTOS DE PLANTA DE BENEFICIO		1,560,000.00
DEPRECIACIÓN		177,600.00
COSTOS DE OPERACIÓN (C_1)		**8,943,360.00**
COSTOS DE COMERCIALIZACIÓN		360,000.00
REGALIAS GOBIERNO CENTRAL (1%)		462,759.01
COSTO TOTAL		**9,766,119.01**
MARGEN OPERATIVO		36,509,781.97
COSTO TOTAL US$ / Oz Eq – Au		205.77
PARTICIPACIÓN DE TRABAJADORES (8%)		2,920,782.56
IMPUESTO A LA RENTA (I.R. = 27%)		9,069,029.84

12.4. FLUJO ECONOMICO DESPUES DE LA INVERSIÓN DEL 2019 (INGRESOS, CO

OPERATIVO)

Table 12,4: Income, costs, investment and profit margin for the year 2019 - Increase fro

ECONOMIC FLOW OF THE YEAR 2019		
		Año 2019
BALANCE METALÚRGICO	UND.	
TONELAJE	Ton	48,000.00
Ley Au	Oz / Ton	0.910
Ley Ag	Oz / Ton	0.656
Ley Cu	%	1.746
RECUP. Au	%	88.64
RECUP. Ag	%	78.23
RECUP. Cu	%	79.89
TOTAL DE ONZAS Eq – Au		47,961.51
VALORIZACIÓN PROGRAMADA (US$)		**46,764,390.95**
DETALLE DE COSTOS POR ÁREA		
PREPARACIÓN, EXPLOTACIÓN Y SS.AA		2,885,280.00
SERVICIOS AUXILIARES COMUNES		430,080.00
GESTIÓN DE UNIDAD MINERA		2,254,080.00
TRANSPORTE DE MINERAL		1,142,400.00
OPERACIÓN Y MANTENIMIENTO DE EQUIPOS		520,320.00
COSTOS DE PLANTA DE BENEFICIO		1,560,000.00
DEPRECIACIÓN		153,600.00
COSTOS DE OPERACIÓN (C_1)		**8,945,760.00**
COSTOS DE COMERCIALIZACIÓN		360,000.00
REGALIAS GOBIERNO CENTRAL (1%)		467,643.91
COSTO TOTAL		**9,773,403.91**
MARGEN OPERATIVO		36,990,987.04
COSTO TOTAL US$ / Oz Eq – Au		203.78
PARTICIPACIÓN DE TRABAJADORES (8%)		2,959,278.96
IMPUESTO A LA RENTA (I.R. = 27%)		9,188,561.18

12.5. NPV CALCULATION OF THE MINE PLAN

Tabla 12,5: Net present value of the Technical - economic Plan - Increase from 2000 to 4000 tor

NET PRESENT VALUE			
	2017	**2018**	**2019**
INGRESOS	$34,550,703.79	$46,275,900.98	$46,764,39
COSTOS DE OPERACIÓN	$6,665,670.00	$8,943,360.00	$8,945,76
MARGEN OPERATIVO	**$27,885,033.79**	**$37,332,540.98**	**$37,818,63**
GASTOS ADMINISTRATIVOS	$812,076.00	$930,240.00	$930,240
GASTOS DE VENTA	$265,500.00	$360,000.00	$360,000
REGALIAS	$345,507.04	$462,759.01	$467,643
PARTICIPACIÓN DE TRABAJADORES	$2,181,922.14	$2,920,782.56	$2,959,27
IMPUESTO A LA RENTA (I.R. = 27%)	6,774,868.24	9,069,029.84	9,188,561
FLUJO DE CAJA	**$17,505,160.37**	**$23,589,729.57**	**$23,912,90**
INVERSIONES	$792,960.00	$1,020,960.00	$1,020,96

12.6. CRITICAL POINTS AND SENSITIVITY ANALYSIS OF THE NPV

Table 12,6: Critical points and sensitivity analysis of Net Present Value (NPV) - Increase from 2000 to 400

	SCENARIOS				
	PESSIMISTIC			CONSERVATIVE	
	NET PRESENT VALUE WITH VARIATION IN THE PRICE OF Au, Ag AND Cu				
CHANGING THE PRICE OF THE MINERAL	(-) 20%	(-) 15%	(-) 10%	BASE	(+
NPV (i = 10%)	$37,109,330.28	$40,592,958.61	$44,076,586.95	$51,043,843.63	$58,0
CRITICAL POINTS	452%	493%	534%	616%	6

	OPTIMISTIC			CONSERVATIVE	
	NET PRESENT VALUE WITH VARIATION OF OPERATING COST				
VARIATION OF OPERATING COST	(-) 20%	(-) 15%	(-) 10%	BASE	(+
NPV (i = 10%)	$55,078,241.33	$54,069,641.90	$53,061,042.48	$51,043,843.63	$49,0
CRITICAL POINTS	664%	652%	640%	616%	5

	OPTIMISTIC			CONSERVATIVE	
	NET PRESENT VALUE WITH VARIATION OF INVESTMENT COST				
VARIATION OF INVESTMENT COST	(-) 20%	(-) 15%	(-) 10%	BASE	(+
NPV (i = 10%)	$51,510,184.36	$51,393,599.18	$51,277,014.00	$51,043,843.63	$50,8
CRITICAL POINTS	772%	727%	686%	616%	5

Fuente: Autor

Table 12.5 shows that by increasing production from 2000 to 4000 tons / month, the net present value (NPV) obtained is US $ 51,043,843.63. For this, it is a base case where the price of the metals involved in this technical-economic analysis, copper, gold and silver, the following $ 2.60 / lb, $ 1100 / Oz and $ 14 / Oz respectively; an operating cost that fluctuates in the range of $ 186.32 and $ 188.30 / ton and an investment cost in the range of $ 21.27 and $ 22.40 / ton. A 10% discount rate has been used.

Table 12.6 shows the critical points, which allow considering external factors to the market which may affect the technical-economic plan raised, but which can hardly be predictable and measurable; such as socio-environmental problems, abrupt collapse of the markets for precious metals (Gold and Silver) and basic metals (Copper), increased tariffs on mineral exports, etc. It follows that, if the discount rate is higher than the calculated critical points, the proposed project becomes unfeasible; while, if it is smaller, the project is still viable.

Figure 12.1 shows the linear behavior of the net present value (NPV), as a function of the essential variables within the mining sector, Price ($ / Oz), Cost ($ / Tn) and Investment ($ / Tn), and its variations raised.

The linear graph shows that the variable that most influences the net present value is the external factor, the price of metals (Gold, Silver and Copper); since it presents a greater slope compared to the other factors analyzed, therefore, the sensitivity of the NPV is greater.

The linear graph shows that the second relevant variable, in comparative terms, is the operating cost ($ / Tn); since a variation of (+, -) 10% of this factor alters the NPV in (+, -) 2'017,198.85 US $. While the same variation of the investment cost only changes the NPV in (+, -) US $ 233,170.37. These costs are internal variables of the mining process; So, to some extent they can be controlled.

CONCLUSIONS

- The start of operation of the Rosita vein meant a considerable increase in monthly production; which varied from 2000 to 4000 tons / month.
- The ore resources and ore reserves calculated, allow to ensure the life of the mine for the next 03 years and 06 months. The prospecting and exploration program of the mine, in the future, could confirm a greater volume of reserves, due to the geological potential of the mine.
- Nicholas's method demonstrates that the most appropriate method of exploitation is Cut and Upward Filling; since the geological and geomechanical characteristics of the mining deposit allow it. In addition, there is a greater selectivity of the mineral, an essential aspect for the average grain power of the mine.
- The foundations for this technical-economic plan to be viable, are the control and monitoring of each stage of the mining process, in order to efficiently perform each unit process, according to this plan.
- Among the most significant variables within the mining sector (Price of metals, Cost of production and Cost of investment), the most influential is the price of metal; since it allows to obtain greater profit margins, in favorable contexts. On the other hand, the role of the operation and investment cost, being internal variables, can be controlled in a certain way; being the most important, the cost of operation.

- The smaller variation of the operating cost (+, -) 10% implied a considerable change over the net present value (+, -) 2'017,198.85 US $; compared to a variation in the cost of investment (+, -) 10% that only causes a variation on the NPV of (+, -) 233,170.37 US $. Therefore, control the cost of operation of the utmost importance to make the objective of this study feasible.

RECOMMENDATIONS

- It is recommended to maintain the monthly production raised in this study; to take advantage of the favorable mineralogical characteristics of the mineralized bodies that the mine has; In addition to the rise in the price of metals involved (Gold, Silver and Copper) and the high expectations that prices will rise even more.
- To continue with the development of indoor work, artificial ventilation is not only necessary for blind work; because, this will allow to have an adequate work environment and deepen the exploitation work to continue obtaining positive results in the mining operation.
- The need for filling for the pits, will make the construction and implementation of a hydraulic filling plant indispensable because if it is expected to continue with the production, raised in this study work, it will have to be deepened and this will entail the need for more material of filling for the cuts of exploitation.
- To expedite the extraction of broken ore to the main levels, it is recommended, the purchase and use of pneumatic shovels because there is part of the equipment, mining cars on rails, to have an adequate mineral extraction system and thus reduce the staff extraction and exposure times.
- The daily control of the costs by area, according to the proposed economic flow, will make the project viable, so it is advisable to implement a cost area, which will control them according to the mining plan.

- According to the economic flow and the sensitivity chart of the NPV, it is advisable to increase the investment in explorations, to increase the volume of ore reserves, while the prices of metals are favorable.

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APPENDIX A

Engineering Standards and Regulations Applied in the Project

Engineering Standards

The following engineering standards have been applied in the project:

ISO 17757:2019
Earth-moving machinery and mining — Autonomous and semi-autonomous machine system safety.
The standard provides safety requirements for autonomous machines and semi-autonomous machines (ASAM) used in earth-moving and mining operations, and their autonomous or semi-autonomous machine systems (ASAMS). It specifies safety criteria both for the machines and their associated systems and infrastructure, including hardware and software, and provides guidance on safe use in their defined functional environments during the machine and system life cycle. It also defines terms and definitions related to ASAMS. Its principles and many of its provisions can be applied to other types of ASAM used on the worksites.

ISO 15176:2019
Guidance on characterization of excavated soil and other materials intended for re-use.
This standard provides guidance on the range of tests that could be necessary to characterize soil and other soil materials intended to be re-used, with or without preliminary treatment (e.g. screening to remove over large material). It is intended to be of use in determining the suitability of soil materials for re-use, and the assessment of the environmental impacts that might arise from re-use. It takes into account the different requirements of topsoil, sub-soil and other soil materials such as sediments or treated soils. International Standard methods are listed that might be of use for characterization.
Soil materials include natural soils and other materials (e.g. fill, made ground) excavated, stripped, or otherwise removed from their original in-ground or above-ground location (e.g. stockpile), dredged materials, manufactured soils, and soil treated to remove or destroy contaminants. For manufactured soils, which are often made using excavated materials together with other materials such as "green waste", the characteristics of the components and of the manufactured product might need to be determined.
It is not applicable to the placement of soil materials in an aqueous environment or to restore underground workings. It does not address geotechnical requirements when soil materials are to be used as construction material.

ISO 18758-2:2018

Mining and earth-moving machinery — Rock drill rigs and rock reinforcement rigs — Part 2: Safety requirements

This standard specifies the safety requirements for rock drill rigs and rock reinforcement rigs designed for the following underground or surface operations:

a) blast hole drilling; b) rock reinforcement; c) drilling for secondary breaking; d) dimensional stone drilling; e) mineral prospecting, e.g. utilizing core drilling or reverse circulation; f) water and methane drainage drilling; g) raise boring.

The standard is not applicable to the following machines: drill rigs for soil and rock mixture; (geothermal drill rigs, water well drill rigs, water jet drill rigs, micro pile drill rigs; surface horizontal directional drill rigs (HDD), kelly drill rigs (and casing drivers); cable tool drill rigs; pre-armouring machines; sonic drill rigs; shaft sinking drill rigs; crane attached drill rigs; drill rigs on derricks; scaling machines.

Mine Safety and Health Administration 30 CFR Part 75 RIN 1219–AA11

Safety Standards for Underground Coal Mine Ventilation.

Section 75.310 Installation of Main Mine Fans

Main mine fans serve a vital role in providing ventilation to prevent methane accumulations and possible explosions as well as providing miners with a healthful working environment. Section 75.310 is primarily directed at protecting the main mine fans from fires and damage in the event of an underground explosion so that necessary ventilation can be maintained. Monitoring of the fans to assure that they are operating properly is an element of this protection.

ISO 19225:2017

Underground mining machines — Mobile extracting machines at the face — Safety requirements for shearer loaders and plough systems

ISO 19225:2017 specifies safety requirements to minimize the hazards listed in Clause 4 that can occur during the assembly, use, maintenance, repair, decommissioning, disassembly and disposal of shearer loaders and plough systems when used as intended and under conditions of misuse which are reasonably foreseeable by the manufacturer, in underground mining.

ISO 19225:2017 does not cover any hazards resulting from explosive atmospheres. Requirements for explosive atmospheres can be found in ISO/IEC 80079-38.

ISO 19225:2017 is not applicable to machines that are manufactured before the date of its publication.

National Regulations on Mining and Environment

The following government regulations have been applied in the project:

Supreme Decree No. 040-2014-EM.
Peruvian Government Ministry of Energy and Mining.
Environmental Protection and Management Regulations for Exploitation Activities, Benefit, General Labor, Transportation and Mining Storage.

Maximum Permissible Levels of Elements and Compounds Present in Gaseous Emissions from Mining-Metallurgical Units.
Ministerial Resolution No. 315-96-EM / VMM
Sulfur anhydride emissions, particles emissions, lead emissions, arsenic emissions, gases and particles concentration, control points. Measurements carried out in accordance with the provisions of the Protocol Monitoring of Air Quality and Emissions for the Mining Subsector, Ministry of Energy and Mining.

Maximum Permissible Levels for Liquid Effluents for Mining and Metallurgical Activities.
Peruvian Government, Ministry of Energy and Mining, Ministerial Resolution No. 011-96-EM.
Effluents coming from: a) Any work, excavation or work carried out on the ground, or of any wastewater treatment plant associated with labor, excavations or work carried out within the boundaries of the Mining Unit. b) Tailings deposits or other treatment facilities that produce water residuals. c) Concentrators, roasting plants, smelters and refineries, provided that the facilities are used for washing, crushing, grinding, flotation, reduction, leaching, roasting, sintering, smelting, refining, or treatment of any mineral, concentrate, metal, or by-product.

APPENDIX B

Multiple Constraints, Restrictions and Limitations

The following constraints, restrictions and limitation have been considered in the project

Uncertainties and Risks

Mining exploration and production is a high-risk venture. Geological concepts with respect to structure and mineral charge are uncertain. On the other hand, economic evaluations have uncertainties related to cost estimation, changing conditions in economically viable sites, changes in mining technology, fluctuations in mineral price and market conditions, political situation, community relations, etc. All these issues must be carefully analyzed in order to ensure the profitability of the project for the most conservative economic conditions and diversity of scenarios. In this project, all these issues have been considered from a conservative scenario and criteria.

Availability of Geological, Geophysical and Geochemical Data

An inherent feature of mining projects is the availability of relevant geological, geophysical and geochemical data. Several information and data sources have been considered to gather proper and significant data to complete the project. The following sources have been considered: National Society of Mining, Petroleum and Energy SNMPE, Geological, Mining and Metallurgical Peruvian Institute IGMMP, Peruvian Geological Institute, Government Ministry of Mining and Energy. All required information and data was finally found and made available.

Safety Considerations

Mining exploration and production present diverse safety issues that must be taken into account in the development of the project. It is important to comply with safety standards pointing to satisfy proper safety levels considering their impact in the project budget. Care of human life, well-being and safety is an important issue to take into account throughout the different stages of the project and its life-cycle.

Environment and Sustainability

The mining and metallurgical industry face diverse and broad environmental issues at both local and global levels which could affect the project sustainability. The project considers environmental issues such as potential effluents spills, soil, air and water pollution, habitat protection and biodiversity. The project also considers community relations with local people as an important stakeholder of the project.

Schedule

The project must be completed in one academic semester. It is estimated the project requires an average of 150 hours of teamwork with 4-5 students per team. Considering that, besides the senior design project course, students are enrolled in 3-4 additional courses in the academic semester, students have to plan ahead in order for identify all required activities, distribute the tasks among all team members and, finally, integrate all partial tasks to configure the final project.

Other Constraints

The following constraints have also been considered in the project:

- Geographical and accessibility restrictions that make difficult the transport of materials and equipment.
- Technology availability and applicability in the well(s) area.