PRELIMINARY REPORT

FOR THE MODERNIZATION OF [illegible]

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(No. 2)

MARCH 1987

JAPAN INTERNATIONAL COOPERATION AGENCY

FEASIBILITY REPORT

FOR THE MODERNIZATION OF MINING FACILITIES IN THE REPUBLIC OF BOLIVIA

(Vol. I)

MARCH 1982

JAPAN INTERNATIONAL COOPERATION AGENCY

PREFACE

In response to the request of the Government of the Republic of Bolivia, the Government of Japan decided to conduct a survey on the Modernization of Mining Facilities and entrusted the survey to the Japan International Cooperation Agency (JICA). The JICA sent to Bolivia a survey team headed by Mr. Minoru Sumita from July 13 to September 25, 1981.

The team exchanged views with the officials concerned of the Government of Bolivia and conducted a field survey in Catavi mine. After the team returned to Japan, further studies were made and the present report has been prepared.

I hope that this report will serve for the development of the Project and contribute to the promotion of friendly relations between our two countries.

I wish to express my deep appreciation to the officials concerned of the Government of the Republic of Bolivia for their close cooperation extended to the team.

Tokyo, March, 1982

Keisuke Arita
President
Japan International Cooperation Agency

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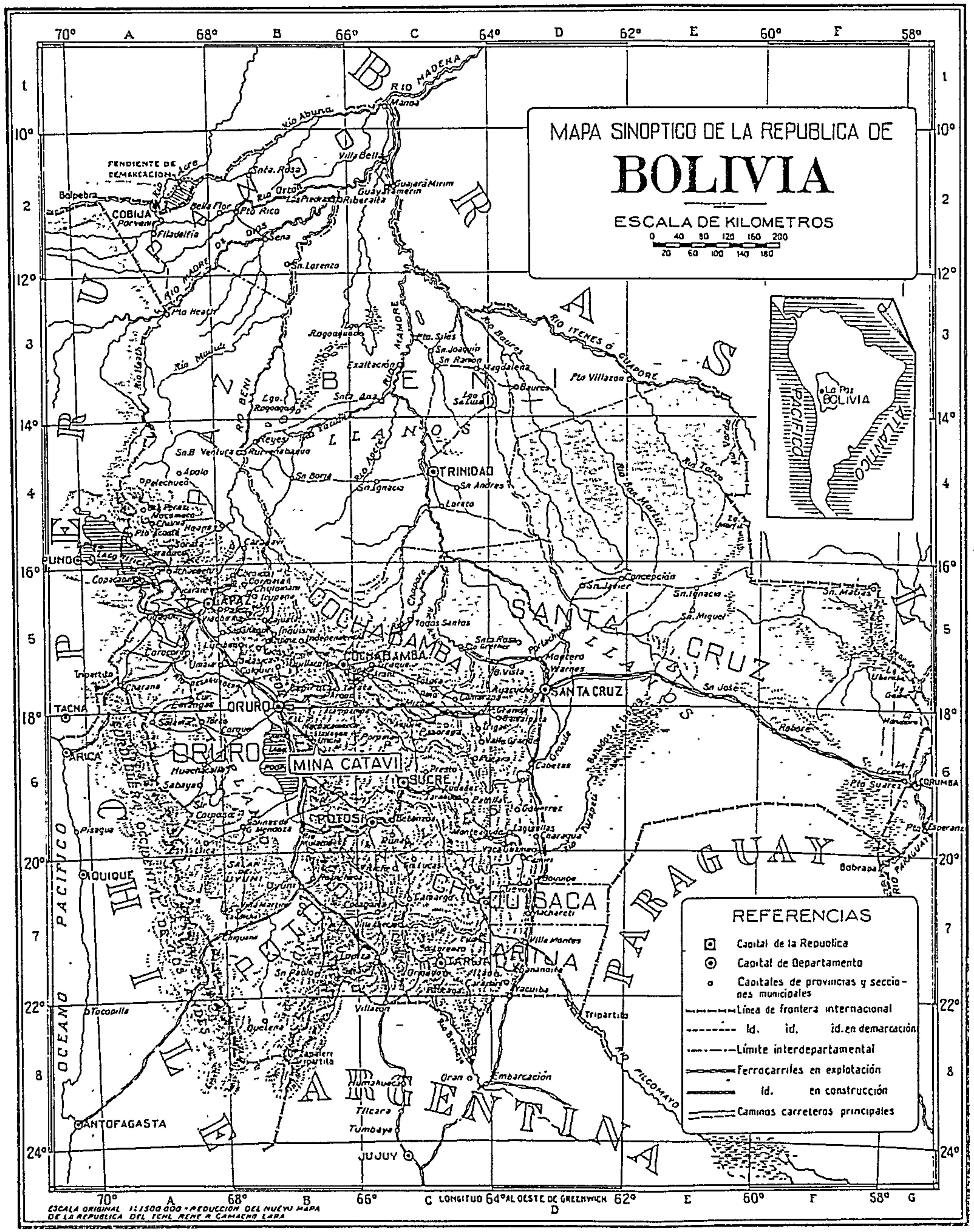


Fig. 1 Location Map

SUMMARY

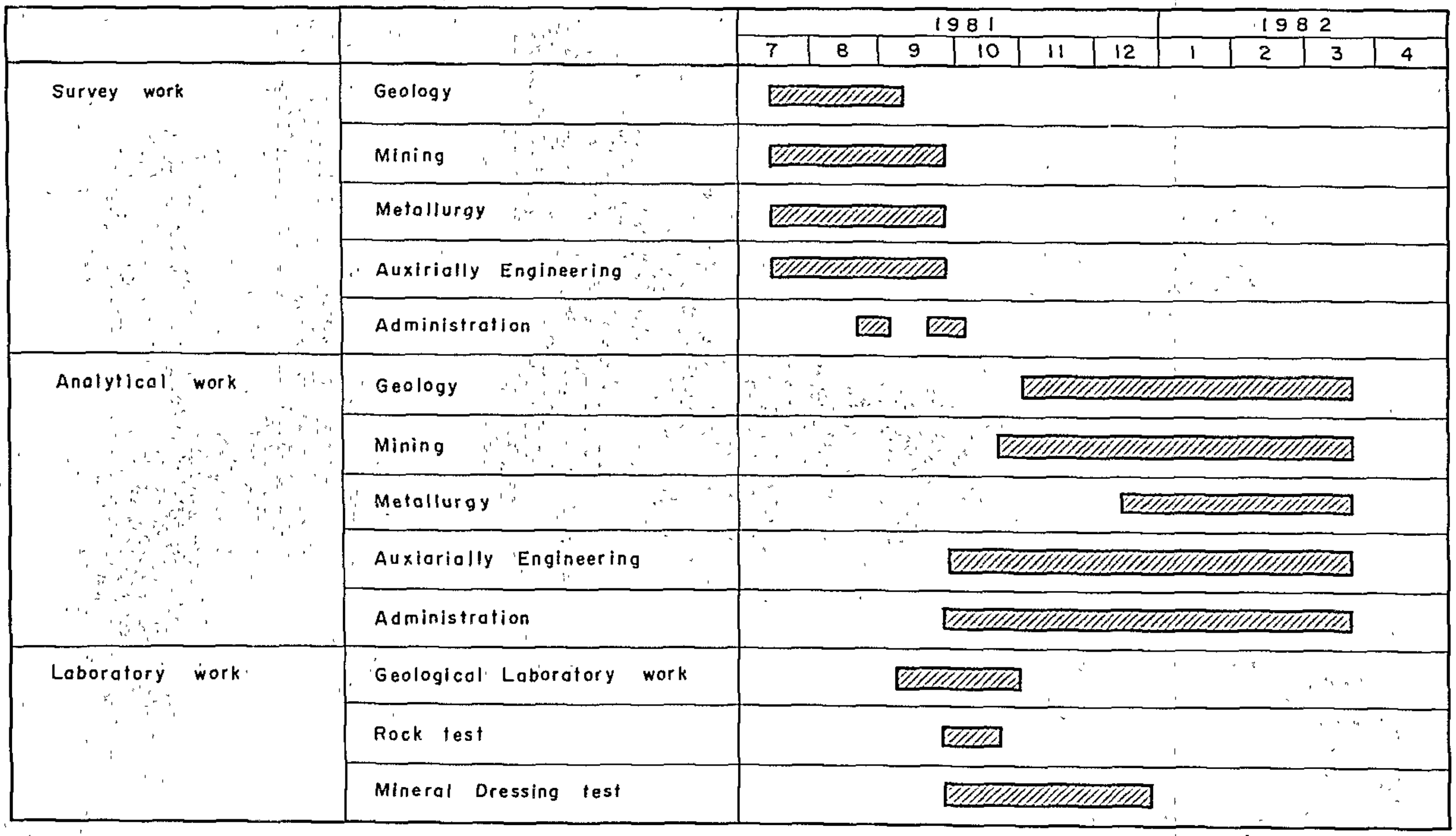


Fig. 2 Schedule of Work.

SUMMARY

1. Objective

The preliminary survey on Catavi mine in the Republic of Bolivia was carried out under the heading "The Survey for the Modernization of Mining Facilities in the Republic of Bolivia" and covered the following.

Survey Period

Exploration Division : July 13 – September 10, 1981 (60 days)

Mining, metallurgy and engineering Division : July 13 – September 25, 1981 (75 days)

Administration Division : August – November, 1981 (30 days)

Analysis in Japan and Report Preparation : September, 1981 – March, 1982

The objective of this survey is to know the present situation of Catavi mine and to collect samples and data in Bolivia, to examine the data, to test the samples and to isolate problems to be dealed deal with in Japan, and based on these results, to form the guidelines to establish the modernization program for the second year.

2. Actual States

1) Exploration

Catavi mine is situated on the west foot of the East Andes, about 300 km southeast of La Paz, the capital of the Republic of Bolivia. It spreads over Mt. Juan del Valle (4,600 m above sea level) and its base, and the office is located 3,700 m above the sea level.

The ore deposit is a xenothermal-type tin deposit embedded in quartz porphyry (La Salvadora) intruding mainly into the anticline. of silurian formation

There are 39 main veins, between which there are about 2,000 branch veins. The main veins have been almost completely mined, and the areas where branch veins are concentrated are presently being mined by the block caving method.

The vein consists mainly of cassiterite generally accompanied with pyrite. During this survey the presence of almost the same quantities of titanium minerals (chiefly rutile) was found. The presence of valuable metal minerals such as wolframite, bismuthinite and galena were observed as well as rare earth minerals were found by EPMA. The gangue mineral consists mainly of quartz and tourmaline.

Besides the veins and deposits, there are two placer deposits of tin, Centenario and Carmen Deposits, on the foot of Mt. Juan del Valle.

2) Reserves

The ore reserves as of June, 1981 are summarized as follows:

	Estimated reserves	Sn %	Tin quantity (t)
Underground (workable)	3,656,200	0.46	16,702
Desmonte	21,961,800	0.27	59,845
Relaves	32,262,200	0.37	118,686
Veneros (placer deposit)	297,249,000	0.01	30,558

Catavi mine is planning large-scale block caving at the areas where branch veins are concentrated for development in future, and the reserves in Block Central was estimated in September, 1981. The result showed the total amount of reserves to be 38,305,920 tons and average tin content of 0.20%.

3) Production

The production in 1980 was as follows:

Crude ore mined – 1,296,776 tons (about 5,000 tons/day)

Tin grade of crude ore – 0.32%

Concentrate – 6,187 tons

Tin grade of concentrate – 37.02 %

Tin quantity in concentrate – 2,288 tons
Tin quantity in ores purchased – 1,661 tons } Total 3,949 tons

4) Mining

The two mining methods are shrinkage for veins and block caving for old gobs and areas in which branch veins are concentrated. The ratio of production by these two methods is 2:8, and the number of shrinkage working faces has decreased rapidly.

The reserve in these areas can be mined only for three years, and for the future, large-scale block caving is being scheduled.

5) Metallurgy

The mined ores are treated by heavy media separation at the Siglo XX Sink and Float Plant, and the sink is sent to the Victoria Mill Plant, where they are treated by table concentrating (partly jig concentrating) and final desulfurizing flotation to obtain tin concentrate.

Slime from the mill plants is dumped in the Lake Kenko, and treated by flotation at the Kenko Flotation Plant, but due to the trouble with dredgers, this plant has not been operated.

The feed for sink and float plant at Siglo XX is about 5,000 tons per day with 0.3% of tin grade. The content of tin in preliminary concentrates is 0.45% and the actual recovery of tin is about 75% .

In the Victoria mill plant, about 2,500 tons of ores are treated daily, and concentrate to about 40% of tin grade at an actual recovery of 60%.

6) Surface Facilities

This mine features a casting factory for mines under COMIBOL, (Corporacion Minera de Bolivia) and two hydraulic power plants in Lupilupi and Chaquiri, as well as various mechanical and electrical work shops.

3. Serious Problems and New Facts

1) High grade ores of content better than the break-even point level have nearly been exhausted and the reserve subjected to mine will hold out for less than 3 years.

2) Block caving is not suitable for existing facilities and for ore deposit conditions.

3) The operating conditions of concentrating plant for high-grade, high-profit ores are being applied to low-grade, low-profit ores as they are.

4) Almost all facilities have considerably become superannuated, and the lack of preventive maintenance is noticeable.

5) In the last three years, the mine suffered a loss of more than 10 million dollars annually. The main reasons for this are increasing costs and high mining taxes (Regalia).

6) Catavi mine has a number of problems as mentioned above. However, it is an important revenue source of the country, and provides support to more than 70,000 people including employees, their families and people living in the vicinity, and if operating conditions of the mine change, they will seriously influence not only the community but also to the nation.

7) Summary of Test Results

It was found that the ores to be mined in future (underground ores, waste and tailings) are hard, the tin ores are fine, and they contain a complex combination of valuable constituents such as titaniferous minerals (chiefly rutile), bismuth containing minerals and rare earth minerals.

The results of metallurgical tests showed that the separability of Desmonte (separated by the heavy media separation at the surface of Siglo XX) was the best, and Colas Arenas (slime from the Victoria mill plant) and Block Central followed.

4. Conclusion of the Survey for the First Year

Because high-grade ores better than the break-even point grade have nearly been exhausted, it is important for maintaining the mine to investigate the underground reserve of remaining low-grade ores, and to study the profitability of surface Desmonte and Colas Arenas as well as placer deposits.

For this, the modernization of exploitation, concentrating and administration respective fields to the new operating system is necessary. For achieving modernization, however, a number of problems such as the investment effects in new facilities, labor issues, and the relation to community have to be solved.

On the other hand, there are many other problems such as the simplification of operation processes, strengthening of maintenance, adequate placement of personnel, and technical and administrative problems which can be improved while the operation is continued. Under such circumstances, the policy to reduce loss should be enforced as soon as possible as the step of the measures for future modernization.

5. Guideline to the Survey in the Second Year

1) Basic design of modernized operating systems

For instance, the design of the sublevel method for underground high-grade ores, the basic design of a new concentration system and the study of a new administration system.

2) Medium- and long-term exploration plans

In the history of mine operation, the largest turning point is the discovery of a new deposit. The comprehensive prospecting plan including geological survey, geophysical and chemical prospecting and drilling in areas covering Catavi mine and Huanuni mines, will be done.

PART I

INTRODUCTION

CHAPTER 1 CIRCUMSTANCES AND PURPOSED OF THE SURVEY

The Republic of Bolivia is a mining country, which produces mineral products such as tin, silver, antimony and tungsten, and these mineral products account for 70% of the total export value. In this country, all large-scale mines are under the control of COMIBOL. Among them, main mines have a lot of problems, that is, decrease in ore grade, superannuated facilities, and other problems concerning the management of the mine, so that the government of the Republic of Bolivia has been striving for the modernization of the facilities and the improvement of the management, of the mines which belong in COMIBOL.

On the other hand, the Republic of Bolivia has highly evaluated the level of Japanese technology including the metallurgical tests and a pilot plant furnishing for Bolivar mine, and the geological survey of San Vicente and Gran Chocaya regions. So, the Republic of Bolivia, with the letter dated April 17, 1980, requested the Japanese ambassador to the Republic of Bolivia to dispatch a survey team from Japan in order to prepare a modernization plan for the facilities under the control of the COMIBOL.

The Japanese government, after receiving the request, has dispatched through JICA (Japan International Cooperation Agency) a pre-survey team for 30 days, from February 3, 1981 to March 4, 1981, to conduct an on-the-spot survey. After making sure the content of the request by the Republic of Bolivia, the "Scope of Work for the Technical Cooperation between COMIBOL and JICA" was concluded.

The pre-survey was carried out at 4 mines obliated to COMIBOL, Catavi mine, Huanuni mine, Santa Fe mine, and Colquiri mine. However, both parties agreed that the full-scale survey was conducted at Catavi mine.

Decrease in ore grade of feed, superannuated production facilities, and other administrative problems of Catavi mine have caused the mine to have a massive deficit every year, actually making worse the financial condition of COMIBOL. On the other hand, Catavi mine accounts for approx. 5% of the nations foreign currency earning, and is contributing to the community to an extremely large extent.

Taking this background into consideration, in the first year the present operational situation of Catavi mine is investigated, analyzed, and discussed to know problems to be solved, and to decide the course for the next year. In the second year, a modernization plan will be made and its economics will be evaluated.

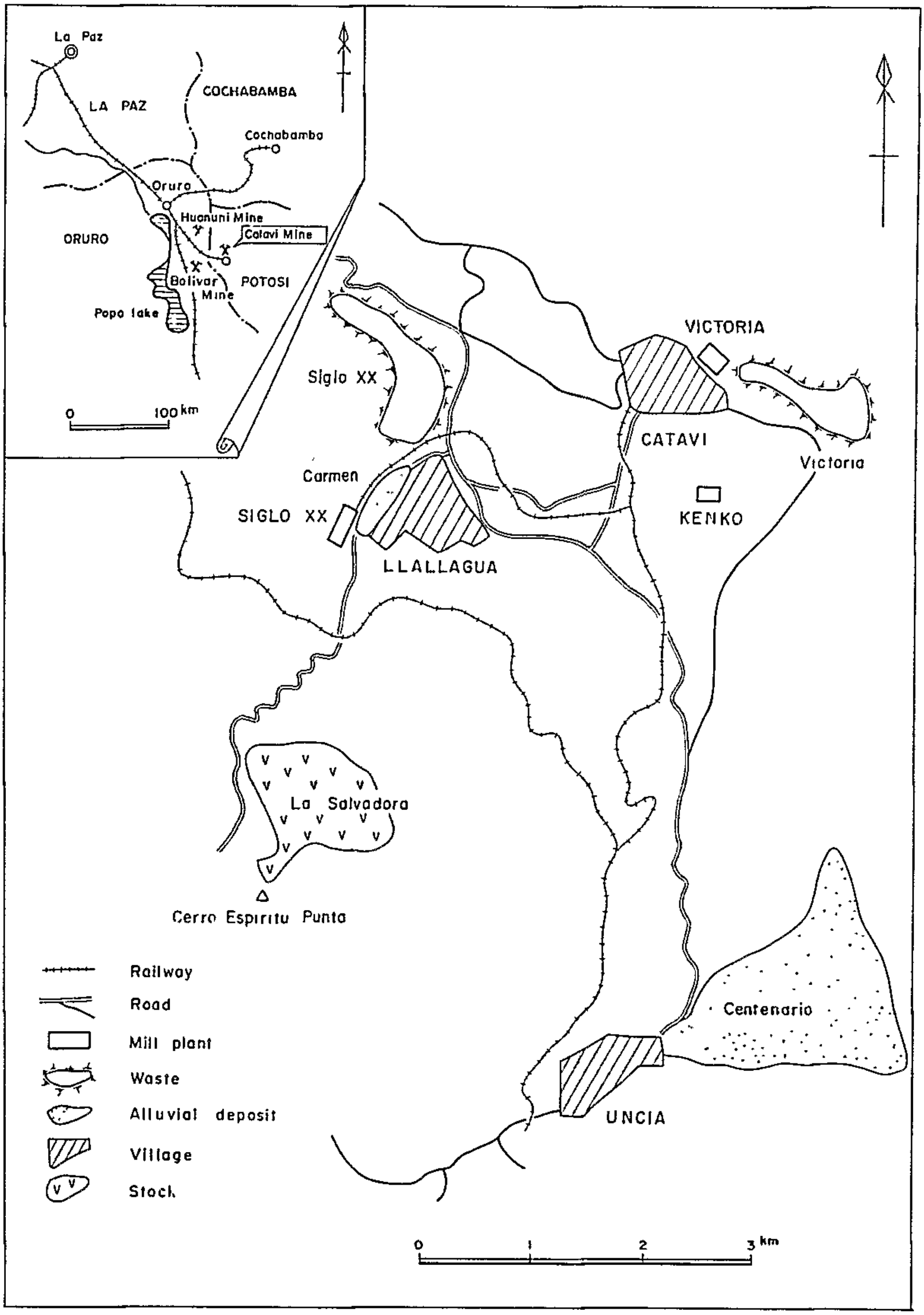


Fig. 3 Location Map of the Catavi Mine

CHAPTER 2 OUTLINE OF THE SURVEY WORK

Since the full-scale survey involves every field in the mining industry, experts of exploration, mining metallurgy, engineering works and economic analysis were appointed as survey team members. They surveyed each field by means of good team work, and after coming back to Japan, analyzed the data in each field.

During the on-the-spot survey, the counterpart experts in each field from COMIBOL have joined the survey to help us.

The survey covered whole range of the operation of Catavi mine, that is, survey on underground and surface geology of the mine, actual conditions of mining work, operational conditions of each concentrating plant, activities of the engineering work division, and also for the administrative field, survey on administration form, production cost, activities of the auxiliary divisions, as well as conditions of the surrounding communities. Also data and samples required for analysis have been collected.

The present surveys have been carried out for 60 days, from July 13, 1981 to September 10, 1981 concerning exploration, 75 days, from July 13, 1981 to September 25, 1981 for the mining, dressing and engineering work fields, and totally 30 days from August to November for economic analysis.

After the survey team came back to Japan , it conducted chemical analysis on ores and rocks, microscopic observation, X-ray analysis, EPMA estimation, and measurement of physical properties concerning the exploration field. In the mining field, rock stiffness tests, and in the metallurgy field, various dressing tests were respectively carried out. Particularly, the metallurgical tests are important for drawing the conclusions of the survey, so that most part of the test procedures was concentrated on this.

The results of the present survey and each test and investigation in Japan were analyzed to prepare the report of the first year.

Work procedures are shown as follows:

The Japanese survey team members and Bolivian members, who joined the survey, were listed below:

Japanese Survey Team Members

Leader :	Minoru Sumita	(General Geology)	* Dowa Koei Co., Ltd.
Member :	Hideo Janome	(Geology)	* ditto
	Hiroji Kuronuma	(Geology)	ditto

	Mizushiro Inoue	(Mining)	*	Dowa Koei Co., Ltd.
	Masanobu Ochiishi	(Mining)	*	ditto
	Mamoru Takeda	(Mining)		ditto
	Akira Kuroda	(Metallurgy)	*	ditto
	Kazuo Shojaku	(Metallurgy)	*	ditto
	Minoru Yoshida	(Metallurgy)		ditto
	Shiro Obinata	(Metallurgy)		ditto
	Akira Funaki	(Engineering)	*	ditto
	Hiroaki Iida	(Engineering)		ditto
	Minoru Shinozaki	(Economic Analysis)	*	ditto

* Members of the present survey team

Bolivian Members

Leader :	César Mercado	(Mining)	COMIBOL
	Aurelio Bustos	(Geology)	ditto
	Juán Maita	(Metallurgy)	ditto
	Jorge Collazos	(Mechanics)	ditto
	Edmundo Contreras	(Civil Engineering)	ditto
	Julio Veyzaga	(Electrics)	ditto
	Javier Salazar	(Economics)	ditto

CHAPTER 3 GENERAL INFORMATION OF THE SURVEYED AREA

3–1. Location and Access

Catavi mine where the survey was carried out is situated in Canton Bustillo, Department of Potosí, the Republic of Bolivia, locating at a position from 100 Km, southwest of Oruro City, the center of mining area of eastern Andes Zone at 18°27′ south latitude and 60°37′ west longitude.

As to the traffic from the capital, La Paz, there are important turncal highway by automobile and truncal railway for transportation available, both reaching Oruro City, and furthermore automobile traffic can reach Catavi mine through Huanuni mine. The time required for the automobile from La Paz is as follows:

	230 Km		90 Km	
La paz	3 hours (Jeep)	Oruro	1–1/2 hours (Jeep)	Catavi

There is a paved way between La Paz and Oruro and from Oruro to Catavi a gravelled road with two lane that is relatively good for Bolivia is available.

As to the railway, a private company's line of COMIBOL started from Machacamarca, approximately 3 Km south from Oruro, reaching Uncia, to the south of Catavi is available, but the service of this line is almost for cargo transportation.

Catavi mine belongs to Department of Potosí located near the border with Department of Oruro, maintaining economically a close contact with Oruro city, while it has only administrative relation with Potosí city as Capital of Departament of Potosí.

3–2. Geography, Climate

The area of survey belongs geographically eastern Andean system in which various mining facilities are found, installed in the parts that form aspects of basin. The highest mountain is Cerro Juan de Valle, 4,700 meters above sea level, and around this area the fan-shaped geographical features become extended, developing the town Uncia at the southern foot of the mountain and the town Llallagua and villages of Catavi mining facilities. The parts of these developed villages are found on the gradual slope, at the lowest part of the basin, small lakes or swamps such as the Lake Kenko are distributed.

Extension of this basin coincides with the stretching out direction of the mountenous zone, forming gently up and down highland geographical aspects. The configuration of the area of survey coincides with the geological structure which characteristic feature indicates the extending direction of both mountenous zone and low level land running from the northwest to southeast. As to the drainage system in this area, in the western part of this area it runs into inland lakes of the Altiplateau and in the eastern part water system forms the watersheds that form sources of river running to the eastward to the Atlantic Ocean.

The area of the survey belongs climatically to the tropical climate by the latitude, but due to its high altitude the climate is rather cold, divided clearly into two seasons, dry and rainy. The rainy season normally continues from December to March and the dry season is from April to November. However, the precipitation registers extremely little, showing an average yearly precipitation of 500 m m. to 700 m.m. Therefore, the water resource of this area is very valuable, contributing not only to mining development but also to local development of the area.

The temperature is estimated approximately 10°C – 12°C as average during the year, falling in night time temperature below the freezing point. There is a great variation of temperature throughout a day, and normally its maximum difference reaches 15°C. Due to such cold temperature, little precipitation, low humidity, the difference in temperature between day time and night time, all these characteristic climatic aspects bring a scant growth of vegetation, producing mostly dry and barren land that limits variety of agricultural growing products with low productivity, thus the climate is the greatest limiting factor to the development of this area.

3–3. Outline of Catavi Mine

Catavi mine is a mine that contains the greatest primary tin ore deposit in the world. This mine was exploited in 1903 by Simon I, Patiño. Since that time rich ore deposit was found one by one and the family Patiño grew into the big financial combines Patiño founded in 1924 Compañia Patiño Mines Enterprises Cons. (Patiño and Enterprises Consolidated) and this company operated not only Catavi mine but also other influential tin ore mines; among them Catavi was chief mine. With the social revolution in 1952, the biggest revolution since the independence of Bolivia, all the mines under the influence of Patiño were nationalized and the administration of the mines was entrusted to COMIBOL.

The ore deposit consists in Xenothermal type vein ore deposit embraced in the quartz latite porphyry that intruded into the anticline of paleozoic strata, and its principal component mineral is mainly consists of cassiterite, generally accompanying with pyrite and marcasite, arsenopyrite, chalcopyrite, etc. As gangue, there are quartz and a little portion of tourmaline. This primary ore deposit is called "Llallagua Ore Deposit", however, deriving from this ore placer tin ore deposits such as Centenario, Carmen, and etc. are formed. At the beginning of exploitation the high grade ore part in vein-like deposit was extracted, producing high grade ore of Sn 12% – 15%. The grade became gradually lower, and reticulated formation of the deposit developed. Then, since 1950 besides shrinkage mining method has been adopted, and now this block caving has become a main mining method. In ore enrichment concentration, sink and float method, gravity method and flotation are used in combination. The result of operation is indicated in the following table.

Table 1. Production During Recent Three Years

Year		1978	1979	1980
Production during recent three years	Crudo Ore	1,432,068 Ton	1,266,625 Ton	1,296,776 Ton
	Assey Sn	0.38%	0.34%	0.32%
	Sn-Conc.	7,386 Ton	6,636 Ton	6,181 Ton
	Assey Sn	40.07%	38.05%	37.02%
	Sn-Metal	2,959 Ton	2,525 Ton	2,288 Ton
Sn Metal in Sold Ore		1,430 Ton	1,408 Ton	1,661 Ton
Total Sn-Metal		4,389 Ton	3,933 Ton	3,949 Ton

Business administration of this mine has become extremely severe dut to a lowering of the grade in ores, and business is getting worse that causes serious problem not only for COMIBOL but also it has become a national problem.

In 1980, the Corporation registered average monthly loss of US$ 1,370,000. Main factors of the deficit consists in fall of metal price, reduction of production, rise of wages and still these tendencies seem to worsen the situation.

3–4. Regional Community

Around Catavi mine, there are villages of Uncia, Llallagua, Catavi, Andavilque etc.. The administrative center of these villages is Uncia where the 1st and 3rd district government prefecture of Bustillo, State of Potosí is located. Llallagua is the biggest village block among them with the population of approximately 34,000 inhabitants that consist of miners and the workers of concentrating plants, sellers of mineral products and the traders, and their families. Thus, Llallagua shows the most brisk activity in this area. Catavi is a village that consists of miners and their families where there is no significant commercial activity. Its population reached approximately 23,000. The population of Uncia is estimated to reach approximately 8,000, the majority of which are people engaged with commence and agriculture and their families.

In this area agriculture and other industries are not well developed.

However, the workers that are engaged with the mining activity in Catavi mine account for nearly 7,000.

There is on the average of one worker in a family of 6 persons that means the livehihood of approximately 42,000 inhabitants are directly dependent on Catavi mine. Moreover, the commercial activities in Llallagua, Uncia and others center around the workers in Catavi mine. Therefore, it is no exaggeration to say that the regional economy depends entirely on Catavi mine. This is also true, for medical and educational facilities.

The contributions of Catavi mine are not limited to providing the source of income, supporting the livelihood of inhabitants. It consists the development of State of Potose, namely through payment of approximately US$ 3,500,000 – as "regalia" to Corporación de Desarrolls de Potasí, and through payment of local tax.

Thus, the mine is making major financial contribution in the area, and the fate of Catavi mine decides the destiny of the region.

PART Ⅱ

ACTUALSTATE AND ANALYSIS OF SITUATION OF CATAVIMINE

CHAPTER 1 EXPLORATION DIVISION

1–1 Organization and Administration

1–1–1 Organization and Equipments and Exploration Works

The present exploring organization belongs to the Mining Department and the contents of its works have the character of an auxiliary division in mining. Its management organization is shown in Fig. 2–1.

The superintendent and the engineers who manage the organization are all geologist and control respective sections.

Drilling sections are divided into surface drilling and underground drilling, the surface drilling are carried out mainly for the purpose of glory-hole ore reserve estimation and the underground ones are carried out for the purpose of drift extension exploration and block caving ore reserve estimation. Drilling machines used are as follows.

1)	Long Year	L–44, L–34	2 (one each)
2)	Suliban	H–15	2
3)	Craelius	Diamac 250	4
		Total	8

The geological survey is conducted by the geologists only, and the workers are engaged in drawing, the calculation of quality and work as the assistants to the engineers.

Sampling work is carried out under the chief who commands six foremen who in turn take charge of 20 workers. Most of the sampling is carried out for the purpose of the ore reserve estimation of block caving, and not only for the veins but also for the country rock between the veins. The method of sampling is to collect samples by digging a band-shaped groove of 10 cm w x 2 cm on the side wall at a height of about 1.20 m. Accordingly, the sampling requires a long time and the amount of sample is 5 – 10 piece/day/man.

In addition, sampling at mine mouth is also carried out to find the grade of extracted ores.

The purpose of exploration includes the confirmation of the extension of known ore deposits and the estimation of block caving and open pit object ore reserves, but most of the exploration time is consumed in the latter.

The exploration plan in 1981 is as follows.

(1) Drilling

1)	Horizontal exploration on levels	1,800 m
2)	Block caving estimation	2,100 m
3)	Open pit estimation	2,100 m
	Total	6,000 m

(2) Tunnel exploration

1)	Drift	1,980 m
2)	Cross-cut	360 m
	Total	2,340 m

Actual exploration costs in 1979 are as follows.

		Unit Price (US$)
1)	Surface drilling	42/m
2)	Underground drilling	69/m
3)	Drift	94/m
4)	Cross-cut	113/m

1–1–2 Actual state of Data Arrangement and Use

Most of the data used now are those from the time of Patiño (decades ago) and the method of arrangement also follows the situation of that time.

Original maps are kept in an original map house (5m x 6m), but they are those of the Patiño times and vast in number. The size of the maps is larger than B-O (103 cm x 146 cm) and inconvenient handling. The maps include tunnel maps, underground geological maps (or route maps) and assay maps.

The geological maps are kept as 1/500 route maps from which 1/2000 geological maps have been made but the route maps have not been completed. The assay maps are arranged into 1/500 tunnel maps, but they represent stoped assay data only, not raw data.

Surface geological maps are preserved on the whole, but they also are left as they were made in Patiño times and later survey has not been carried out. Persons in charge seem to have an idea that the survey of surface geology is unnecessary and there are no recent survey data.

The data and the maps preserved by the exploration division now are as follows.

Kind	Scale	Remarks
Underground Map	1 : 500	Whatman Paper
〃	〃	Tracing Paper
〃	1 : 2000	〃
Underground Geological Map	1 : 500	〃 (Route Map)
〃	1 : 2000	〃
Assay Map	1 : 500	〃

In addition to the above-mentioned original maps, there are various planning maps, related maps, etc.

Assay data are prepared by converting the result of sampling carried out everyday into stope assay data on the same day and offered to the mining division.

Drilling cores are indeed kept in a core warehouse, but the cores obtained by recent drilling are heaped up disorderly, therefore the cores of desired positions cannot be extracted.

Data owned by the exploring division have been kept since Patiño times, but they are not utilized efficiently. Large amount of assay data have indeed been accumulated but they are no more than the calculation of extracted assay, and the proper object of the exploring division to be pursued, i.e., the analysis and investigation of the tendency of grade distribution, the conditions of minerals, correlation between them, etc., cannot be done.

1–2 General Geology

The geology of the mine region consists of Silurian sedimentary rocks on Ordovician sedimentary rocks of and quartz porphyry rocks which are known as the intrusion of the tertiary period.

The ore deposit is mainly in quartz porphyry rocks, which are generally called La Salvadora stock, and form the greater part of the main peak, Juan del Valle above 4,000 m from the sea level.

The Silurian sedimentary rocks are widely spread around La Salvadora stock, being classified into four formations, from the bottom, Cancañiri formation, Llallagua formation, Uncia formation, and Catavi formation.

(1) Cancañiri formation

This entirely consists of graywacke , fresh parts of which are generally extremely hard and have grey colour. In the mine, the formation makes a part of host rock contacting to porphyry. Graywacke accompanies with quartz, chlonite, and sericite (plus plagioclase, ferruginous mineral) are

(2) Llallagua formation

This is made of light grey sandstone and quarzite, which is hard and often in the form of characteristic projecting outcrops. Mainly quartz, and sericite, chlorite and ferruginous mineral are found.

(3) Uncia formation

This formation is composed of greenish grey sandstone and alternation of sandstone and slate. It is extremely thick and distributed around the circumference of the mine, and is an aggregate of quartz, chlorite, and sericite.

(4) Catavi formation

This is made of red sandstone, forming a small outcrop at the foot of Juan del Valle.

(5) La Salvadora intrusive rock

This rock consists of massive quartz porphyry and breccia of same property and its phenocrysts are quartz, biotite and plagioclase.

a) Massive quartz porphyry

At the top of the mountain, there are relatively fresh rocks containing plagioclase phenocrysts with a diameter of 10 mm or more. The host rocks of the deposit is mostly composed of plagioclase, and the biotite has been altered.

Generally the colour of the massive quartz porphyry is light grey to white. The examination under a microscope shows that the phenocrysts are euhedral – corrosion type – anhedral, and consist of quartz with diameters of 0.05 to 4 mm, 0.2 to 1.0 mm of tabular shape biotite and plagioclase of 0.3 to 2.5 mm. Coloured minerals and most of plagioclase have been converted into ferruginous minerals, chlorite and sericite by hydrothermal alteration. The matrix has become an aggregate of fine ferruginous minerals, chlorite and sericite. (see A1 – 3, 4)

b) Brecciated rock

It exists in the massive porphyry quite irregularly. (see Fig. 1 –3, 4)

The brecciated rock is composed of quartz porphyry of various sizes and the breccia

Fig. I-I Geological map of the Catavi mine

Era	Formation	Thickness (m)	Geology	Description
	Form. Catavi	?		Reddish sandstone
SILURIAN	Form. Uncia	2,100		Alternation of sandstone and slate greenish-grey
	Form. Llallagua	70		Sandstone ~ quartzite pale grey, silicous
	Form. Cancañiri	800		Grey wacke, dark grey very hard, with breccia and quartz crystal in part dissaminated pyrite
ORDO VICIAN		?		Sandstone and slate dark grey

Fig. 1-2 Geological columnar section

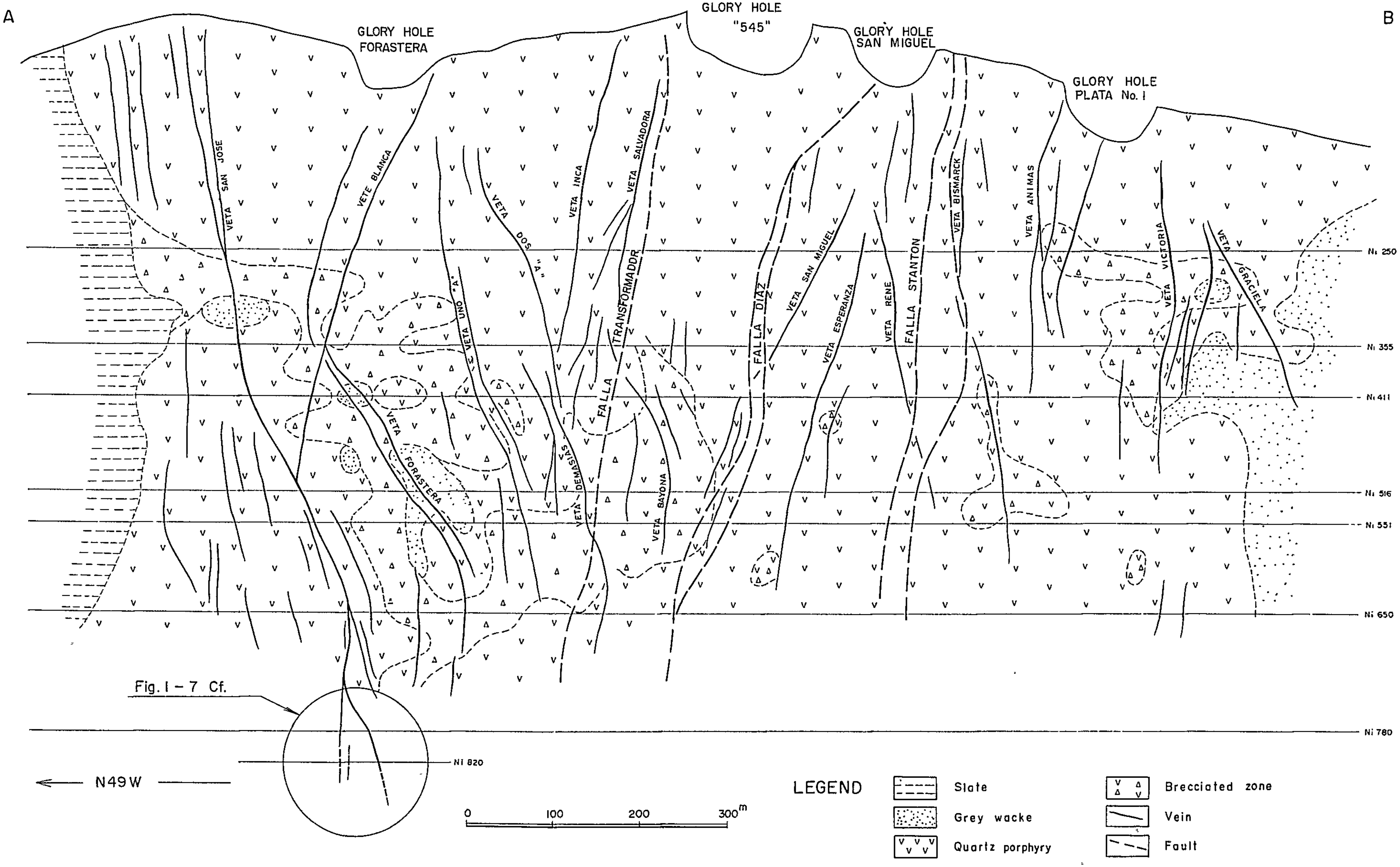


Fig. I - 3 Geological Profile of Llallagua Ore Deposit

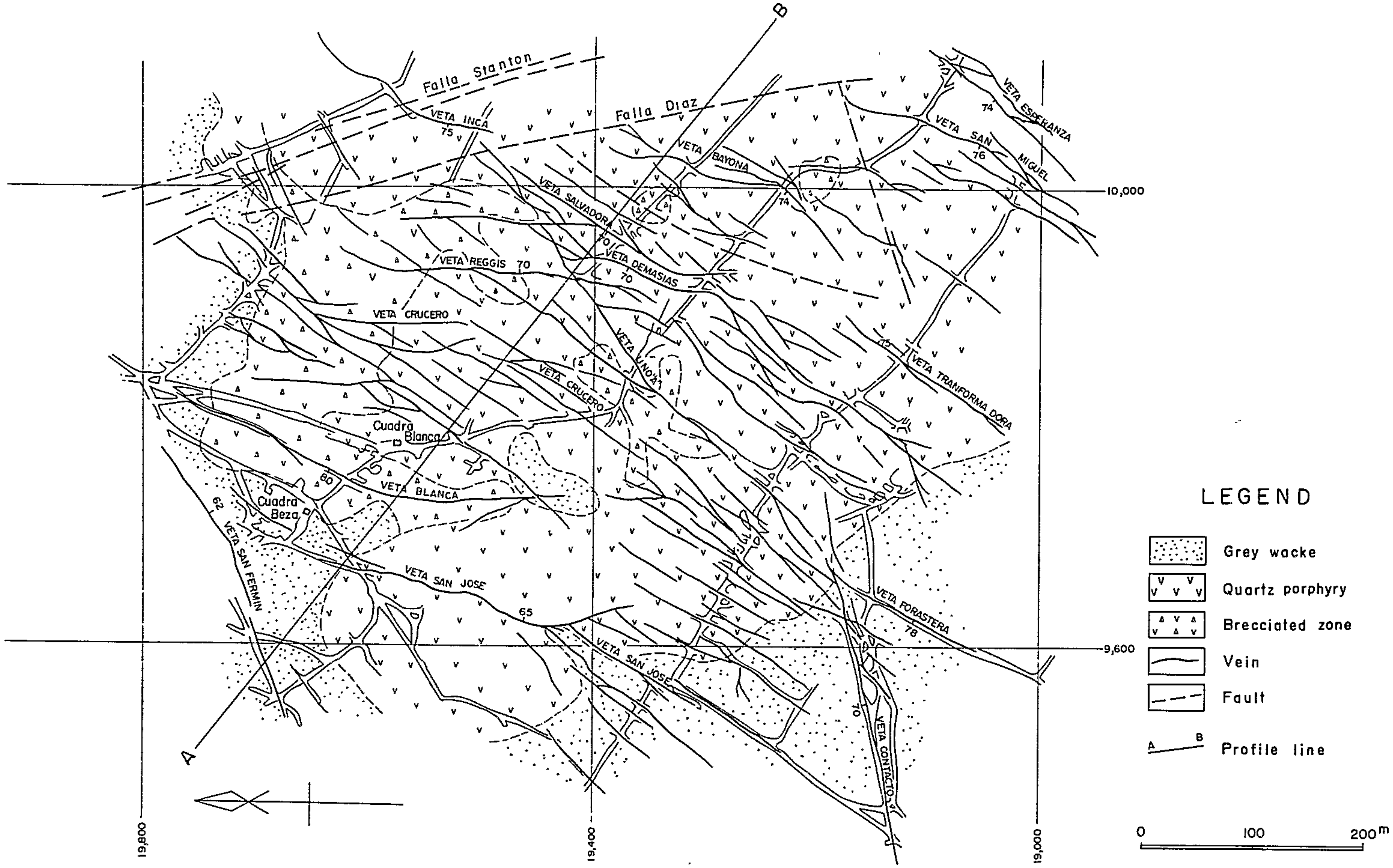
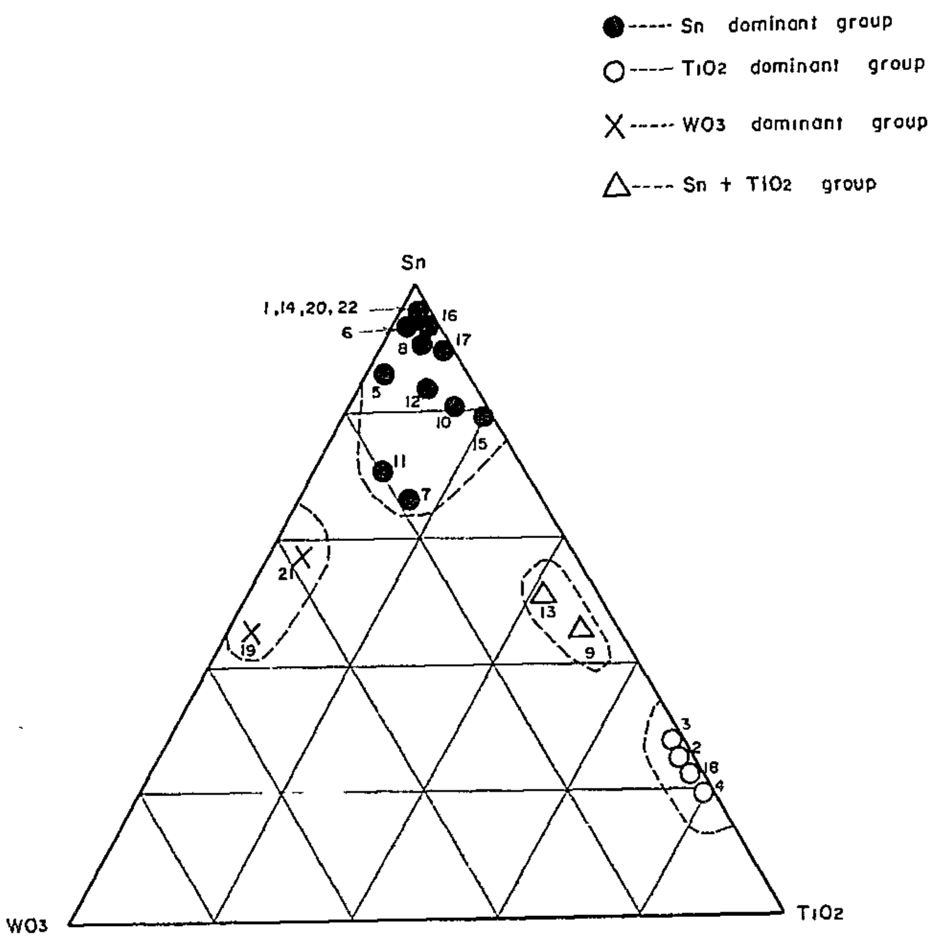
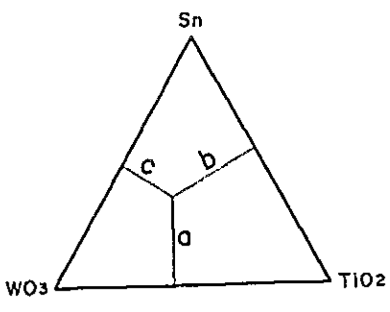


Fig. I-4 Geological map of typical level (411 level)





$$a = \frac{Sn \times 100}{Sn \times 100 + WO_3 \times 100 + TiO_2 \times 100}$$

$$b = \frac{WO_3 \times 100}{Sn \times 100 + WO_3 \times 100 + TiO_2 \times 100}$$

$$c = \frac{TiO_2 \times 100}{Sn \times 100 + WO_3 \times 100 + TiO_2 \times 100}$$

Fig.I-5 Relation between Sn - WO3 - TiO2 illustrated by trigonal diagram

Table 1-1 List of Principal Veins

Vein name	Strike	Dip	Wide (cm)	Length (m)	Mineral
Contacto	N 60° E	60° N	15	400	Py Oz Cs Sp
San José	N 40° E	64° E	10	400	Py Oz Cs Sp
San Fermin	N 48° E	65° N	6	320	Oz Cs Py
Forastera	N 50° E	80° S	5	500	Py Cs Oz
San Pedro	N 40° E	80° E	15	150	Py Oz Cs
Paralela	N 37° E	67° W	10	300	Py Cs Sp
Crucero	N 30° W	70° E	8	200	Oz Py
Blanca	N 40° E	65° W	3	400	Cs Oz Py
Entre Fallas	N 45° E	70° W	4	80	Py Cs
Carnavalito "A"	N 44° E	80° W	10	300	Lim Cs
〃 "B"	N 40° E	65° E	10	180	Lim Cs
Vetilla	N 30° E	70° E	5	100	Py Cs
Nueva C.E.LL	N 50° E	70° N	10	100	Py
Salvadora	N 45° E	70° W	12	450	Py Oz Cs
Bayona	N 43° E	74° W	6	200	Py Cs Oz
Dolores	N 40° E	80° W	15	400	Lim Sp Cs Oz
Inca	N 38° E	75° W	15	400	Py Oz Cs
Transformador	N 50° E	65° S	4	230	Py Oz Cs
Demasias	N 70° E	70° N	10	400	Sp Cs Py
Reggis	N 50° E	70° S	12	320	Py Cs Sp
Uno "A"	N 40° E	70° E	8	260	Lim Py Oz Cs
Esperanza I	N 40° E	74° W	10	260	Oz Py Cs
〃 II	N 40° E	74° W	8	300	Oz Py Cs
Nueva I	N 45° E	77° E	15	250	Py Oz Cs
〃 II	N 38° E	82° E	10	350	Py Oz Cs
San Miguel	N 45° E	76° W	10	200	Oz Py Cs
"545"	N 55° E	60° N	5	300	Py Oz Cs
Reyes	N 58° E	80° W	8	100	Py Oz
Polvorín	N 45° E	70° W	15	470	Py Oz Cs
Graciela	N 38° E	65° E	7	220	Py Oz Cs
Victoria I	N 58° E	68° N	8	380	Py Oz Cs
Animas	N 45° E	65° W	10	300	Py Cs Sp Oz
Bismarck II	N 55° E	58° S	20	300	Lim Cs
Plata	N 55° E	80° N	10	100	Py Cs Oz Sp
Victoria II	N 50° E	78° E	8	150	Py Oz Cs
Rene	N 55° E	76° N	10	400	Py Oz Cs
Cero	N 40° E	65° W	3	100	Py Oz Cs
Dos "A"	N 55° E	70° S	15	150	Py Cs
Serrano	N 38° E	80° E	8	300	Py Sp Cs

Table 1−2 Chemical Analysis of Ore

No	Level	Vien name	Wide	Sn %	W %	TiO_2 %	Note
OC- 1	Ni 446	Block 5D	7	5.43	0.04	0.10	
〃 2	〃	〃		0.18	0.002	0.53	Disseminated rock
〃 3	〃	〃		0.18	0.002	0.50	Network
〃 4	Ni 650	San José	5	0.08	0.002	0.33	
〃 5	〃	〃	10	2.66	0.31	0.05	
〃 6	Ni 551	〃	5	10.35	0.19	0.17	
〃 7	Ni 516	〃	4	1.19	0.26	0.28	
〃 8	Ni 295	Contacto	20	2.20	0.08	0.15	
〃 9	Ni 720	San José	20	0.23	0.02	0.27	
〃 10	Ni 685	〃	15	0.53	0.02	0.10	
〃 11	Ni 650	〃	20	0.54	0.13	0.08	
〃 12	Ni 500	Bismarck	40	0.58	0.04	0.07	
〃 13	Ni 470	〃	10	0.23	0.02	0.18	
〃 14	Ni 383	〃	20	5.69	0.007	0.08	
〃 15	Ni 650	Siglo XX	15	0.45	0.002	0.12	
〃 16	〃	〃	25	0.33	0.002	0.02	
〃 17	Ni 355	Nueva Cell	15	0.90	0.003	0.10	
〃 18	〃	Carnabalito	2	0.16	0.001	0.55	
〃 19	Ni 551	Salvadora	20	0.45	0.42	0.03	
〃 20	〃	〃	3	5.18	0.03	0.22	
〃 21	〃	〃	25	1.03	0.66	0.05	
〃 22	〃	〃	5	8.28	0.06	0.25	

and subbreccia of graywacke , and generally has grey to light grey colour.

(6) Geological structure

The Silurian period formation distributes in the north north west strike, and forms an anticline structure which has an north-south axis passing Juan del Valle peak.

The anticline form over folding towards the east side, and at the region near from the axis, La Salvadora intrusive rock has intruded in the form of a stock.

There are several faults running in the north north west strike, with dips of around 80° dipping west, but there are no big dislocations.

1–3 Ore Deposit

This is a vein type (Xenothermal type) tin deposit, the host rock of which is mainly made of quartz porphyry. Besides the main veins, there are more than 1,000 branch veins, which are quite densely embedded, and the host rock in general, was subjected to severe hydrothermal alteration. Therefore, in the recent study by Silitne, et al., it is called a porphyry tin deposit.

1–3–1 Vein Type Ore Deposit

(1) Vein

The veins have extended quite regularly in the region of north north east to north east, dipping 70° to 90° towards west or east, and seem to converge downwards.

Most of the La Salvadora intrusive rock consists of a mineralized zone, which is 1,200 m x 800 m horizontally and more than 800 m vertically. The veins are partly extended into the grey wacke adjacent to the porphyry.

There are 39 main veins. The vein width is generally 5 to 30 cm, and max. 60 cm, and the length is generally 100 to 400 m, and max. 500 m. A main vein is accompanied with 2,000 branch veins (called Ramos) with a vein width of less than a few centimeters. Furthermore, fine mineralized parts of tin are found between the veins. (Fig. 1–3) (Table 1–1)

(2) Minerals

The ore mineral is cassiterite accompanied with a small amount of stannite. As accessary minerals, in addition to a large amount of pyrite and marcasite, marmatite, arsenopyrite, chalcopyrite, wolframite, galena, siderite, bismuthinite, franokeite and jamesonite are also found. From the examination under a microscope and EPMA on the ores sampled this time, a large amount of titanium mineral identified as rutile was found in close co-existing relation with cassiterite.

The cassiterite is in coarse particles in the main veins, but extremely fine in the branch veins and mineralized parts. It finely co-exists with sphalerite, bithmus mineral, etc., in addition to the aforementioned rutile, pyrite and marcasite. Gangue minerals are mainly quartz and tourmaline.

(3) Observation under a reflecting microscope and EPMA of polished sections (A–1, 2)

Mainly from the veins of San José, Bismark, Salvadora, etc., 20 ore samples were taken at the levels of 295 to 600. Typical pictures are shown. in A–1, 2.

a) Paragenesis of cassiterite and rutile

The paragenesis is found in almost all samples , and no difference in co-existing condition among the veins and levels is observed.

The relationship between cassiterite and rutile varies widely, that is, rutile comes in contact with idiomorphic cassiterite, cassiterite containing titanium (Titan-cassiterite) forms a necleus and stannite surrounds it, cassiterite and rutile form a solid solution, etc. Particularly, as shown in EPMA, the amount of ore in which very fine rutile co-exist, or which is in the state of cassiterite containing titanium or rutile containing tin is quite large and poses difficulties in the metallurgical test described later.

b) Existence of Bi-Pb mineral

The results of EPMA have shown that besides Bi mineral and Pb mineral, there is quite a quite large amount of minerals in which both elements are co-existing.

1–3–2 Placer Deposits

The mineralized zone of the Cerro June, del Valle was eroded and carried to the north to form the Carmen deposit, and carried to the south east to form Centenario deposit which is located east of the Uncia settlement. (Fig. 2)

(1) Centenario deposit

From the eastern end of the Uncia settlement to the east, an alluvial fan is formed; where this deposit is distributed in the range of 3 km from east to west, 1 to 2 km from north to south, and the maximum depth of 90 m. Since 40 years ago mainly high grade part at the upper stream has been mined. Recently, test drillings for checking the ore reserve and grade have been conducted, and the granulmetry on the samples are partly carried out by COMIBOL.

Accordingly to COMIBOL the present ore reserve is approx. 300 million tons with Sn content of 0.01%. However, a outside ore seller, "Veneros" has been mining for 40 years only high grade zone, so that the actual average grade is expected to be even lower.

(2) Carmen deposit

This deposit extends through the valley between the Llallagua settlement and Siglo XX, and is distributed over the range of 300 m from east to west, 800 m from north to south, to the maximum depth of 45 m.

The ore reserve is 16 million tons, only 6% of that of Centenario, but the grade is evaluated to be 3 times higher, Sn content 0.03%. COMIBOL has judged that large-scale mining is impossible from the standpoint of cost, because the mining facilities, company houses, etc. are densely located in the deposit zone. At present, similar to Centenario, mining is partly being done by veneros.

1–3–3 Exploration

(1) Present situation

In fiscal year 1980 the following explorations have actually been carried out.

	Exploration	Evaluation
Drilling (Surface)	576.38 m	231.95 m
Drilling (mine)	873.56	2,787.09
Total	1,449.94	3,019.04
Cross Cuts	398.30	3,153.00
Drifts	2,133.10	0
Total	2,531.40	3,153.00

The surface drilling was carried out mainly for checking the grade by the glory-hole system, and the underground drilling was for exploring the extension of the lower part of the San José vein. The evaluation has been made for the evaluation of ore reserve of the large-scale block under contemplation.

The exploration of cross cuts, 398.30 m has also been carried out for the evaluation of ore reserve of the large-scale block. The exploration of drifts combines with mining at the circumference of the deposit. As mentioned above, the exploration have been limited to the area of the Llallagua deposit, and no explorations have been carried out for exploration of new deposits.

At present, the drilling exploration is being continued in the 650 level, aiming at the extension of the lower part of the San José vein. Formerly, at the same position, the extension of the San José vein was found in the vicinity of 820 level.

(D.D.H No. 811; total width of 3 veins : 1.15 m; average grade : Sn 17.0%) (Fig. 1–3,7)

Furthermore, drillings are being conducted for the evaluation by glory-hole system and block caving.

The exploration plan in fiscal year 1981 is as follows:

Drilling

1)	Horizontal exploration at levels	1,800 m
2)	Evaluation of block cavings	2,100 m
3)	Evaluation of open pits	2,100 m
	Total	6,000 m

Development by entry

1)	Cross cut	360 m
2)	Drift	1,980 m
	Total	2,340 m

(2) Guide Exploration

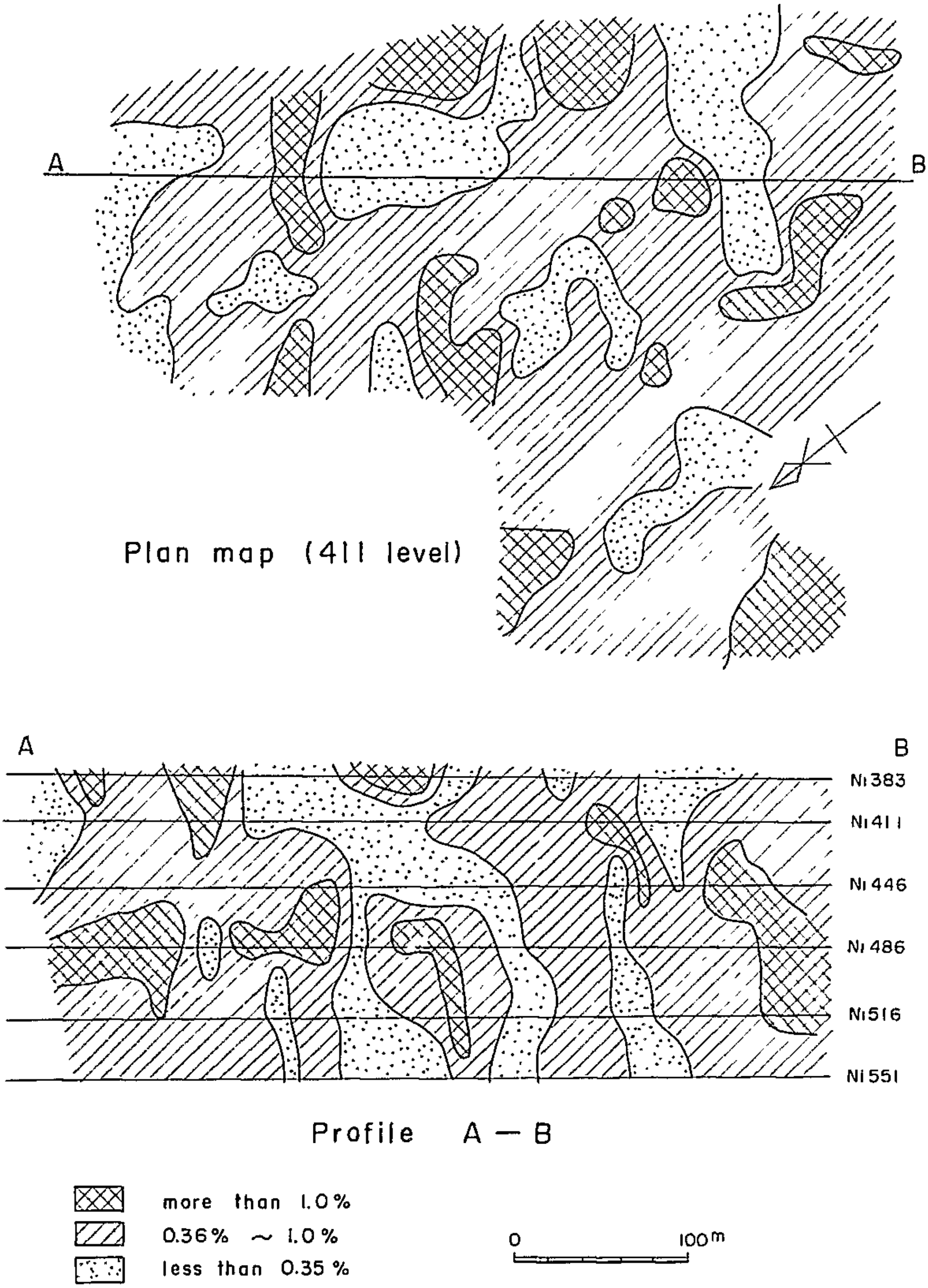
1) Ore shoot

Taking into consideration the entire deposit, it seems to be reasonable for the exploration of big deposits to consider that this deposit is a so-called porphyry type deposit where the veins are densely embedded in the hydrothermal alteration zone of the host rock made of porphyry, rather than to consider it as a simple vein type ore deposit.

At present, the main veins have already been mined almost completely, and it is impossible to investigate the state of ore shoot. However, according to the existing literature, the part particularly rich in high grade mineral was limited to vertically 200 m, and such ore shoot should deepen gradually from the south east side to the north west side. In fact, it has been discovered that the veins of Demasias, Forastera, and San José in northwestern part extend continuously to the level Ni650 or below. Particularly, it has been made sure by drilling that San José vein located at most northwestern part extend continuously to even 820 level.

This tendency indicates that if the La Salvadora intrusive rock exists in more northwestern region, there is a possibility to discover new rich parts in that direction.

In newly designed Block Central, the tendency of grade examined by computer processing indicates that there are zones with less Sn 0.3% vertically at the center. In the blocks without these zones, remarkable increase in grade is expected, and more effective mining



Note: Base on the calculation by computer

Fig. 1-6 Distribution Map of Tin grade of Block Central

would be possible. For this, it is necessary to study and discuss the computer data in stock. (Fig. 1–6)

(2) Alteration and its distribution

The results of the study with X-rays on altered zones show that the sericite alteration, which is most related to principal mineralization, is overwhelmingly strong in the La Salvadora stock (I-Zone). However, alteration which accompanies sericite extends to the surrounding sedimentary rocks, and particularly the alteration at the circumference of Dolores in west suggests the mineralization at the lower part, and exploration is required.

(3) Fluid inclusion test

This test was conducted to understand the tendency of veins from the upper region to the lower region and obtain indications for deep-explorations in future.

Since almost all veins have been mined at present, and continued sampling from the upper to lower part of a vein could not be done, the analytical results of the test allows only an assumption. (Fig. 1–8) (Table 1–3)

1) Homogenization temperature

a) Between the surface and 685, level, veins at lower levels tend to have higher homogenization temperature.

b) The homogenization temperature of the Bismark veins has the characteristic of fluctuating widely between 346 and 528°C. The fluctuation can be classified into three ranges, 352 to 394°C, 457 to 490°C, and 527 to 529°C, and this temperature distribution allows to distinguish between low and high temperature mineralization.

c) At Ni685 of the San José veins, the temperature is higher than that at Ni551. Generally, lower parts have higher temperatures, but sometimes veins with abnormal temperatures are found. In this case, 2 stage mineralization (that is, at temperatures between 300 and 400°C, and over 400°C), or temperature change caused by the circulation of natural water may be assumed.

2) Salinity

a) Salinity was measured on 5 samples.

b) Salvadora veins have the highest salinity, 20% or more.

c) Bismark veins also have high temperature and high salinity 11%.

3) Genetic temperature

a) There are samples which are boiling

For Fig-11, a sample of 391°C is 20.4% (wt) and of 394°C is 20.6%(wt) No pressure-correction is required for these samples, and it can be thought that the genetic temperature is around 400°C.

b) Pressure correction gives a temperature only 20°C higher than the homogenization temperature, so that it can be thought that the genetic temperature is nearly equivalent to the homogenization temperature.

4) Discussion

Generally, lower parts tend to have higher homogenization temperatures with some fluctuation, and it indicates that the veins extend continuously to Ni685 or below. However, according to the salinity, a curve which has its peak around Ni551 can be drawn, and it seems that an ore shoot extends vertically over about 200 m. This phenomenon supports the results of the investigation by F.S. Turneaure (1935). It might be a key to estimate the vertical position of the ore sheet by conducting fluid inclusion study on samples of mineralized zones which are obtained by drilling.

No	Vein name	Level	Number of Inclusion	Temperature of homogenization (400°C – 500°C)
F-2	Rio Tojota	surface	9	322°C 347°C
F-5	Contacto	Ni295	9	391°C 421°C
F-3	Block 5D	Ni446	9	344°C 358°C
F-10	Bismark	Ni470	13	346°C 529°C
F-4	San Jose	Ni551	9	344°C 358°C
F-11	Salvadora	Ni551	9	352°C 394°C
F-8	San Jose	Ni650	12	389°C 416°C
F-7	" "	Ni685	12	315°C 340°C

Fig. 1–8 Renge of Temperature of Homogenization

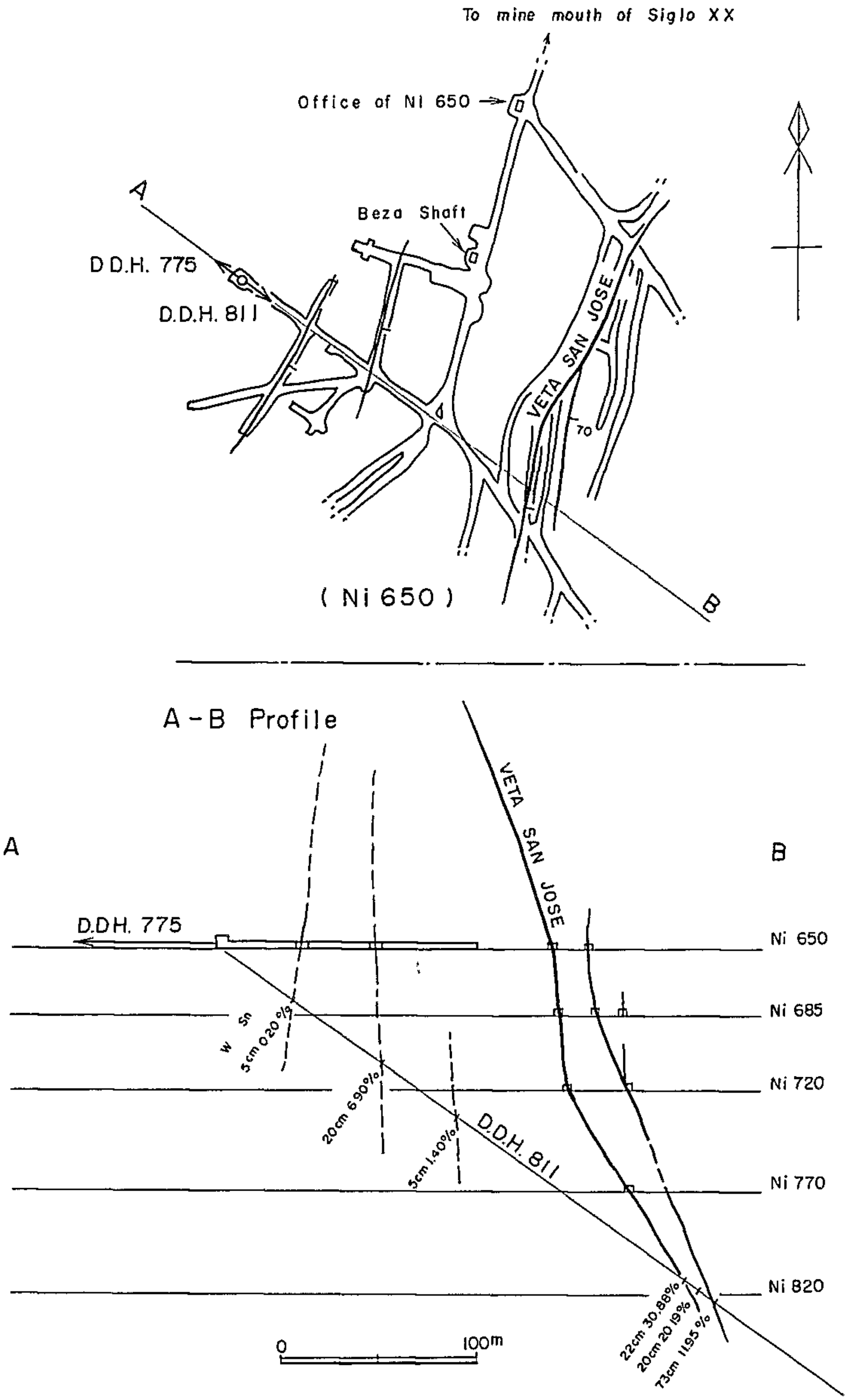


Fig. 1-7 Relation of D.D.H 811 and San José Vein

Table 1–3 Salinity of Inclusion

N	Salinity (wt.% NaCl eq.)	Homogenization temperature (°C)	Origin
F–5	1.5	260	Secondary
	1 7	259	"
F–7	1.9	315	Primary
	1.9	318	"
	1.9	317	"
	2.4	337	"
F–8	2.7	402	Pseudo Secondary
	2.8	402	"
F–10	11.8	346	"
	11.6	364	"
	12 4	368	"
F–11	20 4	391	Primary
	20 6	394	"

1–4. Fissure Pattern

The feature of the veins in Llallagua Ore Deposit is that most of them show a northeast strike, and they are roughly grouped into three systems.

		Strike	Dip
①	SE Dip System	N15°E– N70°E	45° – 70°SE
②	NW Dip System	" – "	45° – 70°NW
③	Vertical System	" – "	90°

The system ① is represented by San José and San Fermin veins, the system ② includes Blanca, Paralela and Salvadora veins and has developed to intersect ①. The system ③ is represented by Serrano vein and generally less continuous compared with ① and ② and has developed in the south of Salvadora stock. F.S. Turneaure regards the system ① and the system ② as the same group because of their similarity and calls the group San José type vein, and calls ③ Serrano type vein, the following description therefore follows this calassification.

(1) San José type vein system

As this vein is represented by San José-San Fermin vein, fissures are those generated by normal faults, and its dips show 45° – 70° SE or NW. Vein widths are generally large and continuity exists both in horizontal and vertical directions. Since fault clay has developed and slickensides are observed, the veins are thought to be those of shear fissure from these phenomena. Their dips include SE system and NW system, and as seen in Fig. 1–3, the veins intersect with each other in the vertical direction. At the same time those veins are seen to cut each other, and it seems that the SE system fissures and the NW system fissures form conjugate faults. When the strikes and dips of the principal veins in Llallagua ore deposit are stereo-projected on a Schmidt net to determine the average azimuth of the conjugate faults from the pole of the maximum density and determine the disposition of principal stress axes, from the viewpoint mentioned above, the maximum principal stress axis is σ_1=N41°E/88°NE, the intermediate principal stress axis is σ_2=S41°W/2°SW and the minimum principal stress axis is σ_3=S41°E/2°SE. Since the San José type veins are shear fissures, the SE system veins and the NW system veins naturally intersect with each other forming an acute angle of 33° in these principal stress axis directions, and this angle nearly coincides with the intersecting angles of the veins actually observed. In such a case, the maximum principal stress is thought to have exerted vertical compression and the tension of intermediate principal stress in NW-SE was caused. From the standpoint of the above-mentioned interpretation, the San José type veins developed in shear fissures must become most stable veins compared with the veins developed in tension fissures, and in fact in Llallagua ore deposit, the veins extend over 400 m and the maximum width of veins reaches 2 m. However, near a –650 level, the width becomes 15 cm – 20 cm, i.e., the vein width decreases in the deeper part.

(2) Serrano type vein system

This vein system shows NE strikes, but its dips differ from those of the San José type ones and are 80° – 90°, i.e., almost vertical. The veins in this system have little continuity, showing branched type or quarterline disposition, their vein widths are generally narrow, and they include little fault clay. From these features, this vein system is presumed to belong to the tension fissure. The veins in this system are distributed mostly in the southern part of Salvadora intrusive rock, showing a distribution in contrast with that of the San José type shear fissure veins in the northern to the central part.

As seen above, the vein system of Llallagua ore deposit consists of veins developed in three system fissures, two system shear fissures of SE system (S_1) and NW system (S_2) and one system tension fissure, and many secondary shear system veinlets have developed accompanied by the veins, forming a very complicated diversified fissure pattern.

Generally, a fissure in the case of a vertical maximum principal stress axis is regarded to be that caused by strucrural stress which does not reach very deep from the surface, and under such a condition, the load of covering rock is comparatively small and the penetration

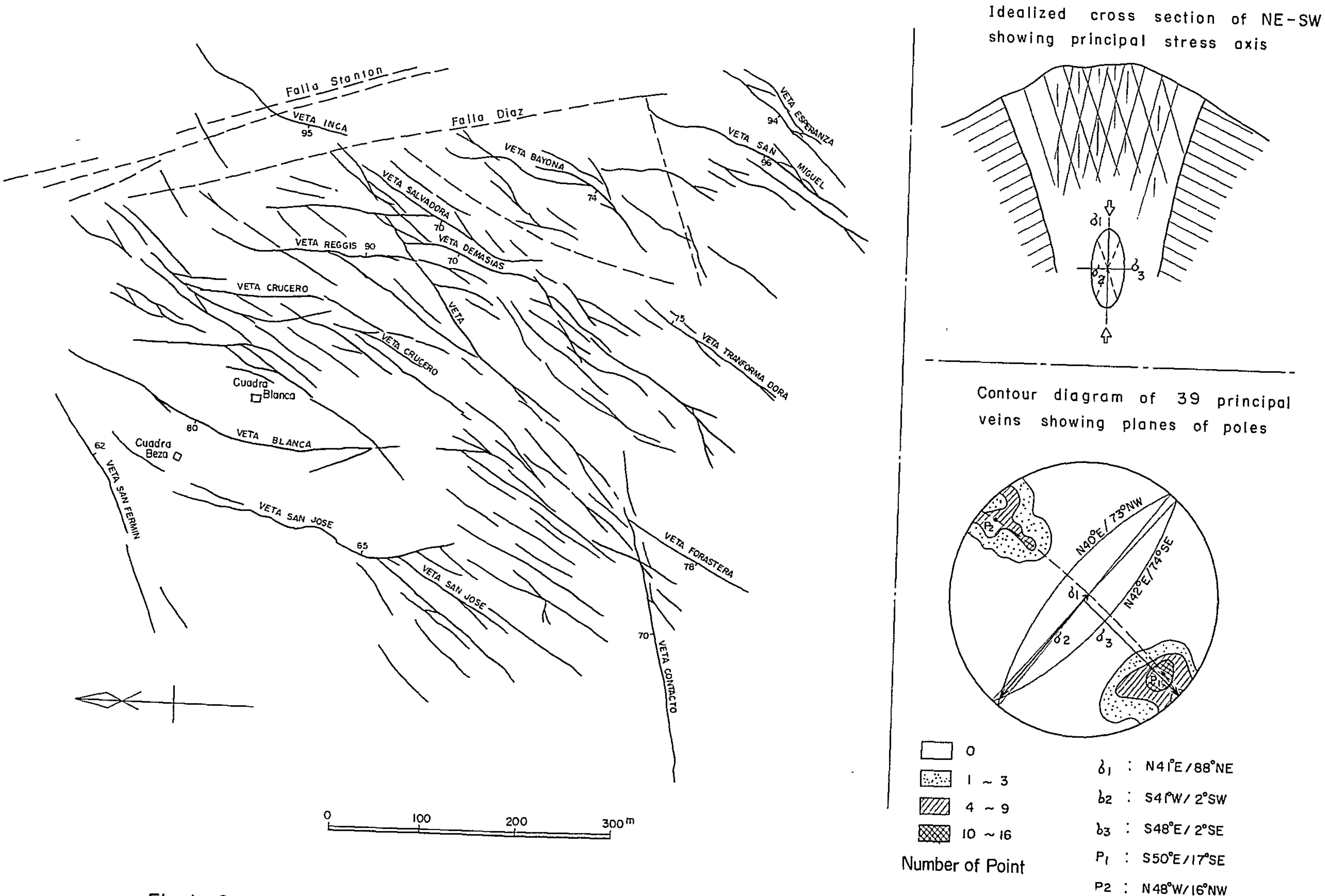
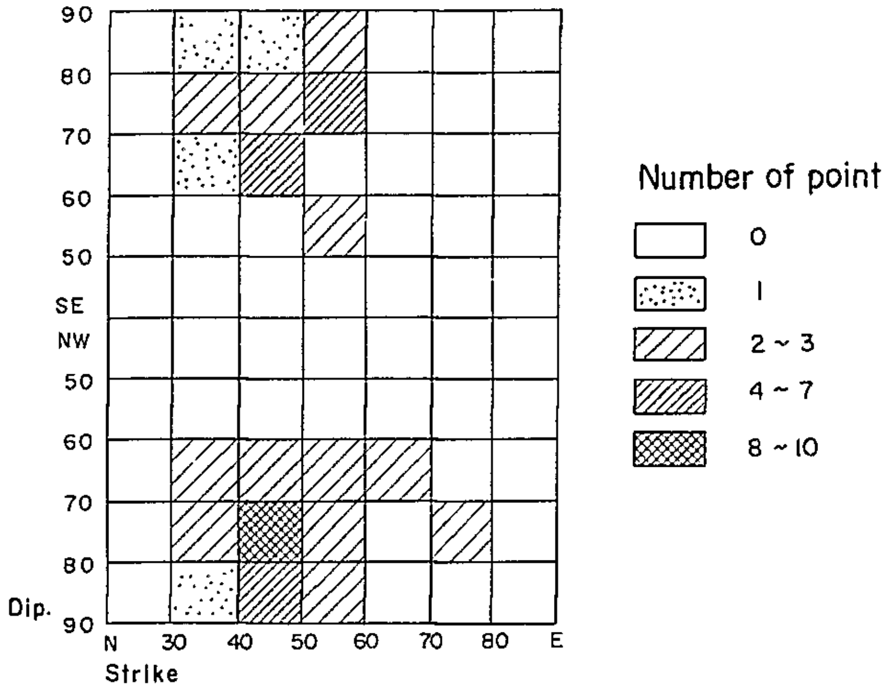


Fig. 1-9 Vein pattern of Llallagua ore deposit



Co – appearance matrix

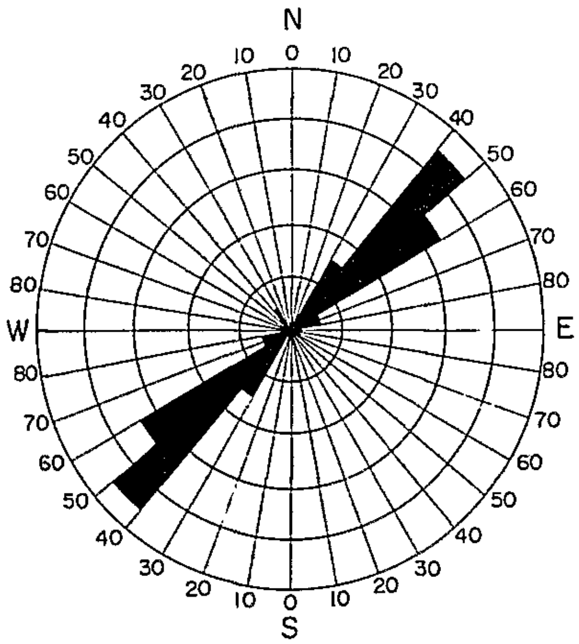


Fig. 1-10 Rose diagram of strikes

of 39 pricipal veins

of stress propagation above is not therefore obstructed, and the fissure is formed.

If the mechanism of fissure generation is considered from the viewpoint mentioned above, it seems that, from the fact that fissures exist only in the stock concentratedly and the principal stress axis σ_1 shows an inclination almost vertical, perhaps the vein systems were formed because many intersecting shear fissures were developed by a compression force caused by an incessant upward force from below at the time of forming the stock and a downward force of gravity on the old sedimentary rocks which covered the top, while spreading fissures occurred simultaneously and mineralization took place there. As mentioned above, a break when the maximum principal compression stress axis is nearly vertical is said to be formed at a place comparatively near the surface, therefore, mineralization will also occur at a comparatively shallow place, while J.N. Grant, if I remember aright, says that, in such a case, mineralization was begun at the time of mineralization by the intrusion of magma-meteric water mixture hot solution system into the intrusive rock at a high level position, i.e., a shallow position, based on his research on D/H and $^{18}O/^{16}O$ isotopes and fluid inclusions. This supports the consideration about fissure generation by the authors supposed simply from the mechanism of the break.

When expectation for the deeper part of Llallagua ore deposit is stated based on the above consideration, the deeper a point is, it becomes farther from the center of the break and, the density at the point is smaller than the density of the vein, therefore, large and many fissures where rich ores are formed can hardly be expected in the deeper part. However, in San José vein system, for example, mineralization exists continuously below –650 level, it is therefore necessary to explore a part where there is possibility of developing fissures by analyzing the fissures in the part and determining the fine changes of stress directions.

1–5 Alteration

Many researches have been made on the alteration of La Salvadora intrusive rock which suffered mineralization.

We have made a research on the alteration of the stock and the surface around it to use the results for the exploration for new deposits in future.

Fifty samples were collected in a 3 km range along the northwest-southeast line passing the center of the intrusive rock altered minerals were detected by the X-ray analysis of the samples, a list of samples was made from the charts and altered zones were investigated. As a result of analysis, it was found that the altered zones can be roughly grouped into the following three zones:

I. Sericite zone

II. Sericite-Chlorite zone

III. K-Feldspar-Sericite-Chlorite zone

Sericite Zone I

All of the stock except its southeast corner is occupied by this zone.

In addition to sericite, metamorphosed minerals generally include albite, alunite, diaspore and carbonate minerals (siderite, etc.). Plagioclase is almost fully albitized.

Sericite-Chlorite Zone II

This zone is the area of sandstone (partly slate) on the western side of the stock. Dolores vein exists near X–21.

Sericite and chlorite are present all over, but in the west of Dolores, sericitization is low.

Near the main ore deposit and Dolores, alteration like that of zone I is seen, but in other parts, diaspore, alunite and carbonate are present in small quantities.

K-Feldspar-Sericite-Chlorite Zone III

This zone occupies the eastern end part of the stock and the sandstone area in the east of the stock.

In addition to the inclusion of sericite and chlorite, the feature of this zone is that feldspar is K-feldspar. As a one moves east, the presence of K-feldspar and sericite decreases gradually.

By the way, montmorillonite exists at the boundary of the intrusive rock and sandstone, and as an X-ray peak appears widely, it seems that montmorillonite was formed secondarily.

Quartz is found all over the zone along with sericite, and as the intensity of the inclusion of it is uniform, it seems that silicification has occurred over a considerably wide area in addition to quartz in the original rock.

From the above-mentioned examination results, the relation of alteration with exploration can be presumed as follows.

(1) Quite universal sericitization in Zone I is the hydrothermal alteration clearly related with cassiterite mineralization, and the farther a place is from La Salvadora stock, the weaker the sericitization.

(2) In Zone II, sericitization near Dolores was caused by the effect of the mineralization and the albite zone near the western end hints that mineralization exists under the zone.

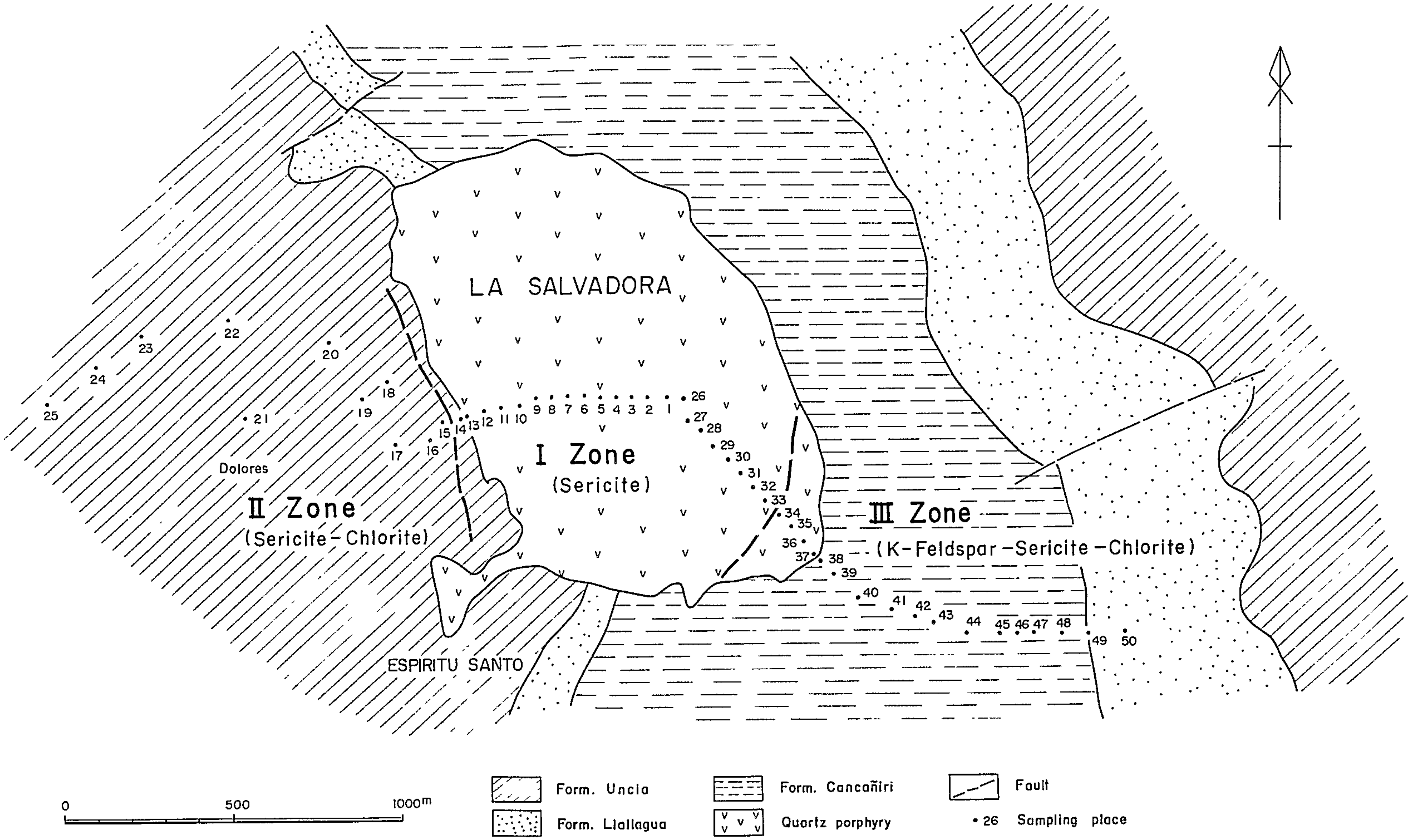


Fig. I-11 Distribution Map of alteration

Table 1–4 Chemical Analysis of Rock

No. 1

No	Locality	Na_2O%	K_2O%	CaO%	MgO%	Note
RC- 1	La Salvadora	0.052	5.14	0.033	0.64	
" 2	"	0.069	3.64	0.070	0.47	
" 3	"	0.080	3.35	0.077	0.49	
" 4	"	0.080	3.88	0.084	0.63	
" 5	"	0.124	2.80	0.038	0.62	
" 6	"	0.056	4.27	0.094	0.59	
" 7	"	0.115	2.22	0.023	0.60	
" 8	"	0.050	3.73	0.084	0.63	
" 9	"	0.075	4.10	0.023	0.67	
" 10	"	0.101	3.49	0.054	0.81	
" 11	"	0.063	4.67	0.033	0.67	
" 12	"	0.063	4.80	0.019	0.73	
" 13	"	0.045	4.51	0.035	0.65	
" 14	Westside of La Salvadora	0.124	3.38	0.050	0.77	
" 15	"	1.142	2.95	0.285	1.82	
" 16	"	0.170	1.98	0.043	0.84	
" 17	"	0.045	2.07	0.027	0.29	
" 18	"	0.055	2.25	0.023	1.89	
" 19	"	0.048	2.33	0.044	1.32	
" 20	"	0.097	2.41	0.031	0.77	
" 21	Dolores	1.062	3.77	0.175	2.41	
" 22	"	0.044	1.12	0.017	0.51	
" 23	"	0.407	3.58	0.043	2.22	
" 24	"	0.025	0.29	0.081	2.87	
" 25	"	0.044	1.04	0.086	2.64	
" 26	"	0.048	4.51	0.042	0.57	
" 27	"	0.042	4.71	0.087	0.67	
" 28	La Salvadora	0.066	4.43	0.052	0.66	
" 29	"	0.112	3.08	0.056	0.64	
" 30	"	0.068	4.95	0.022	0.07	
" 31	"	0.121	4.04	0.039	0.85	
" 32	"	0.142	7.96	0.103	0.62	
" 33	"	0.055	5.56	0.021	0.85	
" 34	"	1.002	7.07	0.094	0.80	
" 35	"	0.123	8.33	0.036	0.50	
" 36	"	1.118	6.19	0.071	0.93	
" 37	"	0.091	5.98	0.065	0.49	
" 38	Eastside of La Salvadora	0.070	4.19	0.031	1.01	
" 39	"	0.056	3.30	0.109	1.07	

No. 2

No	Locality	Na_2O%	K_2O%	CaO%	MgO%	Note
RC-40	Eastside of La Salvadora	0.050	3.07	0.130	0.91	
〃 41	〃	0.040	1.89	0.047	0.88	
〃 42	〃	0.021	0.39	0.022	0.07	
〃 43	〃	0.032	1.18	0.045	0.21	
〃 44	〃	0.021	0.15	0.026	0.04	
〃 45	〃	0.559	2.96	0.082	0.84	
〃 46	〃	0.047	2.52	0.041	0.41	
〃 47	〃	0.051	3.19	0.025	1.07	
〃 48	〃	0.038	1.54	0.084	0.46	
〃 49	〃	0.031	0.27	0.041	0.04	
〃 50	〃	0.035	0.60	0.020	0.76	

1–6 Results of the Measurement of the Physical Properties of Rocks

Samples of the rocks or ores were taken from the circumference and underground of the Catavi mine, and the physical properties of the samples were measured to discuss the adaptation of geophysical exploitations.

The density was measured by weighing the samples in water, and the elastic wave velocity was determined by measuring the P-wave in an artifically wet state with an ultrasonic waves propagation velocity meter.

The measurement of IP and resistivity was carried out in the Frequency Domain method with an IP transmitter-receiver for sample measurement. The natural residual magnetism was measured by a spinner magnetometer. For measuring magnetization rate, the samples after measuring its density were artifically dried and their mass-magnetic susceptibility were measured with a Bison AC magnetic susceptibility meter and converted into the volume magnetic susceptibility by using the density determined previously. The radioactivity was measured with X-ray scintillation survey meter. These measurement values are shown in the Table 1–5.6 and the measurement results are as follows:

(1) Density : The average of the measurement values by rocks is 2.35 for quartz porphyry, 2.44 for sandstones, 2.62 for hard sandstones, and 3.56 for ores. The density of quartz porphyry, the host rock of the deposit, is lower than that of sedimentary rocks or ores. Particularly, the density of altered parts of quartz porphyry is even lower, 2.22 for severely altered parts and 2.50 for less altered parts. The difference between the average value for quartz, porphyry and that for sedimentary rocks (average of values for sandstone and hard sandstone) is 0.17. The difference in average density between sedimentary rocks and severely altered quartz porphyry is 0.30. These differences in density are by enough to distinguish quartz porphyry and its strongly altered parts from sedimentary rocks by measuring the gravity and to know the distribution of the quartz porphyry and its altered parts. It is also possible to assume the existence of dislocations.

Therefore, the Catavi type deposit is considered to be effective for the exploration of blind deposit.

(2) Elastic wave velocity : The average of the measurement values of the elastic wave velocity is 4.37 km/sec for quartz porphyry, 5.03 km/sec for sandstones, and 4.77 for greywacke. The average value for sedimentary rocks is 4.94 km/sec so that the elastic wave velocity in sedimentary rocks is higher than that in quartz porphyry. Also, strongly altered parts of quartz porphyry give markedly lower values of elastic wave velocity. Therefore, it

is considered that the seismological exploration enables the distribution or existence of quartz porphyry to be understood. Particularly, the elastic wave velocity in strongly altered and mineralized parts is lower than that in the surrounding rocks, so that it is thought that they can easily be detected.

(3) Resistivity : As clearly shown in Table 1–5, the samples taken generally have a high resistance without big difference among the rocks. It can be said that the difference, if anything, is caused by weathering and alteration. The severely altered rocks tend to have lower resistance.

(4) Ip : More strongly mineralized quartz porphyries have higher IP values. The average IP value of quartz porphyries, the host rock, is approx. 3%, while ores have extremely high value 39%. Therefore, it is considered that the IP method is effective for deposit explorations.

(5) Radioactivity : The samples taken generally have low values, and the difference among rocks or mineralizations can hardly be determined. Also, uranium is not contained in the rocks, so that the exploration based on this method seems to be unnecessary.

(6) Magnetization rate : The samples taken generally have low values and the relationship between them and alteration is not clear enough.

(7) Residual magnetism : As clearly shown in Table 1–6, all the samples have quite low values, and the bearings and magnetic dips vary widely, having no regularity. It seems to be necessary that the number of measurements is increased in future to check the magnetic stability and the residual magnetism reexamined. However, from the results of this measurement, we believe that the magnetic exploration is not adaptable.

From the above mentioned results of measurement on each of the physical properties, the adaptability of physical exploration methods for the geology of the Catavi mine is discussed below.

a) The gravity exploration is effective for the assumption of the change in geological structure such as quartz porphyry stock, distribution form of altered parts and dislocations.

b) The elastic wave exploration seems to be effective for the assumption of the boundary between quartz porphyry and sedimentary rocks, or of the bottom of quartz porphyry stock (if the stock crops out on the surface of the earth), or of dislocations.

c) For the exploration of a deposit itself, the electric exploration (IP method) is especially suitable.

Table 1–5 Measured Value of Physical Property of Rock and Ore

No.	Rock name	Sampled location	Intensity of alteration	Density (gr/cm³)	Elastic wave velosity (Km/sec.)	Resistivity (Ω-m)	I. P (%)	Radioactive (mR/h)	Magnetic susceptibility (x10-6 emu/cc)	Observation
1	Q. P	La Salvadora	strong	2.15	3.36	575	2.6	0.007	82	
2	″	″	″	2.29						Average value of density of rock
3	″	″	″	2.22						
4	S. S	West side of Salvadora	fresh	2.38	4.92	245	0.5	0.009	232	Quartz porphyry 2.35
5	″	″	″	2.54						Sandstone 2.44
6	Q. P	La Salvadora	strong	2.22						Greywacke 2.62
7	″	″	″	2.09						Ore 3.52
8	G. W	East side of Salvadora	fresh	2.42	4.77	365	1.2	0.007	132	Strong altered Q-P 2.22
9	S. S	″	″	2.41						Weakly altered Q-P 2.50
10	″	″	″	2.42	5.13	190	0	0.008	298	
11	Q. P	Ni 215 Laguna	weak	2.42					122	
12	G. W	″	″	2.75					208	Average value of elastic wave
13	Q. P	Ni 650 Siglo XX	″	2.63					798	Velocity
14	G. W	″	fresh	2.70					102	Quartz porphyry 4.37 Km/sec
15	Q. P	Ni 551 D.D.H 798	strong	2.29	4.15	627	3.2	0.009		Sandstone 5.03 km/s } 4.94 Km/sec
16	″	″	″	2.28	4.01	378	2 8	0.011		Greywacke 4.77 km/s
17	″	Ni 516 D.D.H 802	weak	2.63	5.60	405	4.2	0.007		Strong altered Q-P 3.84 Km/sec
18	″	″	strong	2.35	3.89	312	2.9	0.009		Weakly altered Q-P 5.03 Km/sec
19	″	Ni 650 D.D.H 845	weak	2.40	4.09	209	1.8	0 009	148	
20	″	″	″	2.64	5.40	480	2.4	0.008	14	
21	Ore	Tojota		3.78						
22	″	Ni 551 V. San José		2.70						
23	″	Ni 650 Siglo XX		3.48		4	39.5			
24	″	″		4.29						
								(BG=0.007)		

Q. P : Quartz porphyry
S. S : Sandstone
G. W: Greywacke

Table 1–6 Measured Value of Residual Magnetization

No.	Rock name	Sampled location	Jo (C.G.S. e.m.u.)	Jd (C.G.S. e.m.u.)	Declination	Inclination
1	Greywacke	Cancañiri	2.62×10^{-7}	1.08×10^{-7}	S55°W	−18°
2	"	"	3.91×10^{-7}	1.51×10^{-7}	S69°W	+ 9°
3	Quartz porphyry	Azul	6.99×10^{-7}	3.36×10^{-7}	N17°W	+ 10°
4	Sandstone	"	5.54×10^{-6}	2.23×10^{-6}	N87°E	+ 14°
5	"	Dolores	3.45×10^{-7}	1.38×10^{-7}	S53°W	− 31°
6	"	"	7.49×10^{-7}	2.92×10^{-7}	S66°W	− 2°
7	Greywacke	Siglo XX	1.58×10^{-6}	6.28×10^{-7}	S74°W	+20°
8	Sandstone	"	2.98×10^{-7}	1.17×10^{-7}	N59°W	−21°
9	"	"	2.07×10^{-7}	8.07×10^{-8}	S84°W	−51°
10	"	"	1.15×10^{-5}	4.88×10^{-6}	N12°W	−24°

Note: Upward inclination from horizontal — (−)
Downward " " — (+)

1–7 Ore Reserve

(1) Outline of ore reserve

Catavi mine has besides the ore reserve underground and placer deposits, concentration waste and tailing which have been dumped on the surface. The ore reserve for ore in the mine and waste on June 30, 1981, and that for placer deposits in 1980 have been calculated.

It was naturally impossible to check these huge amount of data with the same accuracy in this research, but the existing state of various ores and sampling methods were repeatedly investigated, and each sample of more than 300 Kg of the particularly important three kinds of ore (Block Central, Desmonte and Colas Arenas) were taken.

Therefore, the calculation of Catavi mine ore reserve is judged to be sufficiently reliable for evaluating the profitability of the mine.

The ore being treated in the mill plant at present is mostly from the block caving in the mine, as well as from other veins, ore sellers such as Locatarios and Veneros, and a part of Desmonte and Relaves.

(2) Explanation of ore reserve

Kind	Explanation
Vetas	Vein (shrinkage working face)
Vetas en blocks	Indicating the veins contained in Gran Block Central and Paralera, so that they are not to be mined at present.
Puentes	Ore pillar
Taqueos	Ore filled in old gobs (mainly shrinkage face) and classified into high grade ore with 0.50% Sn or more and low grade ore with less than 0.5% Sn.
Block caving	There are six blocks which are being mined at present.
Block chicos	Small ones in Block caving 4 blocks.
Existencias	Deposit of ore in the working face in mine, ore shute, and Siglo XX Sink and Float, and Victoria mill plant.
Desmontes	Waste of heavy media fluid separation dumped outside the Siglo XX.
Veneros	2 Placer deposit, Carmen and Centenario.
Relaves	indicates the tail at the Victoria mill plant as well as in the settling pond of the kenko mill plant. It can be classified into the following 3 groups :

Colas, lamas (Kenko) : Slime from Siglo XX and particles with a diameter of 1.5 mm or less. Both are dumped in the Kenko lake, and are classified into Kenko I and II.

Colas lamas golden city (Kenko) : Sulfied mineral flotation froth and tin rougher flotation tailing accumulated in the city region.

Relaves Catavi : Tailing from the Victoria mill plant. It can be classified into the following 5 groups.

Arenas : The tailing of gravimetric concentration with table, dumped in the recent 13 to 15 years.

Quemadillos : The tailing formed in the old system, and it has brown color due to iron.

Piritas A and B : The products of the final process, sulfied flotation, and respectively high grade and low grade.

Granzas (or Grancilla) : The coarse grain parts of colas, arenas.

Table I-7 Comparative Reserves for Years of the Catavi Mine (1977~1981)

TIPO DE RESERVAS	1977			1978			1979			1980			1981			DIFERENCIA EN TONELAJE FINO ENTRE 1980-1981	
	Tons Min	% Sn	Tons Fino	Tons Min	% Sn	Tons Fino	Tons Min	% Sn	Tons Fino	Tons Min	% Sn	Tons Fino	Tons Min	% Sn	Tons Fino	PERDIDAS	GANANCIAS
EN VETAS	521,566	1 86	9,705 4	441,940	1 94	8,586 3	523,855	1 79	9,389 6	429,917	1 54	6,635 5	443,472	1 52	6,757 7	-	122 2
VETA EN BLOCKS	-	-	-	-	-	-	-	-	-	115,399	2 08	2,398 3	115,399	2 08	2,398 3	-	-
PUENTES	-	-	-	-	-	-	-	-	-	44,338	2 88	1,275 2	44 338	2 88	1,275 2	-	-
TAQUEOS	272,266	0 55	1,488 2	221,409	0 56	1,238 7	216,725	0 56	1,210 5	21,909	0 51	111 0	-	-	-	111 0	-
BLOCK CAVING	5,596,614	0 50	27,922 9	4,388,674	0 43	18,977 4	3,798,391	0 41	15,643 8	3,441,697	0 39	13,392 1	3,255,329	0 39	12,797 4	594 7	-
BLOCKS CHICOS	44,584	0 47	207 8	382,741	0 48	1,835 1	249,258	0 40	1,009 2	143,537	0 38	533 5	89 698	0 40	363 1	170 4	-
EXISTENCIAS	108,210	1 03	1,113 0	153,444	0 85	1,308 2	273,063	0 58	1,591 7	132,376	0 75	987 8	103,478	0 92	948 0	39 8	-
TOTAL MINA	6,543,240	0 62	40,437 3	5,588,208	0 57	31,945 7	5,061,295	0 57	28,844 8	4,329,173	0 58	25,333 4	4,051,714	0 61	24,539 7	793 7	-
DESMONTES	8,302,863	0 29	24,098 4	8,229,021	0 29	23,772 6	21,990,914	0 27	59,954 3	21,973,613	0 27	59,894 1	21,961,820	0 27	59,845 2	48 9	-
VENEROS	100,769,422	0 04	39,861 4	100,468,072	0 04	39,740 8	94,732,522	0 04	37,514 6	297,416,778	0 01	30,566 8	297,249,015	0 01	30,558 5	28 3	-
RELAVES	27,886,682	0 44	124,052 0	28,350,261	0 44	125,156 8	31,338,657	0 37	117,495 8	31,921,249	0 37	118,056 4	32,262,227	0 37	118,686 2	-	629 8
TOTAL SUPERFICIE	136,958,967	0 14	188,011 8	137,047,354	0 14	188,672 2	148,062,093	0 14	214,964 7	351,311,640	0 07	208,537 3	351,473,062	0 04	209,089 9	-	552 6
TOTAL EMCATAVI	143,502,207	0 16	228,449 1	142,635,562	0 15	220,615 9	153,123,388	0 16	243,809 5	355,640,813	0 07	233,870 7	355,524,776	0 07	233,629 6	241 0	-

Table I-8 Summary of Reserves of the Catavi Mine (1981.6.30)

TIPO DE RESERVA	RESERVA ACCESIBLE									RESERVA INACCESIBLE									TOTAL		
	POSITIVO			PROBABLE			SUB-TOTAL			POSITIVO			PROBABLE			SUB-TOTAL					
	Tons Min	% Sn	Tons Fino	Tons Min	% Sn	Tons Fino	Tons Min	% Sn	Tons Fino	Tons Min	% Sn	Tons Fino	Tons Min	% Sn	Tons Fino	Tons Min	% Sn	Tons Fino	Tons Min	% Sn	Tons Fino
VETAS	19,938	1 18	236 24	160,024	1 20	1,914.79	179,962	1 19	2,151.03	38,615	1 23	476 22	224 895	1 84	4 130 46	263,510	1 75	4,606 68	443,472	1 52	6,757.71
VETAS EN BLOCKS	2,160	2 32	50 06	25,610	1 53	392 35	27,770	1 59	442 41	1,397	3 72	52 08	86,232	2 21	1,903 85	87,629	2 23	1,955 93	115,399	2 08	2,398 34
PUENTES	-	-	-	-	-	-	-	-	-	44,338	2 88	1 275 16				44,338	2 88	1,275.16	44,338	2 88	1,275 16
TAQUEOS	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BLOCK CAVING	3,255,329	0 39	12,797 36	-	-	-	3,255,329	0 39	12 797 36	-	-	-	-	-	-	-	-	-	3,255,329	0 39	12,797 36
BLOCKS CHICOS	89,698	0 40	363 14	-	-	-	89,698	0 40	363 14	-	-	-	-	-	-	-	-	-	89,698	0 40	363 14
EXISTENCIAS	103,478	0 92	948 04	-	-	-	103,478	0 92	948 04	-	-	-	-	-	-	-	-	-	103,478	0 92	948 04
TOTAL MINA	3,470,603	0 41	14,394 84	185,634	1 24	2,307 14	3,656,237	0 46	16,701 98	84,350	2 14	1,803 46	311,127	1 94	6,034 31	395,477	1 98	7,837 77	4,051,714	0.61	24,539 75
DESMONTES	21,961,820	0 27	59,845 16	-	-	-	21,961,820	0 27	59,845 16	-	-	-	-	-	-	-	-	-	21,961,820	0 27	59,845 16
VENEROS	297,249,015	0 01	30,558 49	-	-	-	297,249,015	0 01	30,558 49	-	-	-	-	-	-	-	-	-	297,249,015	0 01	30,558 49
RELAVES	32,262,227	0 37	118,686 20	-	-	-	32,262,227	0 37	118,686 20	-	-	-	-	-	-	-	-	-	32,262,227	0 37	118,686 20
TOTAL SUPERFICIE	351,473,062	0 06	209,089 85	-	-	-	351,473,062	0 06	209,089 85	-	-	-	-	-	-	-	-	-	351,473,062	0.06	209 089 85
GRAN TOTAL	354,953,665	0 06	223,484 69	185,634	1 24	2,307 14	355,129,299	0 06	225,791 83	84,350	2 14	1,803 46	311,127	1 94	6,034,31	395,477	1 98	7,837 77	355,524,776	0 07	233,629 60

(3) Increase and decrease in amount of tin during 1977 to June 1980.

Class of ore	Increase	Decrease	
En vetas	2,947.7		
Veta en blocks	–	–	
Puentes	–	–	
Taqueos	1,377.2		
Block caving	15,125.5		
Block chicos		174.7	
Existencias	165		
Underground total	16,952.4	174.7	
Desmontes		35,746.6 *	Mostly revised in 1979.
Veneros	9,302.9		
Relaves	5,365.8		

According to the data of COMIBOL, the pay limit grade (called Cut-off in the mine) in the present operation system is as follows :

Condition	1977	1978	1979	1980
pay limit grade (%)	0.57	0.58	0.70	0.61
Sn market price US$/lb	4.39	5.70	6.15	7.05

The data up to April 1981 shows :

Class of ore	Average pay limit grade	
Block caving	0.68%	
Block chicos	0.64	US$0.71 /lb in the entire mine
veins	0.86	
Sn market price	US$ 5.40/lb	

As shown in the Table of Ore Reserve Calculation, the only 700 thousand tons of ores with a grade higher than pay limit grade are as follows:

	Ore Reserve (t)	Sn %	Tin Amount (t)
Vetas	443,472	1.52	6,741
Vetas en Blocks	115,399	2.08	2,400
Puentes	44,338	3.88	1,277
Existencias	103,478	0.92	952

706,687	1.60 %	11,370

80% of about 4.05 million tons of the present reserve in mine, except for Block Central, is the Block Caving ore reserve, but its grade is low, 0.39%.

(4) Discussion on the ore reserve in mine on June 30 1981.

1) Underground ore reserve

Mineral Accessible			Mineral inaccessible		
Ore reserve (t)	Sn %	Tin amount (t)	Ore reserve (t)	Sn %	Tin amount (t)
3,656,237	0.46	16,819	395,477	1.98	7,837.77

As shown in the table, the amount of mineral accessible (defined/assumed) is enough only for 3 years with the present production scale (coarse ore mined, approx. 1.3 million/ year).

2) Large scale Block caving

The evaluation using a computer on Gran Block Central had been completed in September 1981.

These blocks are located at the center of La Salvadora, and relatively high grade zones, where old stopes mined out and filled with vein, and branch veins are densely gathered, were selected.

At 11 levels of 215 to 551, totally more than 20 thousand samples obtained from inside the mine or by boring were used to calculate the ore reserve with computer processing, where a horizontal area of 20 m x 20 m is taken as an unit.

The ore reserve is shown above, but according to the prefeasibility study by COMIBOL, the current metallurgical results are not profitable.

The survey team prepared plain- and cross section-distribution maps of tin grade, by using computer disk offered by the mine. The typical map is shown Fig. 1–6.

These maps show that a low grade zone with Sn content 0.35% or less exists vertically at the center.

Therefore, as described in the clause of mining division, on condition that a selected mining method such as the sublevel stoping is used, a remarkable rise in grade can be expected, if the low grade zone is eliminated.

3) Desmontes

This has been dumped over several tens of years. Desmontes existing in area in the

Table 1–9 Reserves of Relaves (30–VI–81)

Acumulación De Reservas		Tons. Min	%Sn	Tons. Finas	Observaciones
Colas Lamas Kenko	Kenko I	6'340,154	0.39	24,598.61	Según informe TOI-17/79
	Kenko II	4'562,894	0.55	25,095.92	Sin recálculo
Total		10'903,048	0.46	49,694.53	Reserva al 30-VI-81
Acumulación De Reservas	AÑOS	Tons. Min	%Sn	Tons. Finas	Observaciones
Colas Lamas Golden City (Kenko)	1968–1971	293,488	0.34	989.82	Acumulación de reservas 1968–VI–81
	1972–1974	144,170	0.22	323.18	
	1975–1979	646,453	0.27	1,740 66	
	1980–1981	42,049	0.49	238.70	
Total		1'126,160	0.29	3,292.36	
Acumulacin De Reservas	Colas	Tons. Min	%Sn	Tons. Finas	Observaciones
Relaves Catavi	Arenas	18'527,710	0.29	54,461.80	Dos contado de evaluación 1979 comunicado con radiograma TOI-26/80
	Quemadillos	46,578	0 95	444.32	
	Piritas A	16,949	1.37	232.20	
	Piritas B	370,949	0.86	3,190.16	
	Granzas	1'270,833	0.58	7,370.83	
Total		20'233,019	0.32	65,699.31	

Gran Total Relaves	32'262,227	0.37	118,686.20

Table 1–10 Reserve of Block Central

Nivel	Volumen	Toneladas Mineral (Secas)	% Sn	Toneladas Fino
383	2,582 253	5,800 231	0 14	8 120.32
411	2,898 802	6,383.310	0 20	12 766 62
446	3,196 150	7,245 918	0 19	13 767 24
481	2,985.524	6,838.762	0 21	14 361 40
516	2,836 813	6,934 482	0 21	14 562 41
551	2,049 334	5,103 217	0 24	12.247.72
Gran Total	16,548 876	38,305.920	0 20	75 825.71

vicinity of the Siglo XX Sink and Float plant and at the lower part came into being when high grade veins were being mined, having a content of around 0.4%, while the upper part and one being dumped now are mainly mined from Block caving, having a low grade around 0.20%.

4) Veneros

(a) Centenario

The state of reserve is described in the section in which the deposit is dealt with. Since ore sellers (Veneros) have mined the high grade zones for more than 40 years, the recent reevaluation by COMIBOL elimates these mined zones. The average grade is exceedingly low, 0.01%, so that, as compared with the placer deposit of Estalza mine, 0.02 to 0.04%, it can not be said that this deposit is worthy of starting the development immediately.

(b) Carmen

Although the grade is good enough, 0.03%, there are facilities and company houses of the mine on almost entire deposit, and according to COMIBOL's calculation, this deposit is not profitable if these facilities and houses are moved.

5) Colas Arenas

Both grade and ore reserve of Colas Arenas, as the reserve in surface, together with Desmonte, seem to be worthy of exploration study. Quemadillos have been sent to the Kenko mill plant, and at the time of the survey, there was almost nothing.

1–8 Consideration and Suggestion

As a result of the survey and examination of data, the following problems concerning exploration were pointed out :

(1) Profitable high grade zones have become exhausted, the ore reserve which can be mined with the present mining scale is for three years.

(2) The possibility of the existence of a large amount of ore shoot in deep parts and in the vicinity of known deposits, is little.

(3) The present exploration organization and its alloted task are too much based on the service for the mining division to meet the requirements for new deposit explorations.

(4) Compiling, arrangement and investigation of data are insufficient.

(5) Arrangement and investigation on samples, particularly boring cores are insufficient.

For the aforementioned problems, the exploration organization should be reformed and their alloted task should be changed, so that they can concentrate on their proper work, overcoming the present crisis. Also medium- and long-term, and circumference to broad area exploration plan should be made. For this, compiling the old data and increase in boring are also necessary.

From the survey and study, new facts have been discovered concerning the ore reserve in the Block caving zones which are to be mined in future. The exploration division should cooperate with both mining and metallurgy division to study further the existing state of tin minerals and other valuable metal minerals. On the basis of the results of the study, the potentiality of the mine will rise and greatly contribute to the management of the mine in future.

CHAPTER 2 MINING DIVISION

2–1 Organization and Personnel Allocation

2–1–1 Organization and Personnel Allocation

The mining-related organization and personnel allocation are shown in Fig. 2–1, and the organization is roughly classified into the line group and the staff group. The geology department belongs to the staff group.

The line group falls into Northern Mining Section, Southern Mining Section, and Block Caving Section. There are three ore sellers; Locatarios in the upper pit, and Veneros and Lameros out of the pit. Their work covers from stoping to upgrading on the respectively assigned mining blocks.

The staff group is composed of Project-Team consisting of technician groups on stopping and geology, Geology Section (for sampling, boring etc.), Safety and Hygiene Section, and Clerical Section.

Other service sections are Construction Squad, Machine Shop, Material Transportation Squad, Company House Squad, Theft-stoping Squad, Electric Shop, Warehouse Squad, Absence Control Squad, and Welfare Squad in Siglo XX Area (school, movie house, hospital, etc.). Organizationally they belong to Department of Maintenance or Central Office, but functionally fall under control of Mining Department.

2–1–2 Working System

The underground work time shown in Table 2–1 is the real work time, and anyone can leave the work site in the remaining time zone. There are two attendance cards; one is for even-numbered days and another for odd-numbered days. The cards are used alternately.

Table 2–1 Standard Working Time

Term	First Shift	Second Shift	Third Shift
Sunday ~ Friday	7:00 ~ 11.00	15.00 ~ 19.00	23:00 ~ 3:00
	11:30 ~ 14:15	19·30 ~ 22:15	3:30 ~ 6:00
Usual Saturday	7·00 ~ 12:15	12·30 ~ 17.30	18:00 ~ 22:30
Saturday for the Pay Day	7:00 ~ 11:30	12:30 ~ 17:30	18:00 ~ 22:30

The mealtime for each shift is 30 minutes from Sunday to Friday, but no mealtime on Saturday. Laborers take the meal at their own working sites. The entrance times of laborers are 5.30 to 6.00 for the first shift, 13.30 to 14.00 for the second shift, and 21.30 for the third shift. The chief foreman and the foreman, though being staff, enter at the same time as the laborers and depart after preliminaries with the following shift, thus they are on duty with three shifts. The chief of section and the subchief serve only for the first shift; they enter at 7.30 and depart around 15.30 to 16.00, and then they consult with superintendent of mining.

2–1–3 Age Structure and Change of Operating Personnels

The yearlong fluctuations in the number of persons for mining in the past five years are shown in Table 2–2. There is small fluctuation in the number of staff, while a slight increase was found in the number of laborers which, in 1981, has gone down to the level in 1976.

Table 2–2 Year Long Number of Persons (July 1st. 1981)

[Staff] (Number of Resistered Persons)

Year \ Section	Siglo XX	Beza	Salvadora	Laguna	Animas	Block Caving	Trans-portation	Total
1976	14	13	15	14	14	22	3	95
1977	13	14	14	12	13	22	4	92
1978	13	14	14	12	13	22	3	91
1979	13	14	13	10	13	19	4	86
1980	12	15	14	12	14	21	4	92
1981	14	12	10	10	14	21	4	85

[Labor] (Number of Resistered Persons)

Year \ Section	Siglo XX	Beza	Salvadora	Laguna	Animas	Block Caving		Trans-portation	Total
						Preparation of Exploitation	Exploitation		
1976	143	184	134	165	148	89	207	89	1,156
1977	178	184	141	173	155	97	181	94	1,203
1978	178	184	141	173	155	98	181	94	1,204
1979	178	184	141	173	155	98	181	94	1,204
1980	190	180	179	146	155	76	224	87	1,232
1981	156	163	169	137	143	286		95	1,149

There are thirty and mining-related occupational categories, and personnel assignments of every occupational category by sections are shown in Table 2–3.

The table indicates that the stoping -related occupational categories hold about 54 percent of the whole, while the transportation-related ones reach as high as 36 percent, and this fact can be understood to point out that the mechanization and rationalization of the trans-

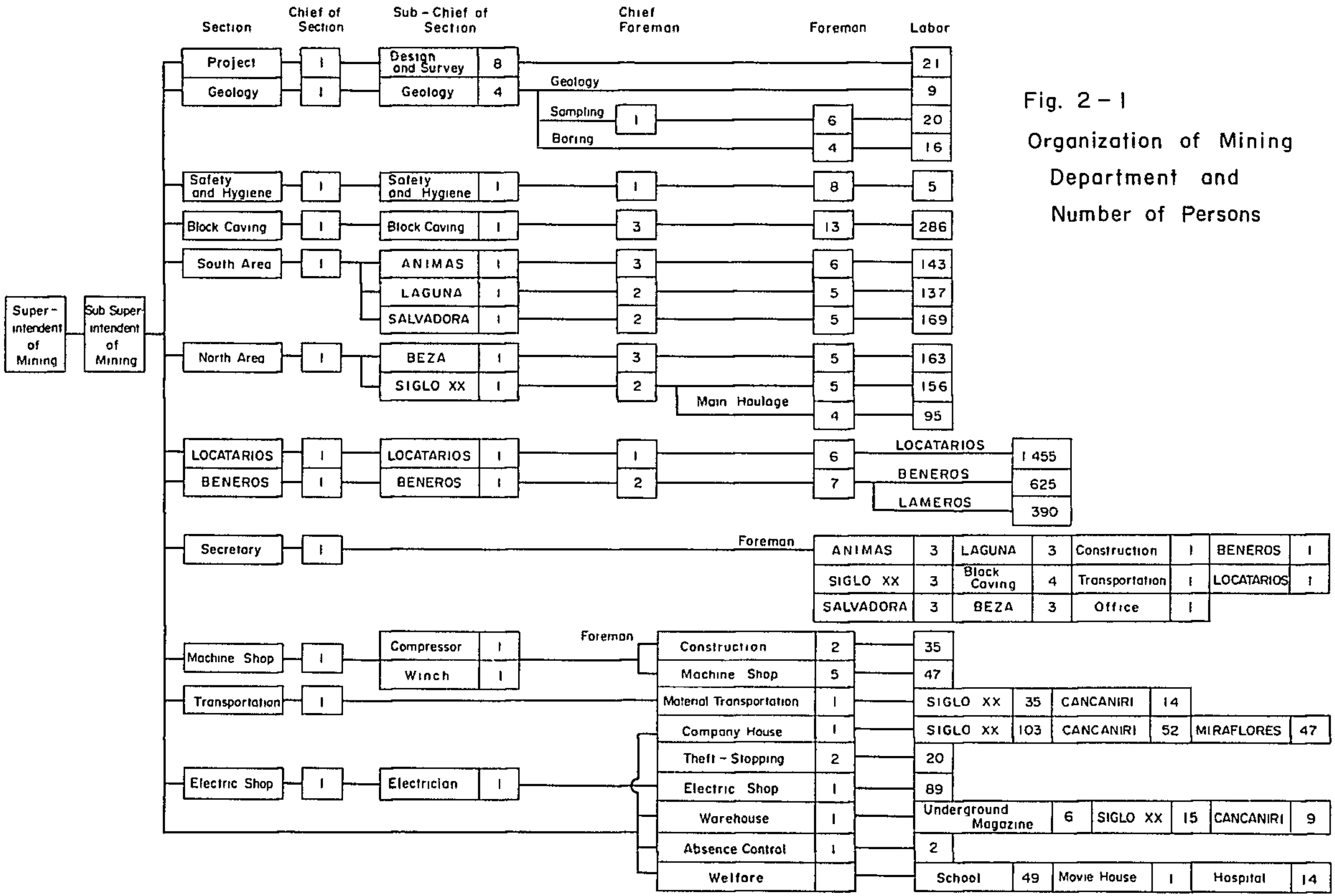


Fig. 2 – 1

Organization of Mining Department and Number of Persons

Table 2–3 Number of Labor

(Jan. 1st, 1981)

(person)

Section / Occupation	Siglo XX	Beza	Salvadora	Laguna	Animas	Block Caving	Trans-portation	Total
Aceitero	1	1	1	1	1	1	–	6
Aydte. Cañerista	2	4	3	3	3	2	–	17
Aydte. Carrilano	3	3	2	3	2	1	2	16
Aydte. Carrocero Int. Mina	–	–	–	–	1	–	–	1
Aydte. Esp. Cundro	–	–	–	1	–	–	1	2
Aydte. Perforista	17	25	20	24	16	16	–	118
Aydte. Polvorinero	1	1	1	1	1	–	–	5
Brequero nivel 650	–	–	–	–	–	–	24	24
Brequero Bateria	5	–	3	–	1	–	–	9
Brequero Trole	7	10	6	8	7	–	–	38
Cañerista Int. Mina	2	4	3	3	3	2	–	17
Cabecilla Contratista	17	25	20	24	16	16	–	118
Cab. Enmdr. Esp. Cuadro	1	2	1	1	1	–	1	7
Carrero Int. Mina	49	34	28	31	21	30	12	205
Carrilano	3	3	3	3	3	1	5	21
Carrocero Int. Mina	1	1	1	1	1	–	–	5
Chapaletero	–	–	–	–	–	–	3	3
Chasquiri	17	23	20	24	18	6	–	118
Enmaderador	3	2	2	1	2	–	1	11
Enmaderador Cuadro	–	2	1	–	–	–	–	3
Herrero Int. Mina	–	1	1	1	1	–	–	4
Lamero	2	2	1	1	3	37	12	58
Mag-Trole nivel 650	–	–	–	–	–	–	24	24
Maquinista Bateria	5	–	3	–	1	–	–	9
Maquinista Trole	7	10	6	8	7	–	–	38
Muestrero Int. Mina	4	5	4	5	4	–	–	22
Parrillero Int. Mina	4	5	6	10	6	–	–	31
Parrillero Block Caving	–	18	–	–	18	178	–	214
Patachero	2	3	1	1	3	–	–	10
Perforista	17	25	20	24	16	16	–	118
Tarrajero Int. Mina	1	1	1	1	1	1	–	6
Timbrero	–	6	6	3	6	–	–	21
Transporte Mina	3	4	3	3	3	–	–	16
Trolista Int. Mina	–	1	1	1	1	–	–	4
TOTAL	174	221	168	187	167	317	85	1,319

portation system has not been well advanced.

The mining-related age structure with 5-year increments by sections is seen in Table 2–4. The retirement ages are defined as 50 for the underground and 55 for the surface, but so highly aged as 62 years old employees are still at work. Although the youngest age is determined as 18 years old, the age of 19 is practically the youngest because post-graduate one year from senior high school has to be devoted to the military service.

Table 2–4 Number of Person by Age Group

(July 1st. 1981)

[Staff]

(person)

Section \ Age	Over 55	54~50	49~45	44~40	39~35	34~30	29~25	24~20	Total
Siglo XX	–	2	3	4	4	1	–	–	14
Beza	3	1	–	3	2	1	2	–	12
Salvadora	–	2	1	3	1	2	1	–	10
Laguna	1	1	2	1	2	2	–	1	10
Animas	2	2	3	2	3	–	2	–	14
Block Caving	1	2	3	9	5	1	–	–	21
Trans-protation	2	1	1	–	–	–	–	–	4
Total	9	11	13	22	17	7	5	1	85

Average age = 42.7

[Labor]

(person)

Section \ Age	Over 55	54~50	49~45	44~40	39~35	34~30	29~25	24~20	Under 19	Total
Siglo XX	2	2	4	12	19	32	55	30	–	156
Beza	9	9	8	9	27	33	47	21	–	163
Salvadora	1	5	15	7	23	32	46	36	1	166
Laguna	5	14	7	11	23	31	32	15	–	138
Animas	8	6	11	16	30	26	29	20	–	146
Block Caving	4	14	31	49	72	66	40	9	–	285
Trans-portation	6	13	21	6	16	9	22	2	–	95
Total	35	63	97	110	210	229	271	133	1	1,149

Average age = 34.6

The table indicates that the average of the staff is 42.7 years, while that of the laborers is slightly younger at 34.6 years.

2–2 Production, Productivity, and Operating Cost

2–2–1 Changes in the Past Ten Years

Changes in the production and productivity on Catavi mine in the past 10 years (1971 to 1980) are listed in Table 2–5.

Table 2–5 Changes for Production and Productivity of Labor from 10 years ago

Year	Production (Ton)	Average Ore Grade (%)	Productivity of Total Labors (ton per man-month)		(B)/(A) (%)
			Underground (A)	Total (B)	
1971	1,630,800	0.50	116.5	31.3	26.9
1972	1,533,432	0.48	105.5	32.5	30.8
1973	1,423,776	0.52	95.3	30.8	32 3
1974	1,443,528	0 44	97.4	31.3	32.1
1975	1,490,244	0.48	105.6	32.5	30.8
1976	1,365,780	0 45	99.2	30 5	30.7
1977	1,610,328	0 42	113.5	35.8	31.5
1978	1,406,136	0 38	98.9	31.9	32.2
1979	1,344,744	0.33	90.7	28.9	31.9
1980	1,356,156	0 32	92.0		

• Number of efficiency of labor was based on number of actual labors.

The production and the productivity, though having a peak in 1971 and returning to the former level in 1977, are generally in downward tendency. The average grade of tin also has gradually declined.

The ratio of the total productivity against the underground productivity B/A in Table 2–5, almost levels off at about 30 percent. Because the ratio in Japan is around 60 percent, this fact indicates that the number of labors in the Surface Department is too great. Table 2–6 shows the changes in the mining operation cost.

The cost per ton of crude ore in 1980 is approximately doubled when compared with that in 1976. The main causes for this fact are, let alone the fall of production, substantial raises in the labor cost and the cover-up burden of supply shop.

2–2–2 Changes in Production, Productivity, and Operating Cost by Mining Methods

The changes in the production and the productivity by the mining method on Catavi mine in the past five years are as follows: the whole mining in Table 2–7, the shrinkage

Table 2–6 Change of Mining Operation Cost

($US)

Item \ Year	1976	1977	1978	1979	1980
Production (Ton)	1,365,780	1,610,328	1,406,136	1,344,744	1,356,156
Salary and Daily Wages	357,125	478,749	741,428	628,022	527,097
Overtime Pay	133,392	169,750	184,627	231,708	206,015
Piece Wages (underground)	769,337	919,442	577,487	1,136,763	1,198,392
Piece Wages (surface)	44,457	15,460	25,483	39,202	37,957
Bonus	249,364	237,283	241,948	357,242	1,340,198
Compensations	52,389	55,504	143,677	219,480	148,239
Direct Labor Costs	1,606,068	1,876,189	2,214,654	2,612,420	3,457,901
Living Compensations	839,335	861,968	878,444	1,076,144	1,623,744
Social Welfare Charges	1,268,503	1,550,640	1,740,600	1,862,001	2,509,705
Indirect Labor Costs	2,107,838	2,412,608	2,619,044	2,938,145	4,133,499
Total Labor Costs	3,713,906	4,288,797	4,833,698	5,550,566	7,591,350
Material Costs	1,292,936	1,335,923	1,341,142	1,519,113	1,931,355
Traveling Expenses	7,800	3,910	8,162	6,972	7,948
Direct Expenses	230,179	189,542	224,893	322,366	342,947
Indirect Expenses (Included power costs)	1,774,818	1,828,903	1,653,517	1,594,063	2,894,632
Total Costs	7,019,639	7,647,075	8,061,412	8,993,080	12,768,232
Cost per Tonnage ($US/Ton)	5.14	4.75	5.73	6.69	9.42

Table 2–7 Changes for Production and Productivity of Underground Labor from 5 Years ago

Item / Year	Monthly Production (Ton)	Number of Labour	Man-shift (monthly)	Efficiency of underground labor		Man-shift per Ton
				Ton per Labour	Ton per Man-shift	
1976	113,815	1,141	29,289	99.73	3.88	0.26
1977	137,470	1,176	33,048	116.83	4.16	0.24
1978	123,336	1,180	32,150	104.55	3.84	0.26
1979	114,878	1,229	31,408	93.47	3.66	0.27
1980	113,777	1,228	32.554	92.64	3.49	0.29

Table 2–8 Changes for Production and Productivity of Underground Labor by Shrinkage Stoping

Item / Year	Monthly Production (Ton)	Number of Labour	Man-shift (monthly)	Productivity of underground labor		Man-shift per Ton
				Ton per Labour	Ton per Man-shift	
1976	41,711	678	17,241	61.51	2.42	0.41
1977	45,572	723	20 187	63.00	2.26	0.44
1978	37,460	747	20,246	53.49	1.97	0.51
1979	34,626	765	19,403	45.29	1.78	0.56
1980	28,627	754	19,844	37.99	1.44	0.69

Table 2–9 Changes for Production and Productivity of Underground Labor by Block Caving

Item / Year	Monthly Production (Ton)	Number of Labour	Man-shift (monthly)	Productivity of Underground Labor		Man-shift per Ton
				Ton per Labour	Ton per Man-shift	
1976	71,095	175	4,473	406	15.89	0.06
1977	86,178	163	4,522	530	19.06	0.05
1978	78,790	163	4,416	484	17.88	0.06
1979	77,106	185	4,679	418	16.48	0.06
1980	84,374	200	5,383	421	15.67	0.06

Table 2–10 Changes for Advance and Development Efficiency by Preparation for Block Caving

Year \ Item	Monthly Advance (m)	Number of Labour	Man-shift (monthly)	Development Efficiency: m per Labour	Development Efficiency: m per Man-shift	Man shift per m
1976	334.2	69	1,763	4.85	0.19	5.27
1977	330.5	80	2,234	4.14	0.15	6.76
1978	238.8	71	1,888	3.38	0.13	7.90
1979	164.6	67	1,684	2.45	0.10	10.23
1980	77.8	58	1,545	1.34	0.05	19.86

Table 2–11 Changes for Mining Operation Costs by Stoping

Year \ Item	Shrinkage Stoping			Recovery Stoping of Filling Material		
	Production (Ton)	Ore Grade (Sn %)	Cost ($US/ton)	Production (Ton)	Ore Grade (Sn %)	Cost ($US/Ton)
1976	96,239	0.92	7.06	281,975	0.48	2.10
1977	80,064	0.94	8.14	338,294	0.45	2.23
1978	96,758	0.90	8.93	317,683	0.44	2.54
1979	69,600	0.85	10.72	272,724	0.45	2.99
1980	84,169	0.73	10.67	229,735	0.47	3.19

Year \ Item	Development			Others		
	Production (Ton)	Ore Grade (Sn %)	Cost ($US/Ton)	Production (Ton)	Ore Grade (Sn %)	Cost ($US/Ton)
1976	6,409	1.11	25.15	24,455	0.53	2.41
1977	8,170	1.20	39.18	69,541	0.52	1.05
1978	3,861	1.32	57.57	41,124	0.50	2.00
1979	4,627	1.27	64.29	46,175	0.51	2.66
1980	5,052	0.73	62.40	40,312	0.50	4.33

Year \ Item	Block Caving			Mini Block Caving		
	Production (Ton)	Ore Grade (Sn %)	Cost ($US/Ton)	Production (Ton)	Ore Grade (Sn %)	Cost ($US/Ton)
1976	859,876	0.53	2.44	85,851	0.47	1.75
1977	1,063,460	0.52	2.28	42,457	0.40	1.54
1978	905,374	0.46	2.74	51,242	0.39	2.34
1979	822,700	0.39	3.47	106,529	0.34	2.48
1980	931,656	0.35	5.10	80,835	0.33	3.67

stoping in Table 2–8, the block caving in Table 2–9, and the block caving preparation of exploitation in Table 2–10.

The changes in exploitation costs by mining methods are shown in Table 2–11.

2–3 Mining Method

2–3–1 Change of Mining Method

The country rock of Catavi mine consists mainly of rock which was silicified, and is so stout that most undergrounds are not equipped with timbering. At the beginning, the vein-type ore deposit was mined by shrinkage stoping. Later, for prevention of deterioration in ore grade, the overhand cut-and-fill stoping in which the lower grade ore is used for filling and only the higher grade ore is producted was adopted in parallel. Although it is not clear how long the cut-and-fill stoping was put in operation, this stoping is out of use now. With the recent degradation in grade of mined ore, the grade of filling material in the cut-and-fill stoping has become higher than the grade of mined ore, thus the recovering of filling material has replaced the cut-and-fill stoping .

The block caving was firstly used as a method to stope waste rock for filling of old shrinkage stope but later the block caving has adopted as a regular stoping for a mass of narrow veins.

At present, three methods are put in practical use: nonfilling shrinkage stoping , block caving and stoping of recovering filling material. Table 2–12 explains the production and the number of stopes by mining methods.

Table 2–12 Production and Number of Stopes by Mining Method

(actual data 1981)

Mining Method	Production (%)	Percentage of Production	Number of Stopes
Shrinkage Stoping	104,181	7.7	54
Recovery Stoping of Filling Material	239,343	17.6	32
Block Caving	1,012,491	74.7	7
Total	1,356,015	100.0	93

2–3–2 Block Caving

The block caving is applied to the mass of narrow veins. Mining blocks are from 7,000 m^2, the largest and about 1,000 m^2, the smallest, and the height varies from about 60 m to 140 m. Table 2–13 shows the changes in working states of stopes since 1960. At present, seven stopes are under exploitation and four stopes are in preparation.

1) Preparation for exploitation

A grizzly level is provided below the mining block to be stoped, and several to several tens of antler-shaped transfer raises (ore-pass: 1.5 m x 1.5 m) are excavated between the grizzly level and the shute gate of the main haulage level at L 650. The grizzly level is excavated in a dimension of 2.0 m width and 2.0 m height with the full utilization of existing drift. Grizzlies are installed in a zigzag on the right and left at a 10 m interval. Finger raises (branched ore-passes) are excavated from the grizzly level to the undercut level which runs 12 m to 14 m over the grizzly level. The horizontal development of the undercut level is conducted by making use of these branched ore-passes. To promote caving in a portion where the rock is too hard, an isolation shrinkage stoping is performed around the mining block from the undercut level, and a sublevel is excavated to do coyote blasting in the mining block. The top of finger raise has cone shape with a 8.0 m diameter.

Plans at mainly level of Block 5–d are shown in Fig. 2–2 to Fig. 2–3.

The grizzly level is previously reinforced with concrete lining because the level will be severely damaged.

2) Exploitation

Ore caved into the undercut level runs out on grizzlies through finger raises, and is put under the secondary blasting which mainly aims at blister shooting of large lumps, and then fall into ore-passes. A grizzly is formed by putting iron rectangular rod (12 cm square) side by side with a 30 cm space. Fig. 2–4 is a typical picture of block caving.

2–3–3 Shrinkage Stoping

1) Preparation for exploitation

The shrinkage stoping is applied to a high-grade vein (about 5% content) which has a slope of 60° to 80° and a width of 30 cm to 40 cm.

The mining block is 40 m to 50 m in span and 30 m to 35 m in height. After excavating a drift, raises for access and sending-in of materials are made up to the upper level at each side of the mining block. Shute gates for ore drawing are installed with a 5 m interval, and the horizontal development is performed after completion of raises. In addition, a raise

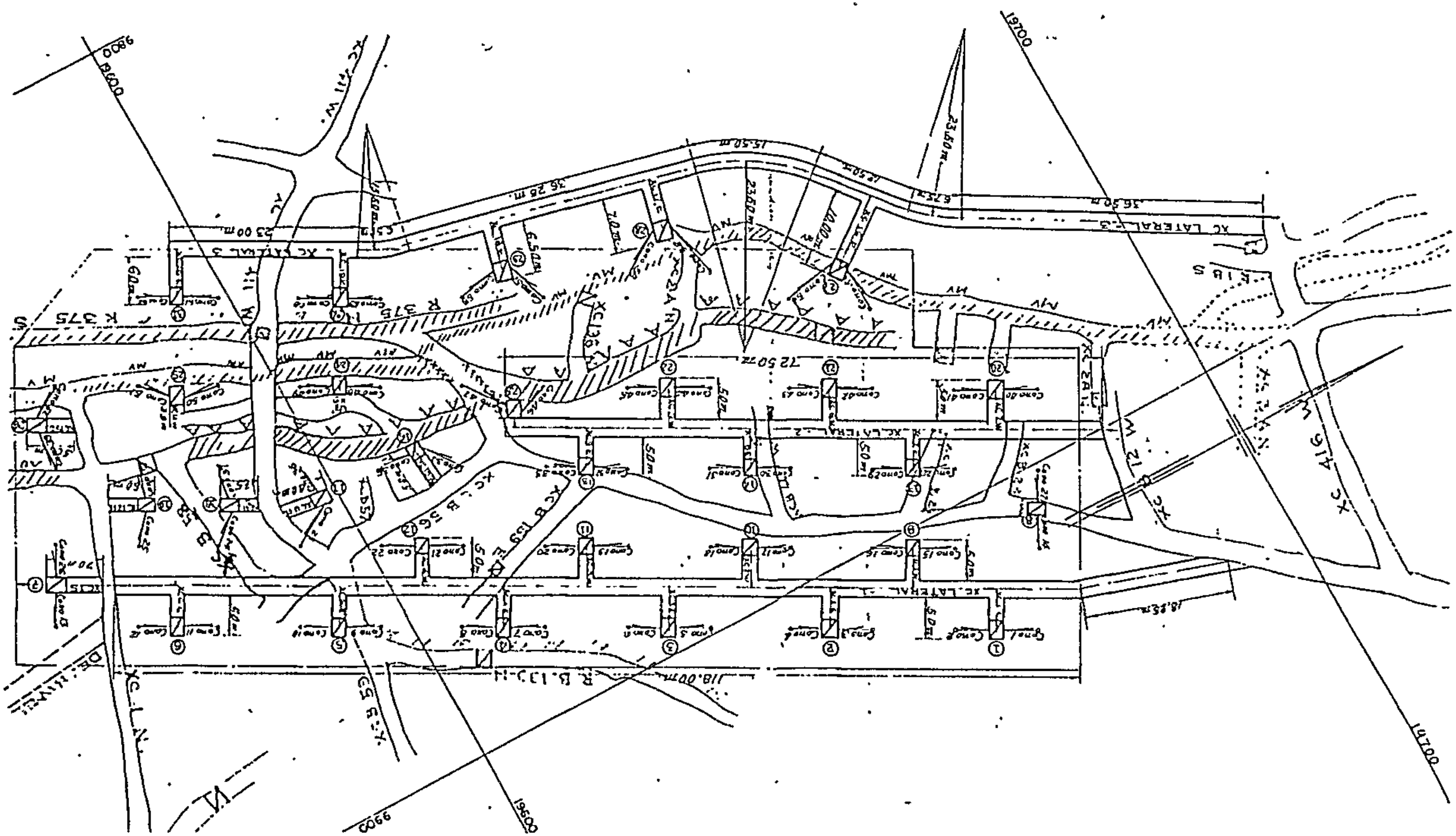
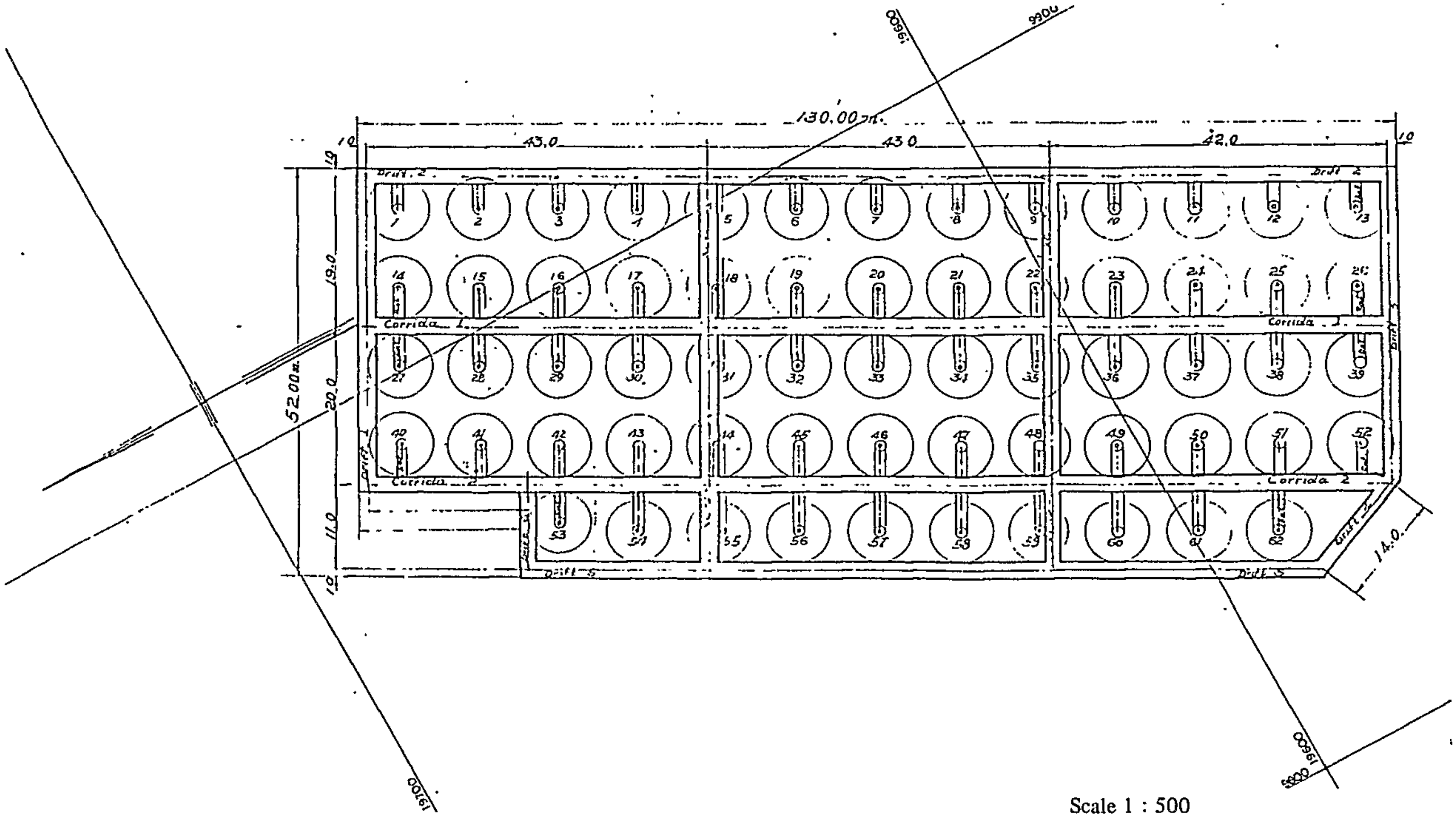


Fig. 2–2 Layout of Drift at Grizzly Level, Block 5–D



Scale 1 : 500

Fig. 2–3 Arrangement of Cones at Undercut Level, Block 5–D

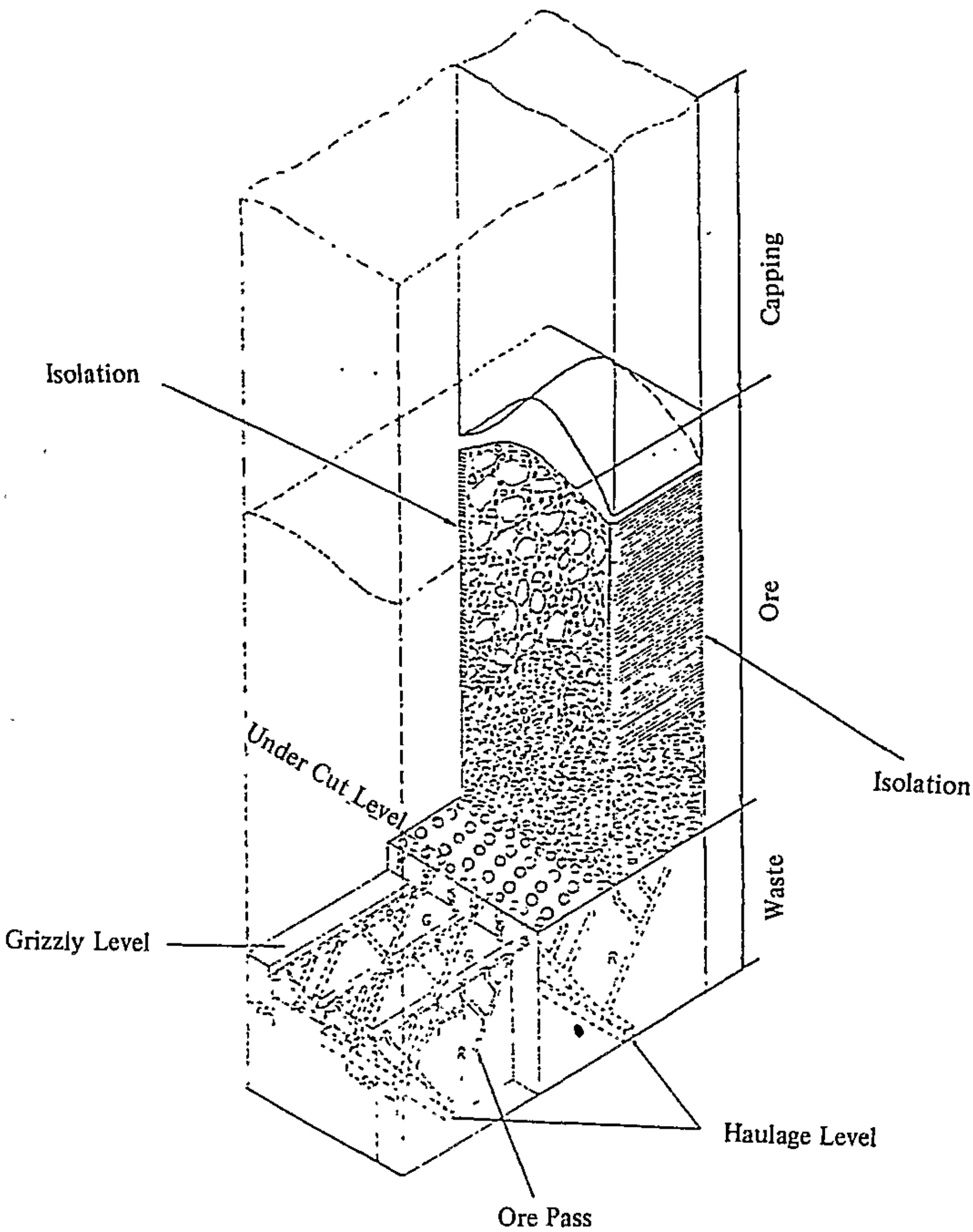


Fig. 2–4 Typical Picture of Block Caving

Table 2-13 Transition of Block Caving Stopes

Block No	General: Reserves of Minable Ore (Dry Ton)	General: Ore Grade (%)	General: Sn Metal (Ton)	Outline of Mining Block: Area (m2)	Undercut Level	Grizzly Level	Haulage Level	Height (m)	Top Level (m)	Influenced Top Level (m)	Outline of Preparation for Exploitation: No of Cone	No of Grizzly	No of Ore-pass	Horizontal Development (m)	Vertical Development (m)	Total Length of Development (m)	Total Length of Development per Man-shift
4-A	313,392	0 73	2,297 00	1,800	421	431	446	75	345	196	32	16	2	982 40	1,854 60	3,052 00	1 70
7	4,298,119	0 59	25,242 63	16,141	471 505	481 516	516 551	102 137	389	Surface	145	88	10	7,736 00	9,560 90	18,683 30	1 16
4-B	666,344	0 71	4,754 70	3,280	436	446	650	99	337	50	32	20	3	1,110 00	2,755 00	4,348 40	1 32
8-B	2,162,715	0 57	12,283 38	6,353	471	481	650	121 4	355	Surface	46	23	2	1,962 00	2,687 00	4,649 00	0 73
4	2,847,773	0 62	17,825 46	7,078	502	516	650	132	370	Surface	42	21	2	1,661 70	2,021 60	3,683 30	0 52
20	344,880	0 42	1,443 65	1,502	438	470	650	42	396	383	8	6	1	550 10	647 30	1,207 40	0 80
21	152,852	0 51	781 56	1,500	398	411	650	46	352	320	8	6	1	340 40	609 80	950 20	0 63
17	126,108	0.59	774 89	946	501	516	551	90	411	383	8	4	—	217 25	379 00	596 25	0 63
18	45,733	0 57	259 35	551	345	355	650	78	267	235	4	2	1	9 40	116 30	125 70	0 23
4-D	1,069,311	0 53	5,622 95	2,517	341	355	650	143	198	Surface	28	14	1	936 30 772 00	1,518 40 1,291 80	* 2,454 70 2 063 80	0 56
5-D	2,053,408	0 44	9,043 13	7,000	469	481	650	115	355	320	62	31	3	2,882 40 1,984 00	3,303 40 2,679 50	* 6,185 80 4,663 50	0 66
3-F	235,649	0.40	942 60	1,401	516	536	650	70	446	411	8	4	1	883 70 349 50	681 00 391 90	* 1,564 70 741 40	0 53
17-A	171,679	0 57	981 61	1,375	502	516	650	56	446	411	8	4	1	328 40 232 50	502 60 361 00	* 831 00 593 50	0 43
23	671,356	0 51	3,422 04	1,056	271	285	650	91	180	140	8	4	1	177 70 98 00	210 10 422 00	* 387 80 520 00	0 05
BAYONA	403,048	0.46	1,854 02	1,568	506	516	650	95	411	—	14	7	1	352 70 541 50	425 00 426 50	* 777 70 968 00	0 62
SAN JOSE	498,278	0.41	2,092 43	2,193	596	610	650	96	500	—	16	8	1	55 40 624 50	33 10 602 50	* 88 50 1,226 50	0 56
7-A	42,114	0.47	197 94	838	535	551	650	54	481	—	6	3	1	13 8 99 0	90 30 324 50	* 85 40 423 50	0 51

Block No	Outline of Others: Beginning Time of Preparation for Exploitation	Beginning Time of Exploitation	Period of Preparation for Exploitation (Month)	Period of Exploitation (Month)	Other Development (m)	Isolation (m2)	Production: Crude Ore (Ton)	Ore Grade (%)	Sn Metal (Sn Ton)	Difference between Crude Ore to Theoretical Reserve: Crude Ore (Ton)	Sn Metal (Sn Ton)	NOTE
4-A	Nov 1955	Jul 1959	30	81	215 00	—	766,549	0 41	3,109 99	+ 453,157	+ 812.99	Finished after exploited drawing over theoretical reserve
7	Nov 1958	May 1963	56	80	1386 40	63 61	5,223,190	0 42	21,927 19	+ 925,071	- 3,315 44	Finished after exploited drawing over theoretical reserve and deficit with Sn metal
4-B	Oct 1960	May 1967	80	—	463 40	19 84	1,053,513	0 44	4,668 45	+ 387,169	- 86 25	Finished after exploited drawing over theoretical reserve and deficit with Sn metal
8-B	Aug 1962	Aug 1970	97	—	20 70	—	* 2,850,682	0 43	12,409 59	+ 687,967	- 126 21	Under exploitation
4	Dec 1965	Aug 1972	80	—	382.60	—	* 2,887,540	0 61	17,566 81	+ 39,767	- 258 65	Exploited drawing over theoretical reserve
20	Jan 1972	Mar 1975	51	—	17 20	84 85	* 239,962	0 40	949 92	- 104,918	- 493 73	Under exploitation
21	Jan 1972	Sep. 1973	20	—	—	27 36	168,285	0 25	664 74	+ 15,435	- 116 82	Finished after exploited drawing over theoretical reserve and deficit with Sn metal
17	—	Jan 1979	—	—	—	—	65,819	0 66	436 00	- 60,289	- 338 89	
18	Oct. 1970	Jan. 1971	4	22	—	—	123,356	0.43	533 23	+ 77,623	+ 273 88	Finished after exploited drawing over theoretical reserve
4-D	Nov 1972	Jun 1975	31	—	—	—	* 463,004	0 32	1,461 30	- 606 307	- 4,161.65	Under exploitation
5-D	Mar 1975	—	—	—	—	898 00	* 512,660	0 38	1,954 58	- 1,540,748	- 7,088.55	Partly under exploitation and partly under preparation for exploitation
3-F	Nov 1975	Aug. 1977	21	—	—	272 00	* 111,714	0 32	361 56	- 123,935	- 581.04	Under exploitation
17-A	Nov 1976	—	—	—	—	—	* 158 412	0 44	703 85	- 13,267	- 277.76	Under exploitation
23	Oct 1977	—	—	—	—	—						Under preparation for exploitation
BAYONA	Nov 1978	—	—	—	—	58 63						Under preparation for exploitation.
SAN JOSE	Oct 1978	—	—	—	—	131 00						Under preparation for exploitation
7-A	Jan 1979	—	—	—	—	—						Under preparation for exploitation.

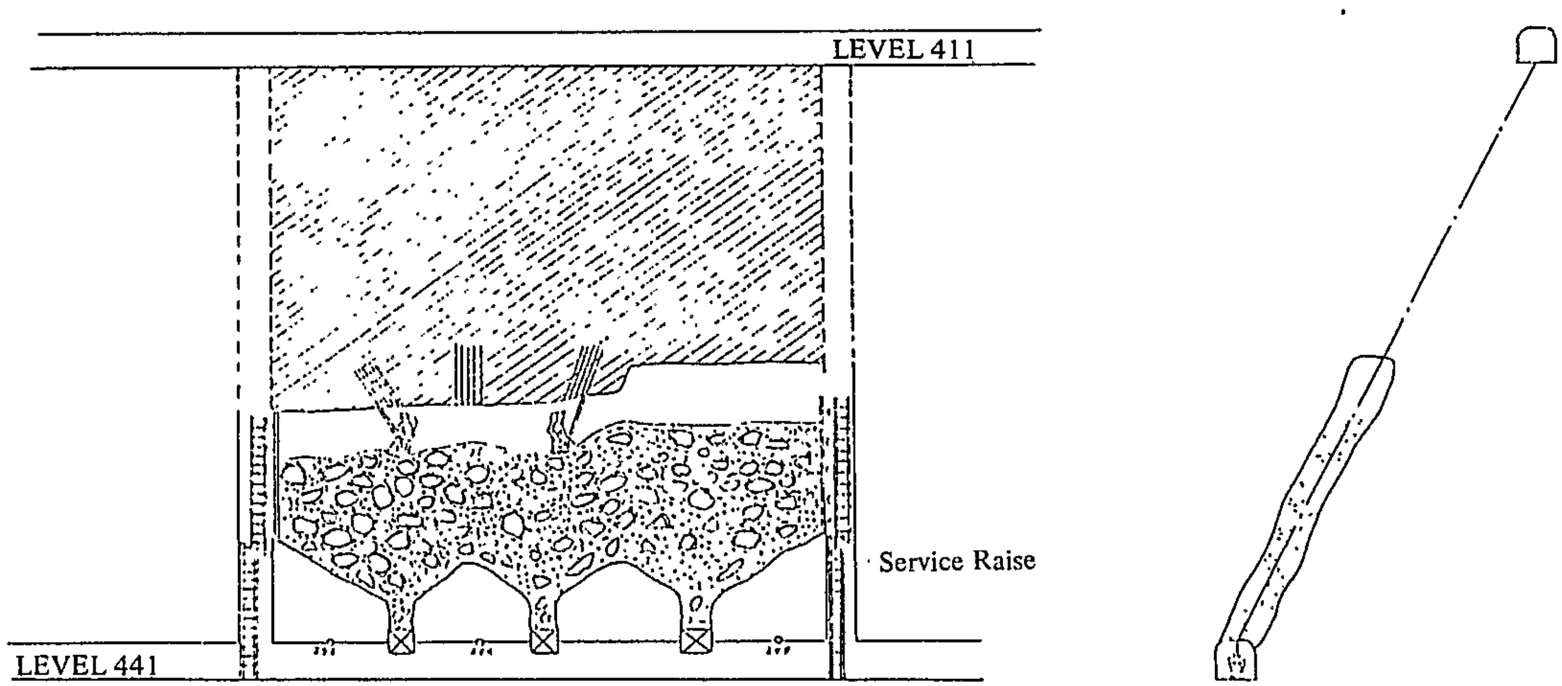


Fig. 2–5 Typical Section of Shrinkage Stopping

is excavated up to the upper level at the center of the stoping span to be used as a free face for blasting and for grade check.

2) Exploitation

Exploitation is carried out in such a way that upward drillings of 0.6 m to 0.8 m width are provided with a stoper in two rows with a 0.4 m interval by using broken ore as a working floor. The drilling length is usually 2.0 m. After completion of drilling on one slice, blast with dividedly several block. The swelled volumes of broken ore are drawn out through shute gates, the level of crushed ore is leveled by labor, and then drilling of the next slice is started.

The ore drawn out through shutes gates are loaded to mine tubs (1.7 ton or 0.75 ton), and transported by a trolley locomotive or a battery locomotive (4 ton or 2.5 ton) to and thrown into the nearest ore chute.

A typical section of shrinkage stoping is shown in Fig. 2–5.

2–3–4 Operational State by each Mining Methods

1) Block caving

(1) Working system

The stoping work is performed under a three-shift system. One grizzlier takes one grizzly, scrapes ore on the grizzly, and dose secondary blasting crushed large lumps. In addition, there are several laboreres for choke blasting. They blast large lumps, which do not flow down, into one enough small to drop. The shift change is every month, and the grizzlier also changes the charged grizzly every month. The timberer works on the change of damaged grizzly with a new one and the roof timbering in the vicinity of each draw-points.

(2) Machine and explosives for work

Rock drill	....	sinker
Rock breaker	....	pick hammer, breaker
Other	....	iron rod, gaff
Explosives	....	dynamite, AN-FO (loose) and fuse for secondary blasting

(3) Working state

Even small lumps of ore cannot easily fall because the gap of grizzly is as narrow as about 30 cm. When ore does not fall from a grizzly by poking with an iron rod or a gaff, blaster shooting is immediately put in practice. Blaster shootings are conducted at about 15 minutes intervals. All the labors, at a siren alarm, take shelter in inlet levels on both sides and rest for four to five minutes. The standard for the gap of a grizzly is 25 to 30 cm, but gaps enlarge gradually during use and some gaps have been widened as much as 50 cm to 55 cm. In general, lumps greater than 60 cm in size have been reported reaching about 50 percent. Drilling for secondary blasting with a rock drill seems to be rarely used; either a rock drill or a breaker gives a heavier physical load than that from a blaster shooting, so that drilling for secondary blasting with a rock drill is not used even if the foreman instructs to do so, and the real efficiency has not gone up.

(4) Application of explosives

Table 2–14 illustrates the application of explosives in block caving.

Table 2–14 Powder Factor of each Block Caving

(Data by 197!

Item / Block	Dynamite (Kg/Ton)	AN-FO (Kg/Ton)	Total Powder (Kg/Ton)	Cap (piece per Ton)	Fuse (m/Ton)
(Block Caving)					
4	0.10	1 27	1 37	1 21	0 79
4-B	0 11	1 48	1 59	1 52	0 97
4-D	0 09	1 51	1 60	1 22	0 79
8 B	0 09	1.17	1 26	1 16	0 75
5-D	0 12	2.78	2.90	1 71	1 39
Average	0 10	1 58	1 68	1 31	0 91
(Mini Block Caving)					
3-F	0 03	0.86	0 89	0 59	0 55
17-A	0.10	1 12	1.22	1 48	1.35
20	0 08	1 72	1 80	1 47	1.13
Average	0 07	1 16	1 23	1 14	0 99

The table indicates that the consumption of explosive is too much for block caving which requires no explosives essentially, and this is a problem also in cost.

2) Shrinkage stoping

(1) Working system

The stoping work, carried out with a three shifts system, is unique because rock drilling and blasting is main work for the first shift, and mucking of ore is for the second and the third shifts.

In the first shift, one group consists of four persons; a head, a driller, an assistant driller and a general assistant. The work is done separatedly at two faces; one is a shrinkage stope and the other is an excavation face of a drift.

(2) Machine for work

Rock drill stoper

Bit, rod insert-type, hexagonal, hollow,

22 mmφ

first rod .... 0.6 m

second rod .... 1.2 m

thrid rod .... 1.8 m

fourth rod .... 2.4 m

(3) Working state

The working state at shrinkage stope, mainly the drilling efficiency, was investigated. The result has made it clear that the drilling speed is not so good because the air pressure is low (about 4 kg/cm^2). Table 2–15 shows the drilling efficiency. The causes for the low air pressure can be due to the convergence of rock drilling operations and air consumption into the first shift, and to the air pressure loss, air leakage, etc. which are brought about owing to the distance from the compressor room.

Table 2–15 Drilling Efficiency

Hole No	Drilling Length (cm)	Requirement Time (min)	Drilling Efficiency (cm/min)	Pressure of Compressed Air (Kg/cm^2)	Note
1	230	11.6	19.8 *1	4.0	*1 drilling only
2	230	6.6	34.8 *1	4.7	
3	230	11.8	19.5 *2	3.5	*2 Lack of pressure of compressed air at 9:35'
4	230	9.9	23.2 *3	4.0	*3 Included with positioning and rod change
Average			24.3		

Should the real working time of the first shift be 6.5 hours, then the number of drillings in one shift will be:

6.5 (hr) x 60 (min/hr) x 24.3 (cm/min) ÷ 230 (cm) = 41

This figure coincides with the figure given by the chief section at site. The efficiency of charging and blasting is about 30 per shift. At a shrinkage stope, when the drilling span is 50 m length, drilling of 2.2 m of one slice is established in one month. Therefore, the production per month can be estimated as follows:

50 (m.L) x 0.8 (m.W) x 2.2 (m.H) x 2.8 (t/m^3) = 246.4 (t)

(4) Consumption of explosives

The consumptions of explosive by shrinkage stoping are listed in Table 2–16.

The table shows that the consumption ratio of low-cost AN-FO is as high as 90 percent, which indicates an effort to keep the lower cost.

The consumption of explosives indicates that explosives are somewhat overcharged, which can be assumed to be adequate by taking the hard rock into consideration.

Table 2-16 Powder Factor by Shrinkage Stopping

(Data by 1979)

Section \ Kinds	Dynamite (Kg/Ton)	AN FO (Kg/Ton)	Total Powder factor (Kg/Ton)	Cap (piece per Ton)	Fuse (m/Ton)
Animas	0 12	0.85	0 97	0 99	1.50
Salvadora	0 09	0.80	0 89	1.16	1 43
Sigro XX	0.13	0 90	1 03	1 22	1.71
Laguna	0.12	1.39	1.51	1 44	1.81
Beza	0 10	0.92	1 02	1 02	1.53
Average	0.11	0 99	1.10	1.15	1 60

2-4 Mining Equipment

Main mining facilities are compressors, drainage pumps, fans, hoisting equipment, haulage equipment, water supply, powder magazine, rock drills and loading machines.

In general, many installed machines are old (about 50 years ago), while portable ones are relatively new.

2-4-1 Specifications, Numbers and Locations of Existing Equipments

1) Compressors

Specifications, numbers and locations of compressors are listed in Table 2-17.

Table 2-17 Compressors

No.	Company	Type	Theoretical Capacity (m^3/min)	Actual Capacity (m^3/min)	Efficiency (%)	Condition	Motor			Location	Cooling Method
							Type	Power (H.P)	Voltage (V)		
1	Atlas Copco	ER-9	99 1	70 0	70	Good	Electric	455	550	Cancañiri	Water Cooling
2	"	ER-9	99.1	70 0	70	Good	"	455	550	"	"
3	JOY	TA-50MNA	142 0	99.4	70	Repaired	"	1,000	3,000	"	"
4	Atlas Copco	AR-9	88.3	52.9	65	Normal	Diesel	570	-	"	"
5	Ingersoll -Rand	PRE-2	181.2	108.7	60	"	Electric	825	3,000	"	"
6	"	PRE-2	90 6	54 4	60	"	"	400	3,000	"	"
7	"	PRE-2	181.2	108 7	60	"	"	900	3,000	"	"
8	"	PRE-2	90 6	54.4	60	"	"	400	3,000	"	"
9	"	PRE-2	50.9	30.5	60	"	"	200	440	Animas L411	Air Cooling

Ingersol-Rand compressors (No. 5 to No. 9) were manufactured in 1920s, and careful operation of these old machines must be admired, but renewal is required because of poor efficiency, and expenditure of much time and labor for trouble-shooting.

2) Drainage pumps

Drainage pumps are summarized in Table 2–18.

Table 2–18 Pumps

No.	Company	Location	Maximum Capacity of Pump (m^3/hr)	Diameter (in.)		Head (m)	P. H. of mine water	Motor	
				Suction	Discharge			H. P.	V
1	Alis Chalman	L 685	20	6	5	35	3.0	100	440
2	"	L 685	20	6	5	35	3.0	100	440
3	"	L 720	20	6	5	35	3.0	100	440
4	"	L 720	20	6	5	35	3.0	100	440
5	"		20	6	5	35		75	220/440

3) Water supply

Water supply is shown in Table 2–19.

Table 2–19 Equipment of Water Supply

No.	Company	Location	Maximum Capacity of Water Supply (m^3/hr)	Diameter (in)		Head (mmAq)	P. H of Water	Motor	
				Suction	Discharge			H. P	V
1	Arudorich	Blanca Surface L50	17	3 1/2	9	200	6.5	24	220
2	"	Blanca Surface L50	17	3 1/2	9	200	6.5	24	220

4) Hoisting equipment

The specifications of hoisting equipment for every shaft and every incline are listed in Table 2–20.

5) Fans

The specifications and numbers of fans at every location are summarized in Table 2–21.

No. 1 and No. 10 fans are out of operation, and it is unknown if they are under repair or out of use.

Table 2–20 Winding Machines

No.	Location	Section	Hoisting Level	Depth (m)	Payload of cage (Ton)	Drum	Rope Diameter (mm)	Motor		Type of Cages
								H.P	V	
1	BEZA Shaft	Beza	411	240	4	Single Drum	22	125	230	2-Setp
2	ANIMAS Shaft	Animas	50 (Surface)	333	4	Double Drum	22	150	440	1-Step
3	BLANCA Shaft	Beza	295	116	4	Single-Drum	22	75	220	1-Step
4	MISTICO Shaft	Laguna	125	258	4	Double Drum	22	121	440	1-Step
5	VICTORIA Shaft	Animas	383	147	4	Single Drum	22	75	230	1-Step
6	SAN MIGUEL Shaft	Salvadora	383	272	4	Double Drum	22	200	3,000	2-Step
7	Incline 620 ~ 800	Sigro XX	620	180	7	Double Drum	25	300	3,000	Skip
8	MAESTRO Shaft	Sigro XX	650	70	4	Single Drum	22	40	220	1-Step
9	Incline 411 ~ 383	Beza	383	50	3	Single-Drum	19	40	220	Skip

Table 2–21 Mine Ventilation Equipment

No.	Ventilation Level	Location		No. of Fan	Power (H.P.)	Type	Voltage (V)	Theoretical Air-quantity (m^3/min)	Theoretical Air-pressure (mmAq)
		Block	Section						
1	385	4-D	Laguna	1	60	Centrifugal	440	1,132	76.2
2	411	3-D	Beza	1	100	Axial	440	1,698	76.2
3	446	8-B	-	1	60	Centrifugal	440	1,132	76.2
4	411	8-B	-	2	20-	Axial	440	566	50.8
5	411	8-B	-	1	150	Axial	440	3,396	76.2
6	516	4	Salvadora	1	215	Axial	440	3,396	76.2
7	516	17-A	-	1	20	Axial	440	566	50.8
8	516	5-D	Siglo XX	1	100	Axial	440	1,698	76.2
9	600	3-D	Animas	1	150	Axial	440	3,396	76.2
10	516	4	Salvadora	1	75	Centrifugal	440	1,132	76.2
11	530	Victoria 3-F	Animas	1	40	Axial	440	311	50.8
12	551	5-D	Beza	1	125	Axial	440	3,396	76.2
13	600	20	Salvadora	1	20	Axial	440	509	50.8
14	600	Victoria 3-F	Animas	1	20	Centrifugal	440	566	50.8
15	650	3-D	-	1	60	Centrifugal	440	1,132	76.2
16	650	Reggas	Salvadora	1	60	Axial	440	1,132	76.2
17	650	4	Ore-Pass No. 1	1	10	Axial	440	170	25.4
18	516	4	Salvadora	2	20	Axial	440	1,019	76.2
19	600	3-D	Animas	1	100	Axial	440	1,698	76.2

6) Haulage equipment

The haulage equipment is mainly composed of locomotives and mine tubs, and their specifications and numbers are shown in Table 2–22. The detailed specification on the 10-ton trolley locomotive is listed in Table 2–23.

Table 2–22 Haulage Equipment

[Locomotive]

No	Type	Weight (Ton)	Power (kw)	Track Gauge (mm)	Number of Locomotive
1	Trolley	10	25kw x 2	610	11
2	Trolley	8		610	9
3	Trolley	7		610	2
4	Trolley	6		610	1
5	Trolley	4		610	23
6	Trolley	2.5		610	7
7	Trolley	1.5		508	13
8	Battery	1.5		508	13
Total					79

[Mine-Car]

No	Type	Payload (Ton)	Track Gauge (mm)	Number of Mine-Cars
1	Rigid-Car	0.65	508	7
2	"	0.75	508	79
3	"	1.70	610	169
4	Granby-Car	2.00	610	44
5	"	3.30	610	11
6	"	5.00	610	130
Total				440

Table 2–23 Specification of 10 Ton Haulage Locomotive

Motor Power	25 KW x 2
Using Voltage	250 V
Weight	1,700 Kg
Length	4,500 mm
Width	1,048 mm
Height	Max. 2,400 mm Min. 1,800 mm
Speed	10.5 Km/hr
Wheel Diameter	680 mm

7) Mining equipment

The mining equipment includes stopers and leg-drills for drilling, mine car loaders for loading, and raise borer made by Alimak Co. and Turmag Co. in West Germany for raise. The specifications and numbers of drilling machines are shown in Table 2–24, and those of loaders in Table 2–25.

There is no large loader, and all loaders are of TAIKU 600-B class in Japan.

2–4–2 Actual Operating Conditions of each Equipment

1) Compressors

(1) Operational conditions

The first shift consumes a lot of compressed air in underground, while the second and third shifts use it for air blowing of faces. Consequently all the compressors are fully operated during the first shift, but only a limited number of compressors are in operation during the second and the third shifts.

(2) Air pressure

The air pressure is usually 4.8 to 5.2 kg/cm^2 during the first shift, while it is about 5.6 to 7.0 kg/cm^2 during the second and the third shifts as well as on Saturday when a little of compressed air is consumed.

The reasons for such a low air pressure are (i) this mine is so high as 3,800 m from the sea level, (ii) machines are old, (iii) the underground piping is too long, and (iv) the inner diameter is too small (12B) for such a long distance of piping.

The mine has a plan to make the compressed air pipe larger in near future; that is to say the existing pipes are replaced with 20B pipes to go up the air pressure at any face site.

(3) Number of labors

The number of operators are three for the first shift, two for the second shift, and three for the third shift. In addition there are several repairmen.

(4) Consumption of compressed air

The actual record on consumption of compressed air in 1980 was about 21,065,000 m^3 in monthly average, and the figure per ton of production was 187 m^3/t.

2) Drainage pumps

(1) Operational conditions

There are two acid-proof drainage pumps; one is in operation and another is standby. The operation of drainage pump is not automated; mechanical operators of the Department of Maintenance patrol constantly to operate the pump watching the drainage conditions. When the power supply stops due to an accident in the power transmission line, the pump can continually run by switching the line to the emergency supply line from the Public Power Supply Corporation (ENDE).

(2) Piping and others

Table 2–24 Drills

No.	Company	Type	Model	Number of Drills	Number of Stock	Total
1	Atlas Copco	Telescopic	BBC-34-W8	1	0	1
2	Gardner Denver	Chichala	S-55	7	0	7
3	"	"	S-33	4	0	4
4	SIG	Jack Leg	PLB-23-CL	24	0	24
5	Atlas Copco	"	PH-656-4W	43	0	43
6	"	"	PH 656-4W	13	0	13
7	Ingersoll -Rand	Telescopic	R-38-A	1	0	1
8	"	"	JB-38 C	3	0	3
9	Falcon	"	BBD-46-N	1	0	1
10	SIG	"	PLS-23-95	1	0	1
11	U.S.S.R.	Jack Leg	PL-25-L	3	0	3
12	Atlas Copco	"	BBD-90-W	145	3	148
13	"	"	BBD 96-W	19	5	24
14	Gardner Denver	Telescopic	R-104	3	0	3
15	"	"	RB-83	124	0	124
Total				392	8	400

Table 2–25 Loaders

No.	Company	Type	Capacity Bucket (m^3)	Track Gauge (mm)	Number of Loaders
1	Aimco	12 B		508	4
2	"	22-B		508	4
3	Gardner Denver			508	4
4	Atlas Copco	LN-56		508	7
5	U.S.S.R	PPW-18		508	21
Total					40

The piping for drainage consists of acid-proof polyvinylchloride pipes (8B), the mechanical strength of which is sufficient because the pump head is small. The rubber liner is manufactured at the Rubber Shop of Catavi mine.

(3) Drainage quantity from underground

The drainage quantity from underground is some 0.87 m^3/min, the quality is strongly acid with 1.5 to 2 in pH.

3) Water supply

(1) Water supply system

The water supply system is illustrated in the following flow sheet.

Catavi reservoir	
↓	
Pump	
↓	
Water supply tank (concrete)	Siglo XX Sink and Float Plant
↓	
Pump	
↓	
Blanca pumping station	
↓	
Pump	
↓	
Bismark level	L50
Water tank for underground	L125
Faces	

(2) Operational conditions

There are two pumps; one is in operation and another is standby. Operation of the Department of Maintenance patrol constantly to check operational conditions.

4) Hoisting equipment

All shafts and inclines other than the large inclines L620 to L800 are used for transportation of men and materials. The large inclines were merely excavated, and they are out of present use as they are filled with water.

(1) Operational conditions

Since the underground working is done in three shifts, one operator per one shift is disposed at each hoisting machine and furthermore two mechanics are assigned to each shift for maintenance and inspection of machines. These hoisting operators and mechanics are under the control of the Department of Maintenance. A signal operator stays always in the cage of each hoisting equipment and pushes the switches with the hand extended from the cage at a plat where the cage speed is lowered, thus he informs the hoisting operator with the specified code signals and notifies the stop level of the cage. The signal operator belongs to the Department of Maintenance.

(2) Rope

The hoisting wire rope is renewed periodically (every two years).

(3) Cage

The cage is made of iron and equipped with a safety door. The gap between the cage and the timbering set is narrow, which may be dangerous. The door has to be improved in its functional structure. All the cages are too small and inadequate for transportation of materials.

5) Ventilation equipment

The ventilation equipment is used at all faces of block caving. The equipment consists of an exhauster to remove dust and blasting fume mainly caused from exploitation, and a blower to send in fresh air. The equipment is not used at shrinkage stopes and drifting faces.

(1) Operational conditions

The operational conditions of ventilation equipment are shown in Table 2–26. Some fans do not operate at the rated quantity of airflow, and it is noticeable that such fans are mostly large exhausters.

Blow pressures are fairly low when compared with the rated blow pressure, and this means that fans do not operate with reasonable efficiency.

(2) Air door

The control on air doors of ventilation equipment is important. The control is relatively good around exhausters but fairly rough in the inlet side.

(3) Fans

There are many fans made in Sweden. Some large fans are under repair; rewinding of burnout motors, replacement of worn wings with home-made ones, etc. However, such repairs may lower the performance. (see Table 2–26)

6) Haulage equipment

Ore is hauled by the combination of a trolley locomotive and mine tubs, and materials by the combination of an locomotive and carriages.

The number of locomotives and mine tubs for the sites are listed in Table 2–27 and 2–28. The partition in classification by purchase year is five years.

Large locomotives are used for main haulages at L560, while small ones for sublevel haulages because of smaller cross-sections. The classification by purchase year indicates that many large locomotives are relatively new, while most small locomotives were made 25 years ago and no its renewal can been seen.

Table 2–26 Actual Condition of Operating Fans

No.	Ventilation Level	Block	Air-quantity Theoretical (m^3/min)	Air-quantity Actual (m^3/min)	Pressure Theoretical mm water	Pressure Actual mm water	Arrangement of Fan
1	385	4-D	1,132	1,075			
2	411	5-D	1,698	1,528	127	76.2	Blowing
3	446	8-B	1,132	991	127	76.2	Blowing
4	481	8-B	566	510		50.8	Blowing
5	481	8-B	3,396	1,189	127	76.2	Exhaust
6	516	4	3,396	1,755	127	76.2	Exhaust
7	516	17-A	566	453		50.8	Blowing
8	516	5-D	1,698	1,641	127	76.2	Blowing
9	600	3-D	3,396		127		
10	516	4	1,132				
11	530	3-F	566	340		50.8	Blowing
12	551	5-D	3,396	1,528	127	76.2	Exhaust
13	600	20	509	481		50.8	Exhaust
14	600	3-F	566	509		50.8	Exhaust
15	650	3-D	1,132	991	127	76.2	Exhaust
16	650	Reggis	1,132	1,104	127	76.2	Blowing
17	650	4	170	142		25.4	Blowing
18	516	4	566	481			Blowing
19	600	3-D	2,264	1,981	127	76.2	Exhaust

Table 2–27 Classification of Locomotives by Location and Years

Location		Trolley · Locomotive							Battery-Locomotive	Total
		10 Ton	8 Ton	7 Ton	6 Ton	4 Ton	2.5 Ton	1.5 Ton	1.5 Ton	
Animas		–	–	–	–	6	1	1	1	9
Laguna		–	1	1	–	2	–	5	2	11
Salvadora		–	–	–	–	2	–	2	4	8
Beza		–	–	–	–	9	–	3	2	14
Siglo XX		–	2	–	1	3	–	2	4	12
L650 Main Haulage		11	–	–	–	–	–	–	–	11
Siglo XX Machine Shop		–	6	1	–	–	–	–	–	7
Cancañiri Machine Shop		–	–	–	–	–	1	–	–	1
Cancañiri Material Haulage		–	–	–	–	–	3	–	–	3
Siglo XX Man Haulage		–	–	–	–	1	2	–	–	3
Total		11	9	2	1	23	7	13	13	79
Year	1976 ~1980	3	–	–	–	2	–	–	7	12
	1971 ~1975	8	3	2	1	–	1	–	–	15
	1966 ~1970	–	1	–	–	1	–	–	1	3
	1965 ago	–	5	–	–	20	6	13	5	49

Table 2–28 Classification of Mine Cars by Location and Years

Location		0.65 Ton	0.75 Ton	1.70 Ton	2.00 Ton	3.30 Ton	5.00 Ton
Animas		1	9	47	–	–	–
Laguna		1	26	23	–	11	–
Salvadora		2	16	25	–	–	–
Beza		1	8	57	5	–	–
Siglo XX		2	20	17	39	–	130
Total		7	79	169	44	11	130
Year	1976 ~1980	3	40	49	5	–	–
	1971 ~1975	4	39	120	–	11	8
	1966 ~1970	–	–	–	1	–	22
	1965 ago	–	–	–	38	–	100

Table 2–29 Classification of Drills by 5 Years

Company	Type	Years 1976 ~ 1980	1971 ~ 1975	1966 ~ 1970	1965 ago	Total
Atlas Copco	Telescopic	1	–	–	–	1
Gardner Denver	Chichala	–	3	–	4	7
"	"	–	–	4	–	4
SIG	Jack Leg	22	2	–	–	24
Atlas Copco	"	11	6	11	15	43
"	"	2	2	2	7	13
Ingersollrand	Telescopic	–	–	–	1	1
"	"	1	1	1	–	3
Falcon	"	–	–	1	–	1
SIG	"	–	1	–	–	1
U S S.R.	Jack Leg	3	–	–	–	3
Atlas Copco	"	90	51	4	3	148
"	"	24	–	–	–	24
Gardner Denver	Telescopic	–	–	1	2	3
"	"	22	66	34	2	124
Total		176	132	58	34	400

Table 2–30 Classification of Loaders by Location and Years

Location		AIMCO 12–B	AIMCO 22–B	Gardner Denver	Atlas Copco LN-56	U S.S R. PPW-18	Total
Animas		–	–	–	1	5	6
Laguna		1	–	–	1	1	3
Salvadora		1	–	1	1	–	3
Beza		–	–	2	3	7	12
Siglo XX		2	4	1	1	8	16
Total		4	4	4	7	21	24
Year	1976 ~ 1980	–	4	–	6	14	24
	1971 ~ 1975	1	–	–	–	7	8
	1966 ~ 1970	3	–	1	1	–	5
	1965 ago	–	–	3	–	–	3