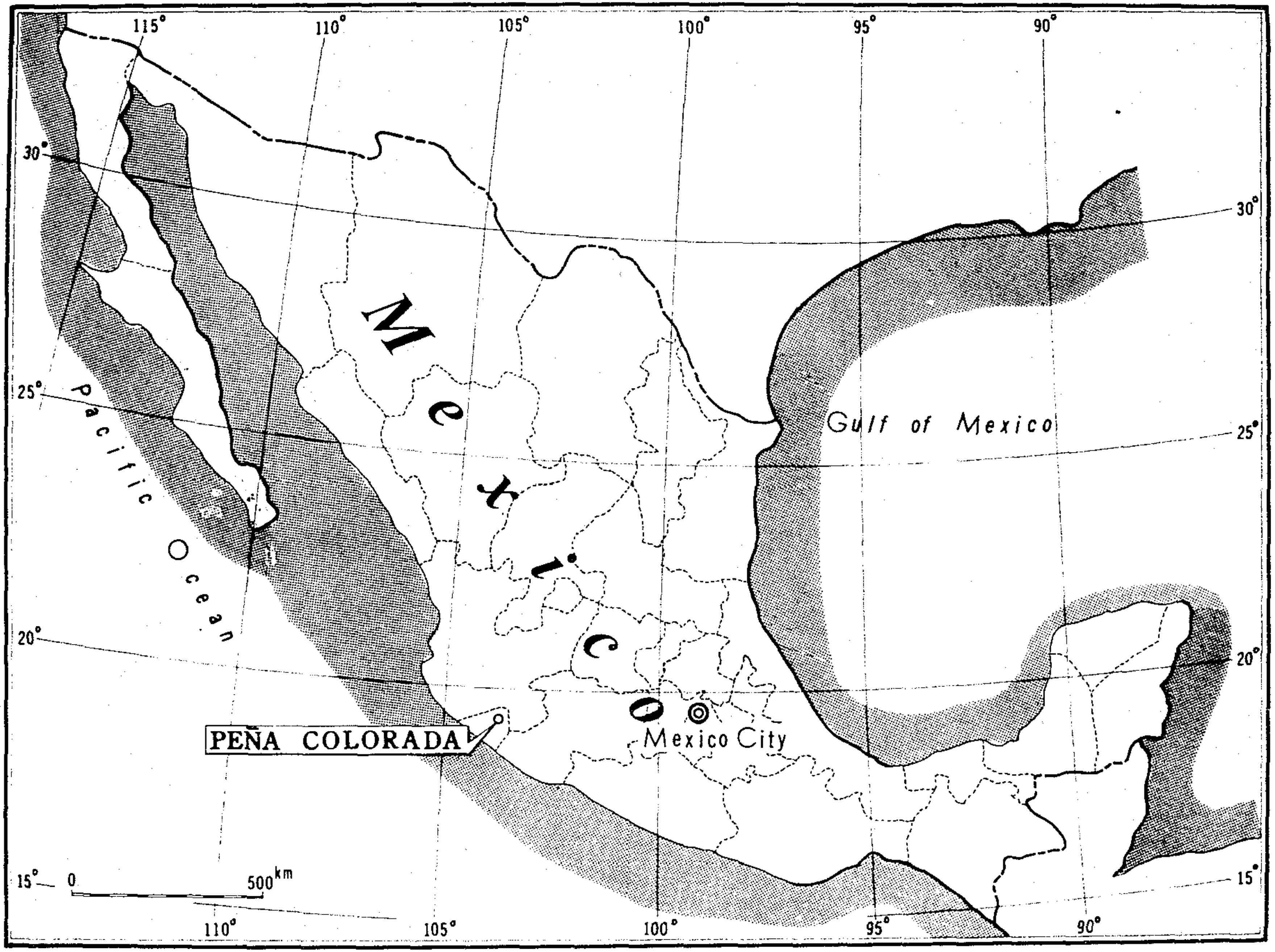
# REPORT ON INVESTIGATIONS OF IRON ORE DEPOSIT AT PEÑA COLORADA MINE

## REPUBLIC OF MEXICO

NOVEMBER 1964

OVERSEAS TECHNICAL COOPERATION AGENCY, JAPAN

# REPORT ON INVESTIGATIONS OF IRON ORE DEPOSIT AT PEÑA COLORADA MINE IN THE REPUBLIC OF *Mexico*


Mexico
Gulf of Mexico
Pacific Ocean
Mexico City
PEÑA COLORADA
115°
110°
105°
100°
95°
90°
30°
25°
20°
15°
0
500km

# FOREWORD

In response to the request made by the Government of Mexico, the Government of Japan undertook to carry out the basic investigations relative to the exploitation of the Peña Colorada mine district located in the Colima Province, Mexico, and entrusted the Overseas Technical Cooperation Agency (OTCA), the executing agency, with the execution of the investigations.

The OTCA consequently organized and despatched to Mexico in March 1964 a Survey Team consisting of 6 experts. The Team engaged in the field survey for a period of about 2 months, results of which are herein contained.

The OTCA was established in June 1962 as the executing agency of the Government of Japan for her overseas technical cooperation, and has since been actively engaged in various fields of technical cooperation on governmental basis including the despatch of experts to developing nations, acceptance of trainees, and performance of basic investigations for exploitation and development programmes designed to promote the public good.

I would feel it a great honour if this Report should serve in some measure for the exploitation of the iron ore resources in Mexico, and for the enhancement of the friendly relations and close economic ties happily existing between our two countries.

My deepest gratitude is hereby expressed to the Government of Mexico, affiliated organizations and other concerns for their invaluable assistance and cooperation.

S. Shibusawa

Shinichi Shibusawa
Director General

The Overseas Technical Cooperation Agency, Tokyo

# TABLE OF CONTENTS



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# 1. INTRODUCTION

# 1. INTRODUCTION

## 1-1 Outline of Investigations

### 1-1-1 Title of Survey Team

The title of the Survey Team is as follows.

*The Japanese Survey Team for Exploitation of Iron Ore Deposit in Mexico.*

### 1-1-2 Formation of Survey Team

Leader: Mr. Masatomo Hotta, Chief geologist, Nittetsu Mining Consultants Co., Ltd.

Member: Mr. Kenji Miki
Mr. Shoji Sato
Mr. Hiroshi Morita
Mr. Taiji Sakaino
Mr. Masatoshi Hasegawa

### 1-1-3 Investigation Items

(1) Peña Colorada Mine

(a) Geological investigations and preparation of a geological map indicating locations of ore deposits.

(b) Estimation of ore reserves and grades.

(c) Preparation of mining and beneficiation plans.

(d) Studies and review relative to the exploitation.

(e) Other related items.

(2) Investigations on geology and deposits of iron ore mines other than the Peña Colorada mine in Colima Province and its vicinity, and affiliated investigations.

### 1-1-4 Period of Investigations

45 days from March 6 to April 29, 1964. (Period of investigations by Mr. Sato and Mr. Hasegawa was 29 days)

## 1-2 Itinerary

See the attached sheet for the itinerary of the Survey Team.

The Consejo de Recursos naturales no Renovables of Mexico rendered the Survey Team various facilities and assistance including the despatch of Mexican engineers who accompanied the Team not only during the investigations at the Peña Colorada

## ITINERARY OF SURVEY TEAM

| Date and Day | Mr. M. Hotta, Leader & geologist | Mr. H. Morita, Geologist | Mr. T. Sakaino, Surveying engineer | Mr. K. Miki, Mining engineer | Mr. S. Sato, Mining engineer | Mr. M. Hasegawa, Beneficiation engineer |
|---|---|---|---|---|---|---|
| Mar. 16, Mon. | (All members) Tokyo —JAL→ Honolulu —JAL→ San Francisco —WAL→ Mexico City | | | | | (Overnight at Mexico City) |
| Mar. 17, Tue. | (All members) Courtesy call paid to the Japanese Embassy and the Natural Resources Bureau; Consultations with Ing. Obregon and Ing. Campo concerning the Team's schedule | | | | | ( " ) |
| Mar. 18, Wed. | (All members) Data and materials provided by, and consultations made with, Ing. Campo of the Natural Resources Bureau; Inspection of core of diamond drilling at the Peña Colorada mine | | | | | ( " ) |
| Mar. 19, Thu. | (All members) Ditto; Final arrangements for the Team's schedule | | | | | ( " ) |
| Mar. 20, Fri. | (All members) Mexico City —SAG→ Manzanillo, Preparations for camping including purchase of provisions | | | | | (Overnight at Manzanillo) |
| Mar. 21, Sat. | Courtesy call paid to the Governor of Colima Province by Mr. Hotta<br>(All members) Manzanillo ——→ Minatitlan | | | | | (Overnight at Minatitlan) |
| Mar. 22, Sun. | (All members) Rough inspection of iron ore deposits of the Pena Colorada mine (La Primorosa, La Encantada, Chinforinazo, & Espinazo del Diablo) | | | | | ( " ) |
| Mar. 23, Mon. | Geological investigations and surveys of the Pena Colorada mine | | | Investigations of proposed site for beneficiation plant near Milan | | (All members overnight at Minatitlan) |
| Mar. 24, Tue. | Ditto | | | Investigations on qualities of water | | ( " ) |
| Mar. 25, Wed. | Ditto | | | Investigations for the stripping plan of the deposits | | Investigations of proposed site for benficiation plant near Milan; Investigations on water qualities ( " ) |
| Mar. 26, Thu. | Ditto | | | Observation of ravines; Study of mining plan | | Investigations of the site for beneficiation plant ( " ) |
| Mar. 27, Fri. | Investigations for the location and water for beneficiation plant, and for drinking water | | | Study of the railway plan | Study of the mining plan | Same as Mr. Hotta ( " ) |
| Mar. 28, Sat. | Ditto | | | Study of the Project | | ( " ) |
| Mar. 29, Sun. | Ditto | | (Overnight at Minatitlan) | Minatitlan ——→ Manzanillo Observation of the route proposed for transporting concentrates | | (Overnight at Manzanillo) |
| Mar. 30, Mon. | Ditto | | ( " ) | Observation of the route proposed for transporting concentrates & earth moving machinery | Investigation of demand-supply situation of electricity; Investigations on port facilities | Same as Mr. Miki |
| | | | | (Overnight at Manzanillo) | | |

– To be continued –

| Date and Day | Mr. Hotta | Mr. Morita | Mr. Sakaino | Mr. Miki | Mr. Sato | Mr. Hasegawa |
|---|---|---|---|---|---|---|
| Mar. 31, Tue. | Investigations for the location of, and water for, beneficiation plant; Investigations for drinking water (Overnight at Minatitlan) | | | Investigations on port facilities (Overnight at Colima) | | Investigations on construction cost of structures |
| Apr. 1, Wed. | Ditto ( " ) | | | Investigations of El Encino mine ( " ) | | |
| Apr. 2, Thu. | Ditto ( " ) | | | Colima $\xrightarrow{SAG}$ Mexico City ; Progress of investigations reported at the Japanese Embassy; Compilation of data and materials (Overnight at Mexico City) | | |
| Apr. 3, Fri. | Ditto ( " ) | | | Consultations with Ing. Campo at Natural Resources Bureau (Overnight at Mexico City) | Investigations on earth moving machinery | Same as Mr. Miki |
| Apr. 4, Sat. | Preparation of a geological map indicating locations of deposits ( " ) | | | Investigations on earth moving and mining machinery (Overnight at Mexico City) | | Investigations on construction cost of structures |
| Apr. 5, Sun. | Ditto ( " ) | | | Compilation of data and materials ( " ) | | |
| Apr. 6, Mon. | Ditto ( " ) | | | Observation of Pachuca mine ( " ) | | |
| Apr. 7, Tue. | Minatitlan → Manzanillo; Specimen ores shipped to Japan (Overnight at Manzanillo) | | Surveying at the Pena Colorada mine (Overnight at Mititlan) | Mexico City → Dorango; Observation of Durango mine (Overnight at Durango) | | |
| Apr. 8, Wed. | Manzanillo → Observation of El Encino mine → Colima (Overnight at Colima) | | Ditto ( " ) | Durango $\xrightarrow{SAG}$ Mexico City (Overnight at Mexico City) | | |
| Apr. 8, Thu. | Observation of El Encino district ( " ) | | Ditto ( " ) | Investigations on earth moving machinery; Inspection of machine shop (Overnight at Mexico City) | | Electric power situation explained by the Committee for Electric Power |
| Apr. 10, Fri. | Colima $\xrightarrow{SAG}$ Mexico City (Overnight at Mexico City) | | Ditto ( " ) | Consultations for the Project; Courtesy call paid to the Japanese Embassy and the Consejo de Recursos Naturales no Renovables (Overnight at Mexico City) | | |
| Apr. 11, Sat. | Consultations with Ing. Campo re: observation of Las Truchas ( " ) | | Ditto ( " ) | Compilation of data and materials (Overnight at Mexico City) | | |

- To be continued -

| Date and Day | Mr. Hotta | Mr. Morita | Mr. Sakaino | Mr. Mikk | Mr. Sato | Mr. Hasegawa |
|---|---|---|---|---|---|---|
| Apr. 12, Sun. | Compilation of data & materials (Overnight at Mexico City) | | Surveying at Peña Colorada mine (Overnight at Minatitlan) | Compilation of data and materials (Overnight at Mexico City) | | |
| Apr. 13, Mon. | Power situation explained by Vice-chairman of Committee for Electric Power; Consultations with Chief of Planning Sec. of Admiralty ( " ) | Study of data of Las Truchas mine | Ditto ( " ) | Same as Mr. Hotta ( " ) | Departure from Mexico for Japan | |
| Apr. 14, Tue. | Mexico City —SAG→ Uruapan —Car→ Playa Azuru (Overnight at Playa Azuru) | | Minatitlan —Car→ Manzanillo (Overnight at Manzanillo) | Same as Mr. Hotta | | |
| Apr. 15, Wed. | Playa Azul ⇄Car Las Truchas Observation of Las Truchas ( " ) | | Manzanillo —SAG→ Mexico City (Overnight at Mexico City) | Ditto | | |
| Apr. 16, Thu. | Playa Azul —Car→ Uruapan (Overnight at Uruapan) | | Compilation of data of the Peña Colorada mine ( " ) | Ditto | | |
| Apr. 17, Fri. | Uruapan —SAG→ Mexico City (Overnight at Mexico City) | | Ditto ( " ) | | | |
| Apr. 18, Sat. | Consultations with the former chief of railway section of Communication Ministry concerning the railway construction plan from Manzanillo to Pena Colorada ( " ) | | | | | |
| Apr. 19, Sun. | Study of profiles of deposits of the Pena Colorada mine; Calculation of ore reserves; Study into the mining plan ( " ) | | | | | |
| Apr. 20, Mon | Ditto ( " ) | | | | | |
| Apr. 21, Tue. | Ditto ( " ) | | | | | |
| Apr. 22, Wed. | Ditto ( " ) | | | | | |
| Apr. 23, Thu. | Results of investigations reported to the Japanese Ambassador; Collection of data and materials on Mexican mining industry ( " ) | | | | | |
| Apr. 24, Fri. | Results of investigations explained to Ing. Obregon and Ing. Campo; Re-inspection of core of diamond drilling. ( " ) | | | | | |
| Apr. 25, Sat. | Courtesy call paid to the Japanese Embassy; Collection of data on Mexican mining industry ( " ) | | | | | |
| Apr. 26, Sun. | Compilation of data and materials; Preparations for departure ( " ) | | | | | |
| Apr. 27, Mon. – Apr. 29, Wed. | Mexico City —MAL→ Los Angels —JAL→ Honolulu —JAL→ Tokyo. | | | | | |

mine but also when the El Encino mine and Las Truchas mine were observed by the Team. The Team's request for relevant data and materials was also met by the Council with sincerity, enabling the Team to smoothly conduct the investigations as scheduled.

1-3 Location

The mine is located about 5 km west to Minatitlan village (Municipios Minatitlan, Departamento Colima) which is about 43 km north-east from Port Manzanillo on a direct line. In terms of longtitude and latitude, it is in the proximity of Long. 19° 21' 37" N. and Lat. 104° 03' 39" W.

1-4 Accessibility

Mexico City —By plane / 550 km, 8 hrs.→ Port Manzanillo —Truck road / 62 km, 8 hrs.→

Minatitlan —Jeep road / 6 km, 40 min.→ Mine

The traffic route is available for truck transportation connecting Port Manzanillo and Minatitlan, but the road condition is bad and no bridges are found constructed over the rivers. From Minatitlan to the mine, the traffic route for jeep communication is available in the dry season. In the wet season, however, the jeep communication becomes extremely difficult.

1-5 Climate (Outline of Meteorological Observation)

The results of meteorological observations made at Minatitlan for 3 years and 8 months from June 1960 to March 27, 1964 are as summarized below.

(1) Precipitation

The wet and dry seasons are clearly separated. The wet season starts from mid-June and ends around October 10, and the duration of the wet season recurs at almost regular intervals. During the dry season, there is very little rainfall, with practically no rainfall at all during 5 months from January to June.

During the 4 month period from June to October in the wet season, there are 15 - 20 rainy days each month, with precipitation recording 5 - 30 mm per day for half of the rainy days, 30 - 50 mm per day for 3 - 5 rainy days, and 50 mm and up for about 2 rainy days.

According to the above observation, the largest amount of rainfall recorded during the past 3 years and 8 months is 93 mm per day, with 5 rainy days which recorded 70 mm and up per day. Rainy days with the precipitation of more than 70 mm are therefore assumed to be 1 - 2 days throughout a year.

(2) Velocity of wind

Maximum wind velocity of 8 - 12 m/s is recorded most frequently.

(3) Temperature

Results of observations during the period from January to March 1964 indicate that the temperature rises to a maximum of 30 - 34°C and falls to a minimum of 8 -15°C. Throughout the year, the temperature never drops below 0°C.

(4) Humidity

The humidity is expressed by the volume of evaporation. The recording of evaporation during January ~ March period in the dry season is 2 - 6 mm per day. During June - September period in the wet season, it averages 2 - 7 mm per day, indicating that there is no fluctuation throughout the year.

*Meteorology at Minatitlan*

(As summarized from the records of Minatitlan Meteorological Observatory)

April 23, 1964 (2)

No. of Days by Precipitation and Velocity of Wind

Table No. 1-June to December 1960

| Month | No. of days by precipitation (mm) | | | | | | | No. of days by wind velocity (m/s) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0 | 0-5 | 5-15 | 15-30 | 30-50 | +05 | Max. mm/day | 0.5-4 | 4-8 | 8-12 | 12-16 | 16-25 | +25 |
| 6 | 19 | 7 | 3 | 1 | - | - | 22 | 2 | 10 | 18 | - | - | - |
| 7 | 10 | 5 | 10 | 3 | 3 | - | 43 | 2 | 12 | 13 | 6 | - | - |
| 8 | 10 | 7 | 7 | 5 | 2 | - | 33 | - | 3 | 23 | 4 | 1 | - |
| 9 | 13 | 5 | 4 | 5 | 1 | 2 | 62 | 4 | 15 | 9 | 2 | - | - |
| 10 | 26 | - | 3 | - | 1 | 1 | 53 | 2 | 1 | 25 | 3 | - | - |
| 11 | 26 | 1 | 1 | 2 | - | - | 28.5 | 4 | 11 | 14 | - | 1 | - |
| 12 | 24 | 4 | 3 | - | - | - | 6.5 | 5 | 5 | 19 | 1 | - | - |

Table No. 2 - January to December 1961

| Month | Days by precipitation (mm) 0 | 0-5 | 5-15 | 15-30 | 30-50 | +50 | Max. mm/day | Days by wind velocity (m/s) 05-4 | 4-8 | 8-12 | 12-16 | 16-25 | +25 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 27 | 2 | 1 | - | 1 | - | 50 | 2 | 11 | 18 | - | - | - |
| 2 | 28 | - | - | - | - | - | 0 | - | 1 | 22 | 5 | - | - |
| 3 | 31 | - | - | - | - | - | 0 | - | - | 21 | 10 | - | - |
| 4 | 30 | - | - | - | - | - | 0 | - | 2 | 21 | 7 | - | - |
| 5 | 30 | 1 | - | - | - | - | 25 | - | 3 | 28 | - | - | - |
| 6 | 6 | 5 | 11 | 5 | 2 | 1 | 60 | 1 | 4 | 18 | 5 | 1 | 1 |
| 7 | 13 | 4 | 6 | 2 | 5 | 1 | 67 | 3 | 6 | 17 | 1 | 3 | 1 |
| 8 | 14 | 3 | 6 | 6 | 2 | - | 44 | 1 | 11 | 12 | 7 | - | - |
| 9 | 10 | 1 | 8 | 7 | 4 | - | 55 | 2 | 7 | 16 | 5 | - | - |
| 10 | 25 | - | 1 | 3 | 1 | - | 40 | 4 | 10 | 15 | 2 | - | - |
| 11 | 29 | 1 | - | - | - | - | 1 | 3 | 11 | 16 | - | - | - |
| 12 | 31 | - | - | - | - | - | 0 | 5 | 22 | 4 | - | - | - |

Table No. 4 - January to December 1962

| Month | Days by precipitation (mm) 0 | 0-5 | 5-15 | 15-30 | 30-50 | +50 | Max. mm/day | Days by wind velocity (m/s) 0.5-4 | 4-8 | 8-12 | 12-16 | 16-25 | +25 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 31 | - | - | - | - | - | 0 | - | - | 24 | 7 | - | - |
| 2 | 28 | - | - | - | - | - | 0 | - | 1 | 10 | 18 | 1 | - |
| 3 | | | - | - | - | - | | - | - | | | - | - |
| 4 | 29 | 1 | - | - | - | - | 1.5 | - | - | 5 | 22 | 2 | 1 |
| 5 | 27 | 4 | - | - | - | - | 30 | - | - | 7 | 24 | - | - |
| 6 | 16 | 7 | 3 | 2 | 1 | 1 | 83.5 | - | - | 4 | 21 | 5 | - |
| 7 | 6 | 9 | 6 | 3 | 5 | 2 | 77.5 | - | 3 | 24 | 1 | 2 | 1 |
| 8 | | | - | - | - | - | | - | - | | | - | - |
| 9 | 8 | 6 | 6 | 4 | 6 | - | 47 | - | - | 22 | 7 | - | 1 |
| 10 | 18 | 5 | 7 | 1 | - | - | 19 | - | - | | | - | - |
| 11 | 26 | 3 | 1 | - | - | - | 6.5 | - | - | 28 | 2 | - | - |
| 12 | 26 | 2 | 2 | 1 | - | - | 21.5 | - | - | 30 | 1 | - | - |

Table No. 5 - January to March 1964

| Month | Days by precipitation (mm) 0 | 0-5 | 5-15 | 15-30 | 30-50 | +50 | Max. mm/day | Days by wind velocity (m/s) 0.5-4 | 4-8 | 8-12 | 12-16 | 16-25 | +25 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 30 | 1 | - | - | - | - | 0.5 | - | 1 | 27 | 3 | - | - |
| 2 | 29 | - | - | - | - | - | 0 | - | - | 25 | 4 | - | - |
| 3 | 27 | - | - | - | - | - | 0 | - | - | 16 | 11 | - | - |

1-6 Topography

Pena Colorada district is located around the end of the mountain range which stretches along the coastline of the Pacific Ocean. The ore deposits are located on the highland with EL.1,000 - 1,500 m, near the point where the River Marabasco, which runs westward in this area, changes its name to Paticajo Minatitlan. Outcrops of ore body are found on the slope extending from the north-eastern to south-eastern side of the Pena Colorada Peak, as well as over the adjoining ridge (EL 950 - 1,200 m) forming a cliff.

The River Paticajo Minatitlan maintains, even in the dry season, a considerable rate of flow which, it is assumed, may be utilized for industrial purposes when the mine has been exploited.

## 2. REGIONAL GEOLOGY, AND ORE DEPOSITS

### 2-1 Regional Geology

Stratigraphic Column in the Peña Colorada Mine Area

| Era | Period | Sedimentary Rocks: Formation | Sedimentary Rocks: Rocks | Igneous Rocks |
|---|---|---|---|---|
| Cenozoic | Quartanary | Formation of terrasse | Alluvial deposits (Pebble - cobble gravel deposits) | |
| Cenozoic | Upper Tertiary | | Breccia | Porphyrite |
| | | | | Diorite |
| Mesozoic | Cretaceous | | Limestone | |

# 2. REGIONAL GEOLOGY AND ORE DEPOSITS

The deposit area is geologically composed of lime stone belonging to the Cretaceous of the Mesozoic Era with diorite intrusives forming the batholith, both being penetrated by porphyrite dyke and covered by breccia.

The lime stone is distributed, as roof pendant in the diorite batholith, in limited areas on the slope facing south, west of Espinazo del Diable as well as on the slope facing north, east of Primorosa, both located upstream of the Arroyo Encantada. It was found to have transformed into crystalline lime stone by thermal methamorphism caused by the intrusion of diorite.

The diorite, which was widely skarnized as a result of the deposit formation, contains certain amounts of impregnated magnetite. The fresh diorite can be found only in the mid-stream of the A. Encantada Ravine.

The porphyrite in this area forms a dyke with the width of less than 5 m, and intrudes diorite and the ore deposits at different points in the directions of N 60° E, N 60° W and N 5° - 10° W, etc.

The porphyrite is not affected by mineralization by iron. The breccia is the newest of all the rocks in the area and is found widely distributed over the ridge line extending in the west from the ridge of Peña Colorada north of this area. It contains diori te, porphyrite, skarn, iron ore and andesite breccia,

2-2 Ore Deposits

The iron ore deposits at this mine are bedded or irregular massive magnetite deposits found mostly in diorite and partly at the contact zone of diorite and lime stone. The massive ore deposits (high grade ore) can be divided into 6 bonanzas, i.e., La Encantada (North), La Encantada, Chinforinazo, La Chula (North), Espinazo del Diablo, and La Primorosa. The first 4 merge into disseminated ores (low grade ores). The ore consists mainly of magnetite, with small amount of hematite and extremely small quantities of chalcopyrite, sphalerite, bornite, chalcocite. Gangue minerals are skarn minerals including feldspar, chlorite, pyroxene (augite and hedenbergite), epidote, calcite, phlogopite, and extremely small amount of apatite, zircon, cassiterite, titanite and minerals similar to brushite or dufrenite.

The deposits are almost all embodied in diorite. They are considered to have been formed by the intrusion of diorite into lime stone which resulted in the latter's being found in diorite and further caused some portions of the diorite to be rich in lime content by hybridism, and by subsequent mineralization which led to the replacement of the said portions. Judging from the minerals discovered, they are metasomatic deposits.

## 2-3 Description of Each Deposit

### 2-3-1 La Encantada (North), La Encantada, Chinforinazo

The deposits extending on the steep slope facing east on the western bank of A. Encantada Ravine are called, from north to east, by the above names.

The deposits are contained mostly in diorite. La Encantada Deposit (North) exists at the contact of diorite and lime stone which forms the footwall of the deposit. These deposits are joined with one another by low grade ores and are considered to be a chain of linked deposits.

Since these deposits strike in N - W with a gentle dip of about $10^{o}$ SW, outcrops can be traced for about 1,500 km from north to south on the steep slope facing east.

The thickness of the deposits are as follows:

| | | |
|---|---|---|
| La Encantada (North) | : | 15 - 35 m in the high grade ore |
| La Encantada | : | 30 - 65 m in the high grade ore |
| Chinforinazo | : | Fluctuations between 15 - 50 m is noticed; the central part is the thinnest, becoming thicker towards north and south. |

9 diamond drilling tests covering a total of 1,127.28 m of bore length were conducted between the depths of 50 - 200 m of the deposits in order to clarify the condition of development. Each bore reached the ore body and not much fluctuation was noticed with regard to the thickness of the ore body. (Besides these 9 drilling tests, 2 drillings with bore length of 114.91 m were conducted, but one of them was suspended before reaching the ore body)

These high grade ores were sometimes found accomapnied by disseminated ores on their hanging or foot wall side. The thickness of the disseminated ores is as follows:

| | | |
|---|---|---|
| La Encantada (North) | : | 50 - 20 m on the hanging wall side |
| La Encantada | : | 10 - 40 m on the hanging and foot wall side |
| Chinforinazo | : | 10 - 20 m on the hanging wall side or on the foot wall side |

### 2-3-2 Espinazo del Diablo

The deposit extending over the ridge area on the east of A. Encantada Ravine is called Espinazo del Diablo Deposit. This deposit lies mostly in diorite, and is slightly linked with La Encantada Deposit by disseminated ores. It is presumed that it is an extension of the deposit in the west which was mostly worn by heavy erosion in the past. The present deposit is therefore considiered a part of this deposit in the west. At the central part of the deposit, diorite is found on the hanging wall side. The deposit, 550 m in length and 10 - 50 m in thickness, consists mainly of massive ores containing 55 - 56% Fe, with disseminated ores on some parts of the foot wall side.

2-3-3 La Primorosa

This deposit lies in diorite exposed for 250 m on the slope facing east, located to the north-west of Mt. Peña Colorada. It strikes N-W with a dip of $10^{\circ}$ SW. It is an extension of the main deposit group in the south, and consists of thin massive ores with the belt of disseminated ore on its hanging wall side. The ore grades are extremely poor when compared with those of the southern deposit group, and cannot therefore be the object of mining. At the present stage, it is not considered to be linked with the deposit group in the south by massive ores.

2-3-4 La Chula (North)

This deposit lies in diorite and extends over the ridge to the west of the southern end of the Chinforinazo Deposit. Ore grades at this deposit rank high among major deposits. The original deposit was almost eroded in the past and only a portion of it remains as the present deposit. Though small in scale with the length of 120 m max., width of 50 m and thickness of 10 - 50 cm, it consists mostly of massive ore of high grade.

2-4 Estimation of Ore Reserves and Grades

Estimation of ore reserves was made based on the overall results of investigations on outcrops as well as of the magnetic prospecting and 10 diamond drilling test conducted in the past. It is to be noted that 10 drilling tests do not at all suffice to obtain detailed and accurate data on the deposit which has a total extension of 1,500 m. Figures given below are the best obtainable results at the present stage. It is therefore suggested that diamond drilling tests be continuously performed in the future to secure increased ore reserves and to check their grades.

2-4-1 Tabulation of Ore Reserves and Grades

(1) Massive Ore (High grade ore)

| Deposit | | Proved | Probable | Total | Grade (%) | | |
|---|---|---|---|---|---|---|---|
| | | | | | Fe | P | S |
| La Encantada (North) (A - C) | | 850,000 t | - t | 850,000 t | 53.01 | 0.262 | |
| La Encantada (E - H) | | 5,649,000 | 656,000 | 6,305,000 | 56.83 | 0.253 | |
| Chinforinazo | North (6-12) | 6,641,000 | 2,067,000 | 8,708,000 | 54.24 | 0.073 | |
| | South (12-18) | 11,616,000 | 2,170,000 | 13,786,000 | 61,15 | 0.076 | |
| | Sub-total | 18,257,000 | 4,237,000 | 22,494,000 | 58.47 | 0.075 | |
| Espinazo (1-11) | | 3,644,000 | - | 3,644,000 | 55,48 | 0.268 | |
| Total | | 28,400,000 | 4,893,000 | 33,293,000 | 57,70 | 0.134 | |

(2) Disseminated Ore (Low grade ore)

| Deposit | Proved | Probable | Total | Grade (%) | | |
|---|---|---|---|---|---|---|
| | | | | Fe | P | S |
| La Encantada (North) (A - D) | 576,000 t | - t | 576,000 t | 23.59 | 0.259 | |
| La Encantada (D - H) | 2,293,000 | 8,000 | 2,301,000 | 31.12 | 0.186 | |
| Chinforinazo (H - 16) | 7,112,000 | 2,082,000 | 9,194,000 | 34.70 | 0.141 | |
| Espinazo (1 - 11) | 836,000 | | 836,000 | 47.91 | 0.250 | |
| Total | 10,817,000 | 2,010,000 | 12,907,000 | 34.42 | 0.161 | |

| GRAND TOTAL | 39,217,000 | 6,983,000 | 46,200,000 | 51.20 | 0.142 |
|---|---|---|---|---|---|

Remarks: Grade percentage is expressed, as shown in the formula below, by the weighted average of boring and coutcrop specimens.

Formula: $\frac{\text{Bore length x grade + Total sampling length x grade}}{\text{Bore length + Total sampling length}}$

(3) Other Deposit

| Deposit | Proved | Probable | Total | Grade (%) Fe |
|---|---|---|---|---|
| **Primorosa** | - | 652,000 t | 652,000 t | (55) |
| La Chula (North) | - | 84,000 | 84,000 | (54) |
| Total | - | 736,000 | 736,000 | (54.89) |

Remarks: Grade percentages are presumed figures.

2-4-2 Ore Grade by Diamond Drilling Test (%)

| Kind of ore | Deposit | Drilling Test No. | Fe | S | P |
|---|---|---|---|---|---|
| Massive Ore (High grade ore) | La Encantada | No. 10, 11 | 54.08 | 1.650 | 0.0591 |
| | Chinforinazo (North) | No. 9, 8, 1 | 50.87 | 2.847 | 0.0631 |
| | Chinforinazo (South) | No. 2, 4, 5, 6 | 57.39 | 2.338 | 0.0614 |
| Disseminated Ore (Low grade ore) | La Encantada | No. 10 | 36.51 | 1.782 | 0.0569 |
| | Chinforinazo | No. 6, 8, 9 | 34.75 | 2.95 | 0.0621 |

| Drilling Test No. | Depth (ft) | Thickness (ft) | Fe | S | P |
|---|---|---|---|---|---|
| No. 1 | 50 - 132 | 82 | 58.02% | 3.236% | 0.0259% |
| No. 2 | 290 - 505.2 | 215.2 | 58.12 | 1.819 | 0.0813 |
| | 61 - 75 | 14 | 66.01 | 2.179 | 0.0159 |
| No. 3 | 94.6 - 156 | 61.4 | 62.01 | 2.279 | 0.0458 |
| | 61 - 156 | 95 | 49.81 | 1.804 | 0.0322 |
| No. 4 | 171 - 308 | 137 | 58.08 | 3.192 | 0.287 |
| No. 5 | 186 - 232 | 46 | 50.78 | 1.287 | 0.0557 |

| Drilling Test No. | Depth (ft) | Thickness (ft) | Fe | S | P |
|---|---|---|---|---|---|
| No. 6 | 360 - 527.33 | 167.33 | 57.71 | 2.595 | 0.0642 |
| | 305 - 360 | 55 | 38.41 | 1.854 | 0.0957 |
| | 305 - 527.33 | 222.33 | 52.93 | 2.411 | 0.0720 |
| No. 8 | 256 - 335 | 79 | 46.91 | 3.28 | 0.0859 |
| | 335 -385 | 50 | 32.43 | 3.015 | 0.0526 |
| | 256 - 335 | 129 | 41.30 | 3.178 | 0.073 |
| No. 9 | 50 - 200 | 150 | 49.05 | 2.405 | 0.0714 |
| | 6 - 50<br>200 - 255 | 99 | 33.89 | 3.534 | 0.0483 |
| | 6 - 255 | 249 | 43.02 | 2.480 | 0.0622 |
| No. 10 | 17.15 - 260 | 88.5 | 50.31 | 1.174 | 0.0910 |
| | 260 - 423.3 | 163.3 | 36.51 | 1.782 | 0.0569 |
| | 171.5 - 423.3 | 251.8 | 41.36 | 1.568 | 0.0689 |
| No. 11 | 60 - 190 | 130 | 56.65 | 1.973 | 0.0374 |

Remarks : Ore grades revealed by outcrop specimens are higher than those by diamond drilling tests for both iron (massive ore in particular) and phosphorus. See the Grade Table below.

2-4-3 Ore Grades by Outcrop Specimen Test (%)

| Kind of Ore | Deposit | No. of specimens & outcrop extension (m) | Fe | P |
|---|---|---|---|---|
| Massive Ore | La Encantada (North) | 4 Sample 126 m | 53.01 | 0.262 |
| | La Encantada | 14 Sample 461 m | 57.22 | 0.281 |
| | Chinforinazo, (North) | 7 Sample 165 m | 56.17 | 0.079 |
| | " (South) | 6 Sample 172 m | 64.91 | 0.091 |
| | Espinazo | 10 Sample 309 m | 55.48 | 0.268 |

| Kind of Ore | Deposit | No. of specimens & outcrop extension (m) | Fe | P |
|---|---|---|---|---|
| Disseminated Ore | La Encantada (North) | 2 Sample 39 m | 23.59 | 0.259 |
| | La Encantada | 8 Sample 112 m | 29.87 | 0.216 |
| | Chinforinazo | 8 Sample 280 m | 34.69 | 0.159 |
| | Espinazo | 3 Sample 149 m | 47.91 | 0.205 |

## 2-5 Exploration Plan

The Peña Colorada iron ore depoist is characterised by the following features.

(1) It is a bedded and metasomatic deposit, and its mother rock, diorite, is slightly skarnized. It accompanies disseminated ore on the hanging and foot wall side of the massive ore.

(2) Up to date, 9 diamond drilling test were conducted for the purpose of exploring along the vertical extension of the deposit, witn the result that each bore reached the ore body. The ore body was found extending with virtually no fluctuation in thickness.

(3) The condition of massive ore extension as revealed by the outcrop specimen tests and by diamond drilling tests showed excellent stability, with little fluctuation in the ore grade. However, in the low grade ore which is poor in stability, it is presumed that contraction and expansion of the ore body and the fluctuation of ore grade are prevalent.

(4) Judging from the present ore reserves, the annual production of concentrates would be limited to 1.2 million tons, which calls for prospecting for more ore reserves.

From the features given above, it is considered quite important for the mining of both massive and disseminated ores to clarify their distribution and grades. It will accordingly be necessary to furter conduct drilling tests in the future in order to secure more ore reserves and to confirm their grades as well.

Desired Drilling Points and Bore Length (m)

| | No. | Bore length | Dip |
|---|---|---|---|
| | 1 A | 200 | -90° |
| | 2 A | 140 | " |
| | 3 A | 150 | " |
| | 4 A | 250 | " |
| | 5 A | 200 | " |
| | 1 B | 200 | " |
| | 2 B | 320 | " |
| | 3 B | 380 | " |
| Total: | 8 bores | 1,840 m | |

Remarks: No. 1 A - 5 A are included in the drilling programme in 1964 by Mexico.

## 3. EXPLOITATION PLANS

The exploitation of the Pena Colorada mine can be carried out based on two different plans.

The first of the two plans aims at producing iron ores for domestic consumption. In the second plan which comes up to the desire of the Government of Mexico, it is assumed that investment in the Peña Colorada mine by foreign concerns would continue until the iron mills in Mexico become capable of processing an additional 2 million tons of cencentrates annually, and that repayment therefor would be made by ores.

The Survey Team conducted, chiefly for the second plan, investigations on ore reserves, basic investigations relating to mining and beneficiation and further performed beneficiation tests. On the basis of the results of these investigations and tests, the Team prepared Exploitation Plan A.

As for the first plan, Exploitation Plan B was prepared on the assumption that a new iron mill would be established in the vicinity of Manzanillo as the transportation of ores to the existing iron mills, located far from the mine, was considered disadvantageous. In this Plan B, profit calculation was not possible due to the fact that grades of Fe and P contents in the concentrates, size of lump ores and selling prices which the existing iron mills required

# 3. EXPLOITATION PLANS

were not available. However, trial calculation of initial investment amount and of estimated cost price was made based on various conditions for exploiting the mine.

The major difference between Plan A and Plan B is the grade of P content in the ores. If the ores are to be sent to Japan as suggested in Plan A, the grade of P content should be less than 0.05%, and the results of beneficiation tests call for the grinding to -200 mesh in order to obtain the desired low grade. The proposed grinding process would incur higher cost price of the ore when compared to that in Plan B which is not bound by such grade limitation of P content.

## Exploitation Plan A

(Prepared on the assumption that iron ores would be shipped to Japan)

1. Proper Production Amount

As a result of outcrop investigations and of explorations hitherto made, the ore reserves were assumed to amount to 46,200,000 tons (Fe 51.20, P 0.142). Workable ore reserves, presumed to be as tabulated below, vary by the condition of deposits, crude ores to be selected to maintain grade stability and by the conditions for mining.

| Mining method | Object ore reserves | Workable ratio | Workable ore reserves (dry ton) | (wet ton) |
|---|---|---|---|---|
| Open pit mining | 11,600,000 t | Approx. 90% | 10,200,000 t | 10,500,000 t |
| Underground mining | 31,700,000 | " 60% | 18,100,000 | 18,600,000 |
| Total | 43,300,000 | | 28,300,000 | 29,100,000 |

As regards the object reserves in open pit mining, mining districts were confined to areas with the ratio of stripping 1 : 1. This was because of the extreme increase in the stripping volume which would occur on account of the steepness of the outcrop area and consequent expansion of the mining district.

Based on the above-tabulated figures, and in due consideration of the life of the mine and the conditions for underground mining as studied from the viewpoint of deposit conditions, it is considered appropriate, at the present stage, to set the scale of production at 1 ~ 1.2 million tons.

Since there is not much difference in the amount of initial expenses required for the annual production of 1 million tons and 1.2 million tons, the Survey Team set the proper production amount at 1.2 million tons a year, in which case the life of the mine would be about 16 years.

2. Preconditions for the annual production of 1.2 million tons of pellet

(1) Mining

Ratio of crude ores by open pit mining against those by underground mining was set at 1 : 1. After completion of mining of the object reserves in open pit areas, the entire production would be obtained by underground mining.

Ratio of stripping against crude ores should be 1 : 0.83. Underground mining is to be mechanized as far as possible.

(2) Beneficiation

As already stated in 2-4 (Estimation of ore reserves, etc.), the grade of P content in the ore is rather high. Since it was considered necessary to reduce the grade of P content to less than 0.05%, and also to utilize the ores in the form of pellet, the beneficiation plan was drawn up with the grain size at -200 mesh, which is in accordance with the results of the beneficiation tests.

All sliming magnetic separation process is to be adopted at the beneficiation plant to be established in Milan district about 2 km from the deposit on a direct line.

Yield percentage : 65.5%
Size of concentrates : -325 mesh 85%
Grade of P content in concentrate: 0.03%

(3) Production Plan of Concentrates

| Output | Concentrates (in dry tons) | Crude ores | Stripping | Total output | Drifting |
|---|---|---|---|---|---|
| Annual output | 1,200,000 t | 1,800,000 t | 750,000 t | 2,550,000 t | 2,700 m |
| Monthly " | 100,000 | 150,000 | 75,000 | 225,000 | 225 |
| Average output/day | 3,220 | 6,000 | 3,000 | 9,000 | 9 |
| Maximum output/day | - | 7,000 | 3,600 | - | - |
| Maximum output/hour | - | 500 | 500 | - | - |

(4) Ore Transportation

Ores can be transported from the mine to Manzanillo by 3 different means, i.e., (a) railway transport, (b) land transport by trucks, and (c) slurry transporting. As already stated, ores must be ground to -200 mesh in order to maintain the grade of P content below 0.05%. For the purpose of maintaining the desired low grade of P content and to cut down the cost price, the Survey Team considered it more preferable to establish, at the foot of the mine, a beneficiation plant from which the processed ores are to be directly transported by slurry transporting to the pelletizing plant at Manzanillo rather than to transport ores by railway or trucks and perform the beneficiation at the beneficiation plant at Manzanillo. The Survey Team therefore adopted slurry transportion in this Report.

It is to be noted, however, that further review should be made on the problem of ore transportation since no reconnaissance was conducted on the proposed transportation route nor experts specialized in railways or roads were among the Team members.

Outline of the 3 different methods of ore transportation is as given below.

(a) Railway transport

Consultations with the Mexican authorities resulted in the assumption that if a railway line were to be established, the amount to be invested therein should be refunded by exploiting the Peña Colorada mine.

The cost for railway construction would, according to the Mexican engineers, be approximately ¥50,000 per m (US$140.- per m). They reported, however, that since no reconnaissance had been made on the proposed route between the mine and Manzanillo, the above unit cost would be liable to a considerable change in case the field survey be conducted in the future.

Judging from the topographical map prepared on the basis of aerial photographs as well as from the observation made within a limited area, the Survey Team reached the conclusion that the unit cost per m would amount to at least about ¥70,000 (US$190.-). An estimated investment amount of as much as ¥6 - 7 billion (US$16 - 17 million) would consequently be required for the construction of the railway line that covers the 70 km distance between the mine and Mazanillo, as well as for the purchase of locomotives, freight cars and other necessary facilities.

Repayment amount per ton of concentrates (annual production: 1.2 million tons) for the above investment amount of ¥7 billion would be as follows provided that the interest is 10% per annum.

In case of 10 year depreciation period: ¥949/ton (US$ 2.64)
In case of 25 year depreciation period: ¥642/ton (US$ 1.78)

As indicated above, there would be a difference of about ¥300 (US$0.83) according to the length of depreciation period.
(Judging from the life of the mine, it is believed that the depreciation should be completed in 10 years, though it is desired by the Mexican authorities to protract it over a 25 year period)

With regard to the transport cost, it was estimated at ¥1.80/t/km (US$0.005/t/km) on the basis of data made available by the Mexican authorities. In consequence, the cost of transport from the mine to Manzanillo would be ¥126/t (US$0.35/t). If the loading and unloading charges are added to this amount, the total transport cost would amount to about ¥226/t (US$0.63). It is presumed, from the above calculation, that the cost of ores would be ¥1,175 (US$3.26) per ton.

(b) Land Transport by Trucks
As in the case of railway transport, no reconnaissance had been made along the proposed route, resulting in the inability to obtain the definite stripping volume. It was therefore impossible to compute the unit construction cost.

Since the transportation of the annual output of 1.2 million tons would naturally call for the use of big trucks, a paved road with the width ranging from 10 m (effective width : 9 m) to 15 m (effective width : 13 m) would be required. Further, the roadbed should be at least 0.57 m in thickness, and the unscreened gravels of 0.30 m thickness should be laid at the bottom where the ground condition is found deteriorated.

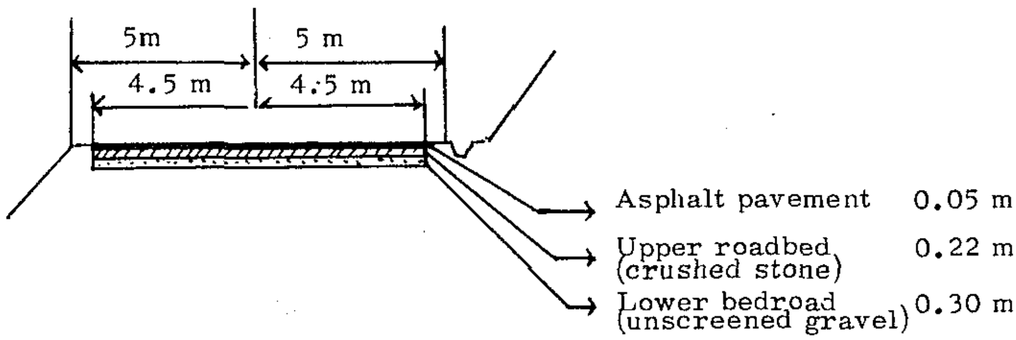
The cost for constructing such a road is estimated to range between ¥30,000 (US$80.-) and ¥40,000 (US$110.-) per m, which leads to the inference that the construction cost covering the entire 70 km distance from the mine to Manzanillo would roughly be 2.5 billion yen (US$7 million). Assuming that the cost for constructing bridges, etc. were ¥500 million (US$ 1.3 million), the total cost required would be as much as ¥3 billion (US$8.3 million).

Repayment amount per ton of concentrates (annual production : 1.2 million tons) for the estimated ¥3 billion (US$ 83 million) investment amount would be about ¥407 (US$1.13) provided that the interest is 10% per annum and the depreciation period is 10 years.

Cost of transport is estimated to amount to at least ¥10 - 15/t/km (US$0.028 - 0.042/t/km). Cost covering 70 km distance would therefore be ¥700 - 1,050/t (US$1.94 - 2.92/t).

From the above calculation, cost of ores to be transported by trucks is presumed to average ¥1,282 (US$3.56).

Profile of Road




(c) Slurry Transportation

This item is described in detail under 4-4.

It is estimated that the initial expenses required would amount to approximately ¥1.6 billion (US$440 thousand approx.). This leads to the estimation that the repayment amount per ton of concentrates (annual production : 1.2 million tons) for the above-mentioned sum would be ¥217 (US$0.60). Operation cost per ton of concentrates is estimated not to exceed ¥74 (US$0.20). Transport cost of concentrates from the mine to Manzanillo is therefore estimated to be about ¥241 (US$0.80) per ton, which is apparently by far the cheapest when compared to the cost estimated to be incurred by railway or land transportation. And it is the opinion of the Survey Team that the Slurry Transportation would be the most preferable.

The only outstanding problems in materializing this plan are a) the unit cost which is liable to change after the field survey has been conducted, since no reconnaisance has been made along the proposed route excepting a small portion, and b) the complete tests on the slurry transportation over a distance of 70 km which should be conducted prior to the implementation of the proposed exploitation.

(5) Pelletizing Plant

The pelletizing plant will be established in the industrial zone near Port Manzanillo.

As stated in (c) above, ores will be transported by slurry transportation from the mine to the pelletizing plant. A pipe line will be laid for the 70 km distance between the mine and Manzanillo, and along the pipe line way will also be constructed a communication road for automobiles.

The annual productive capacity of the plant will be set at 1.2 million tons. Ore conveyance from the plant to the loading port is to be performed by belt conveyors, and the stock pile yard will be in the loading area.

(6) As regards the construction works required at the port, the mine side will undertake only the construction of loading facilities and shore protection works, and the Mexican Navy will carry out the channel and drainage works.

(7) For marine transportation of ores, a freighter of 45,000 - 50,000 tons is to be utilized.

(8) Other related matters

(a) Electric power required is to be purchased at ¥4/KW (US$0.01/KW). The mine side will be responsible for the construction of power receiving facilities only.

(b) Working days will be as follows.

| | |
|---|---|
| Mining and drifting | : 12 months/year (actual working days - 300 days) |
| Stripping | : 10 months/year (Work to be suspended during 2 months of the wet season when the precipitation is heavy) |
| Beneficiation | : 12 months/year (actual working days - 300 days) |

(c) Machines, equipment and their spare parts as well as materials required for the Plan are to be imported free of import tax.

3. Personnel Plan for Pellet Production of 1.2 million tons/year

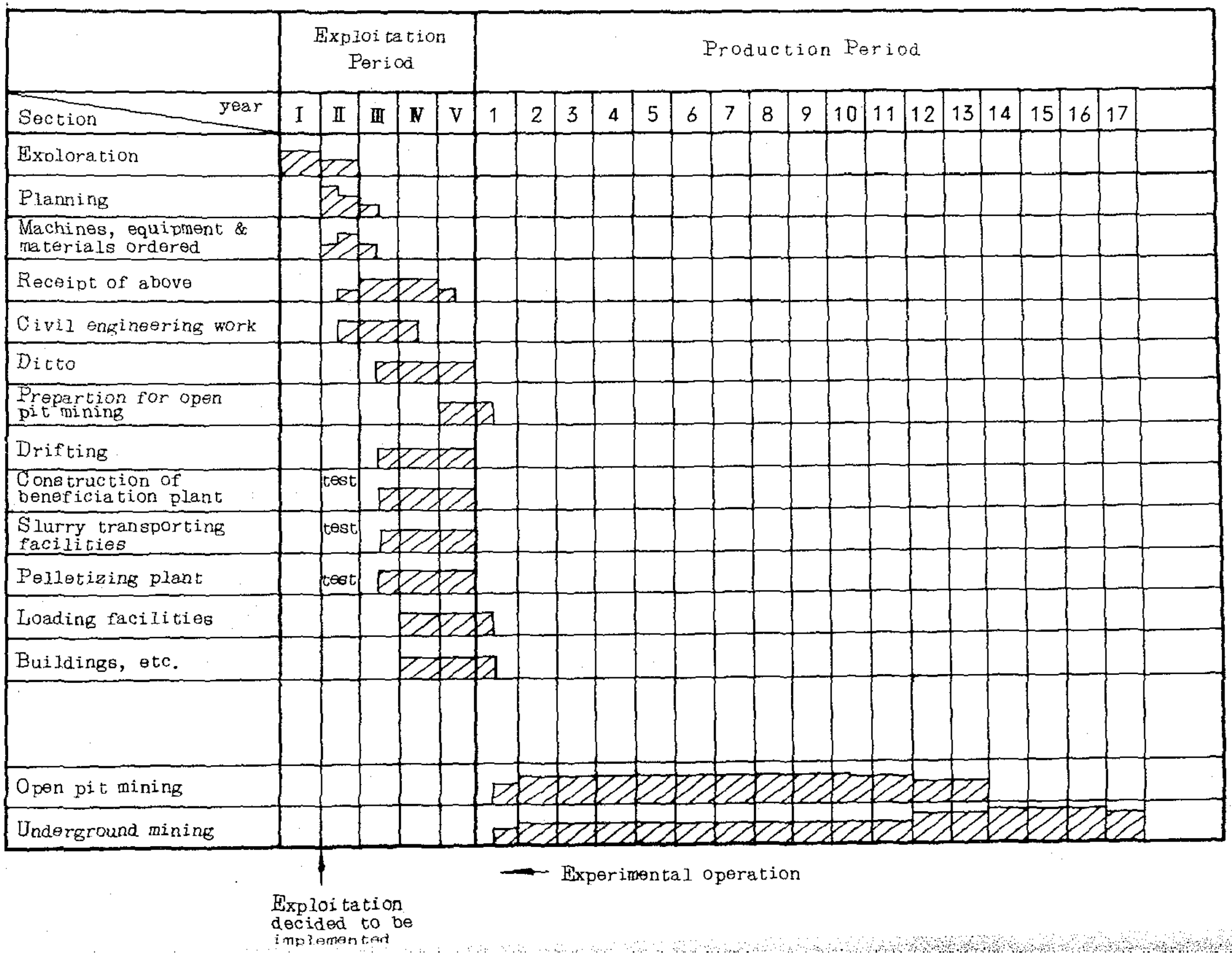
| Section | No. of actual working personnel | | | No. of registered personnel | | |
|---|---|---|---|---|---|---|
| | Staff | Worker | Total | Staff | Worker | Total |
| Mining | | | | | | |
| Open pit mining | 11 | 82 | 93 | 11 | 91 | 102 |
| Underground ming | 16 | 170 | 186 | 16 | 180 | 196 |
| Sub-total | 27 | 252 | 279 | 27 | 271 | 298 |
| Beneficiation | 8 | 55 | 63 | 8 | 65 | 73 |
| Electric & mechanical facilities | 8 | 25 | 33 | 8 | 30 | 38 |
| Slurry transportation | 4 | 30 | 34 | 4 | 36 | 40 |
| Office and school | 24 | 44 | 68 | 24 | 44 | 68 |
| Total: | 71 | 406 | 477 | 71 | 446 | 517 |
| Dehydration | - | 6 | 6 | - | 8 | 8 |
| Pelletizing plant | 13 | 42 | 55 | 13 | 46 | 59 |
| Loading facilities | 3 | 30 | 33 | 3 | 30 | 33 |
| Total: | 16 | 78 | 94 | 16 | 84 | 100 |
| GRAND TOTAL: | 87 | 484 | 571 | 87 | 530 | 617 |

4. Process of Exploitation Work for Pellet Production of 1.2 million tons/year

During the first stage of the exploitation works, priority should be given to the construction of the road for transportation of earth moving machinery along the proposed pipe line route. Efforts should be made in utilizing the existing road, wherever possible, for constructing such a road. Construction of the channel and drainage facilities should be completed within the proposed period of the exploitation works.

Process of exploitation works is as shown in the chart on the next page.

## EXPLOITATION PROCESS



5. Calculation of Plant and Equipment Investment and of Estimated Cost Price

(1) Total Depreciation Funds

(See the tabulation of investment amount by section)

Construction period for the exploitation of the mine will be 5 years, and the total amount of funds required during this period for equipment and facilities will be about ¥12,979 million (US$36.05 million approx.).

The above-mentioned funds for equipment and facilities will be required approximately 1.7 years before the year of commencement of production, though there will of course be some lag of time when the funds are actually required by each section of the exploitation work. With the interests of ¥2,206 million (US$6.13 million) for 1.7 years added to the above funds, the total depreciation funds would amount to ¥15,185 million (US$42.18 million).

(2) Yearly Depreciation Amount

(See the tabulation of investment amount by section)

If the above-mentioned funds are to be refunded, being equally divided for each year over a 10 year period after commencing the production, the yearly depreciation amount would be ¥2,470 million (US$6.86 million) provided that the interest is set at 10% per annum.

| (US$42.18 million) | (Depreciation %) | (US$6.86 million) |
|---|---|---|
| ¥15,185 million | x 1.67745 | ÷ 10 yrs = ¥2,470 million/year |

Conversion of this amount into one ton of concentrates is as follows.

¥2,470 million ÷ 1.2 million tons = ¥2,059/ton (US$5.72/ton)

(3) Aggregate Cost Price of Concentrate per ton

(See the tabulation of operation cost)

| | |
|---|---|
| Estimated operation cost | : ¥1,890/t (US$11.58) |
| Yearly depreciation amount | : ¥2,059/t (US$5.72) |
| Aggregate cost price | : ¥3,949/t (US$17.30) |

Tabulation of Investment Amount by Section

| Section | Investment Amount | |
|---|---|---|
| | (Million Yen) | (Thousand Dollars) |
| Mining | 1,875 | 5,208 |
| Beneficiation | 1,870 | 5,194 |

Tabulation of Investment Amount by Section - Cont'd -

| Section | Investment Amount (Million Yen) | (Thousand Dollars) |
|---|---|---|
| Mechanical & electrical facilities | 107 | 297 |
| Slurry transportation | 1,600 | 4,444 |
| Pelletizing plant | 3,500 | 9,722 |
| Port facilities | 904 | 2,511 |
| Administration | 435 | 1,208 |
| Others | 2,688 | 7,466 |
| Total: | 12,979 | 36,050 |

Tabulation of Operation Cost by Section

| Section | Cost per ton of Concentrates (Yen) | ( Dollars ) |
|---|---|---|
| Mining | 416 | 1.15 |
| Beneficiation | 390 | 1.08 |
| Mechanical & electrical facilities | 38 | 0.11 |
| Slurry transportaton | 74 | 0.21 |
| Pelletizing plant | 625 | 1.74 |
| Port facilities | 74 | 0.21 |
| Administration | 189 | 0.52 |
| Sub-total | 1,806 | 5.02 |
| Management expenses | 42 | 0.12 |
| Interests payable | 42 | 0.12 |
| GRAND TOTAL: | 1,890 | 5.25 |

## Exploitation Plan B

(Prepared on the assumption that ores will be produced for domestic consumption)

1. Production Amount

Of the total ore reseves of 46.2 million tons (Fe - 51.20%, P - 0.142%), only massive ores (Fe -57.70%, P - 0.13%) can be the object of exploitation by this plan. Due to their poor grades, disseminated ores cannot be exploited.

The workable ore reserves, calculated on the basis of the conditions for mining, are as tabulated below.

| Mining method | Object reserves | Workable ratio | Workable ore reserves (Dry ton) | (Wet ton) |
|---|---|---|---|---|
| Open pit mining | 8,500,000 t | Approx. 90% | 7,700,000 t | 7,950,000 t |
| Underground mining | 24,800,000 | " 60% | 13,800,000 | 14,200,000 |
| Total: | 33,300,000 | | 21,500,000 | 22,150,000 |

Remarks: Open pit mining is limited to areas with the ratio of stripping below 1 : 1.

If lump ores are to be produced on the basis of the above figures, and on the presumption that the yield percentage would be 75% and the recovery percentage of beneficiation 90%, the concentrates to be produced would amount to about 13.5 million tons. Since no beneficiation tests were conducted on lump ores, ore grades were assumed to be Fe 60% and P 0.15%. It would therefore be proper to set the production amount at 1.5 - 1.7 million tons. However, for the purpose of comparing Plan B with Plan A, an assumption was made that the annual production would be 1.2 million tons. The life of the mine would be 11 years.

2. Preconditions

(1) An iron mill is to be established near Port Manzanillo and lump ores are to be transported to the mill for processing.

(2) Sizes of lump ores are set at 1 - ½", ½ - 1/4".

(3) The fine ores and lump ores were assumed to be in the ratio of 25% (fine ore) to 75% (lump ore).

(4) Crude ores are to undergo primary and secondary crushing process and be concentrated after being sieved into two groups of the above-mentioned different sizes.

(5) Concentrates will be transported to the iron mill by a railway line to be constructed covering the 70 km distance between the mine and the mill.

3. Calculation of Investment Amount and Estimated Cost Price

Plan B differes from Plan A in that the grinding and de-watering are excluded from the beneficiation process, and that no pipe transportation, pelletizing plant nor port facilites are included. Ores are to be transported by rail directly to the iron mill at Manzanillo. Estimation of cost price was made on the assumption that the bases of calculation are identical as those used for Plan A.

(1) Total Investment Amount

| | | |
|---|---|---|
| Investment Amount | : ¥ 12800 million(US$ 36 million) | Total: ¥15,006million(US$ 42million) (See the tabulation below) |
| Interest payable during exploitation period | : ¥ 2,206 million(US$ 6 million) | |

(2) Aggregate cost price of concentrates per ton

| | | |
|---|---|---|
| Operation cost | : ¥1,095(US$ 3.04) | Total : ¥ 3,129(US$ 8.69) (See the tabulation below) |
| Yearly depreciation amount | : ¥2034(US$ 5.65) | |

If ores are to be transported by trucks, amounts given (1) and (2) above would change as follows.

(1)' Total Investment Amount

| | | |
|---|---|---|
| Investment amount | : ¥8,100 million(US$ 22 million) | Total: ¥9,477million(US$26million) (See the tabulation below) |
| Interest payable during exploitation period | : ¥1,377 million(US$ 4 million) | |

(2)' Aggregate cost price of concentrates per ton

| | | |
|---|---|---|
| Operation cost | : ¥2,151(US$ 5.98) | Total : ¥ 3249(US$ 9.02) (See the tabulation below) |
| Yearly depreciation amount | : ¥1,098(US$ 3.04) | |

Tabulation of Investment by Section (Railway Transportation)

| Section | Investment Amount (Million Yen) | Investment Amount (Thousand Dollars) |
|---|---|---|
| Mining | 1,875 | 5,208 |
| Beneficiation | 1,370 | 3,806 |
| Mechanical & electrical facilities | 87 | 242 |
| Railway line | 7,000 | 19,444 |
| Administration | 435 | 1,208 |
| Others | 2,033 | 5,647 |
| Total: | 12,800 | 35,555 |

Tabulation of Operation Cost by Section (Railway Transportation)

| Section | Cost per ton of concentrates (Yen) | (US$) |
| --- | --- | --- |
| Mining | 416 | 1.15 |
| Beneficiation | 150 | 0.42 |
| Mechanical & electrical facilities | 30 | 0.08 |
| Railway line | 226 | 0.62 |
| Administration | 189 | 0.53 |
| Sub-total | 1.011 | 2.80 |
| Management expenses | 42 | 0.12 |
| Interests payable | 42 | 0.12 |
| GRAND TOTAL: | 1,095 | 3.04 |

Tabulation of Investment Amount by Section (Land Transport)

| Section | Investment Amount (Million Yen) | (Thousand Dollars) |
| --- | --- | --- |
| Mining | 1,875 | 5,208 |
| Beneficiation | 1,370 | 3,806 |
| Mechanical & electrical facilities | 87 | 242 |
| Transportation (Investment in road construction only) | 2,500 | 7,000 |
| Administration | 435 | 1,208 |
| Others | 1,833 | 5,092 |
| Total: | 8,100 | 22,556 |

Tabulation of Operation Cost by Section (Land Transport)

| Section | Cost per ton of Concentrates | |
|---|---|---|
| | (Yen) | (US$) |
| Mining | 416 | 1.15 |
| Beneficiation | 150 | 0.42 |
| Mechanical & electrical facilities | 30 | 0.08 |
| Transportation | 1,282 | 3.56 |
| Administration | 189 | 0.53 |
| Sub-total: | 2,067 | 5.74 |
| Management expenses | 42 | 0.12 |
| Interests payable | 42 | 0.12 |
| GRAND TOTAL: | 2,151 | 5.98 |

N.B. Transportation of ores is to be undertaken by a contractor.

# 4. EXPLOITATION PLAN IN DETAIL (Plan A)

## 4-1 Mining Section

### 4-1-1 Ore Reserves (In thousand tons)

| Kind of ore | Confirmed | Presumed | Total |
|---|---|---|---|
| Massive ore | 28,400 | 4,893 | 33,293 |
| Disseminated ore | 10,817 | 2,090 | 12,907 |
| Total: | 39,127 | 6,983 | 46,200 |

### 4-1-2 Ore Reserves by Object Mining Area (In thousand tons)

| Area | Object ore reserves | Workable ratio | Workable ore reserves | |
|---|---|---|---|---|
| | | | (dry) | (wet) |
| Open pit mining area | 11,600 | Approx. 90% | 10,200 | 10,500 |
| Underground mining area | 31,700 | " 60% | 18,100 | 18,600 |
| Total | 43,300 | " 65% | 28,300 | 29,100 |

Remarks: Decrease in the workable ratio is caused by refraining from mining disseminated ore, thereby to maintain the grade stability.

# 4. EXPLOITATION PLAN A IN DETAIL

4-1-4 Life of Mine (As judged from the present ore reserves)

Production scale : 1.2 million tons of concentrates per year (dry ton, Fe - 67%)
1.752 million tons of crude ore per year (dry ton, Fe - 50%)

Life of the Mine : 28.3 million tons (workable ore reserves) ÷ 1.752 million tons = 16.2 years

4-1-5 Production Plan by Year (In thousand wet tons)

| | Open pit mining | | Underground mining | | Total | |
|---|---|---|---|---|---|---|
| | (Annual output) | (Accumulated output) | (Annual output) | (Accumulated output) | (Annual output) | (Accumulated output) |
| 1st year | 450 | 450 | 450 | 450 | 900 | 900 |
| 2nd " | 900 | 1,350 | 900 | 1,350 | 1,800 | 2,700 |
| 3rd " | 900 | 2,250 | 900 | 2,250 | 1,800 | 4,500 |
| 4th " | 900 | 3,150 | 900 | 3.150 | 1,800 | 6,300 |
| 5th " | 900 | 4,050 | 900 | 4,050 | 1,800 | 8,100 |
| 6th " | 900 | 4,950 | 900 | 4,950 | 1,800 | 9,900 |
| 7th " | 900 | 5,850 | 900 | 5,850 | 1,800 | 11,700 |
| 8th " | 900 | 6,750 | 900 | 6,750 | 1,800 | 13,500 |
| 9th " | 900 | 7,650 | 900 | 7,650 | 1,800 | 15.300 |
| 10th " | 900 | 8,550 | 900 | 8,550 | 1,800 | 17,100 |
| 11th " | 900 | 9,450 | 900 | 9,450 | 1,800 | 18,900 |
| 12th " | 550 | 10,000 | 1,250 | 10,700 | 1,800 | 20,200 |
| 13th " | 500 | 10,500 | 1,300 | 12,000 | 1,800 | 22,500 |
| 14th " | | | 1,800 | 13,800 | 1,800 | 24,300 |
| 15th " | | | 1,800 | 15,600 | 1,800 | 26,100 |
| 16th " | | | 1,800 | 17,400 | 1,800 | 27,900 |
| 17th " | | | 1,200 | 18,600 | 1,200 | 29,100 |
| TOTAL | 10,500 | | 18,600 | | 29,100 | |

4-1-6 Crude Ore and Specific Gravity

| | | Grade | Specific gravity |
|---|---|---|---|
| Massive ore | : | 57% | 4.2 |
| Disseminated ore | : | 34% | 3.2 |

4-1-7 Volume of Stripping (In thousand tons)

| Deposit | Volume of stripping | Remarks |
|---|---|---|
| La Encantada | 7,780 | S.G. = 3 |
| Espinazo | 720 | Stripping hardly noticed |
| Total: | 8,500 | |

4-1-8 Output by Unit Working Period (In wet tons)

| | Mining | | | Stripping | Drifting (m) |
|---|---|---|---|---|---|
| | (Open pit mining) | (Under-ground mining) | (Total) | | |
| Annual output | 900,000 | 900,000 | 1,800,000 | 750,000 | 2,700 |
| Monthly output | 75,000 | 75,000 | 150,000 | 75,000 | 225 |
| Average output per day | 3,000 | 3,000 | 6,000 | 3,000 | 9 |
| Max. output per day | 3,500 | 3,500 | 7,000 | 3,600 | - |
| Max. output per hour | 250 | 250 | 500 | 300 | - |
| Average planned working hour per day | 14 hrs | 14 hrs | 14 hrs | 16 hrs | - |
| Shifts per day | 2 | 2 | 2 | 2 | 2 |

Remarks: Mining and drifting - 300 working days a year

Stripping - 10 months working period a year, with 2 suspending months when the precipitation is the heaviest in the wet season

4-1-9 Open Pit Mining Plan

(1) The combination of large shovels and heavy dump trucks is not suitable for stripping work due to the steep topographical conditions. It should therefore be conducted by bench mining utilizing angle dozers, and the stripping should be thrown into the glory shaft.

(2) 10 m bench method is to be employed for mechanical mining which should be carried out by the combined use of shovels and trucks, and the ores are to be thrown into the small glory shaft.

(3) Transportation of ores is to be performed by trolly type locomotives and granvy type dump cars.

4-1-10 Outline of Mining

(1) Glory shaft

| | | |
|---|---|---|
| Stripping | : No. 5G, No. 6G | Total : 7 shafts |
| Mining | : No. 1G, No. 2G, No. 3G, No. 4G, No. 7G | |
| Length of shaft | : About 500 m | |

(2) Angle of the last bench: 45°

(3) Stripping volume classified by glory shaft

| | | |
|---|---|---|
| No. 6G | : About 6,000,000 tons | Total: 8,420,000 tons |
| No. 5G | : " 1,200,000 tons | |
| " " (Extrusion) | : " 500,000 tons | |
| No. 3G, No. 2G | : " 720,000 tons | |

(4) Mining

Mining is to be carried out by 10 m bench method and the ores are to be thrown into No. 2G, 3G, 4G and 7G. The bore holes, 3" in diameter, are to be drillled vertically by an air trac drill (2 shifts) utilizing AN-FO for blasting. The shovels, which are also to be used for construction works, should be diesel shovels (2.3 $m^2$). The trucks should be 4 wheeled Athey 30 ton dump trucks with the minimum turning radius.

Boulder blasting at the face is to be done by a secondary drilling machine with compressor, with further cobbing to be performed in the block holing chamber.

(5) Roads

A main road for transportation, 8 m in width, dip about 1/8, 7,700 m in length, leading to the mine, and a main access road connecting the mine office and the top of the mountain, 7 m in width, dip about 1/7, 2,500m in length, are to be constructed. From the main access road, communication roads leading to each face are to stem. The roads for shovels will be about 2,000 m in length, roads for angle dozers about 1,200 m, and other communication roads 1,000 m.

The shovel communication roads on 1,100 m and 1,050 m levels are to be constructed by means of rejecting yards.

(6) Machine shop

Machine shop for earth moving machinery should be established near the mine office.

4-1-11 Underground Mining

(1) Mining

(a) Sublevel stoping is to be employed when the deposit is 25 m or more in thickness. For thinner deposits with thickness ranging from 2 - 25 m, open stopes with supports should be employed. Size of the chamber will be 70 x 40 m, with 20 m ore pillar being left in between the chambers.

(b) In order to prepare for the mining work, drifting covering a total distance of 2,700 m should be performed each year.

| | |
|---|---|
| Tunnel at face | : 1,600 m/year |
| Cross cut & shaft | : 500 m/year |
| Prospecting tunnel | : 600 m/year |
| Total | : 2,700 m/year |

Drifting distance per 1,000 tons of crude ore : 3 m

(c) Number of faces and ore output

As listed below, 7 faces are required to be in constant operation. Further, for the purpose of maintaining the stability of ore grade, an additional 10 faces should always be ready for immediate operation.

Sublevel stoping

| | | |
|---|---|---|
| Stoping | : 360 t/shift x 2 faces x 2 shifts = | 1,440 t/day |
| Under cut, etc: | 60 t/shift x 2 faces x 2 shifts = | 240 t/day |
| | Total : | 1,680 t/day |

Open stopes with supports

| | | |
|---|---|---|
| Stoping | : 180 t/shift x 3 faces x 2 shifts = | 1,080 t/day |
| Under cut, etc : | 60 t/shift x 2 faces x 2 shifts = | 240 t/day |
| | Total: | 1,320 t/day |
| GRAND TOTAL: | 7 faces | 3,000 t/day |

(d) Drilling method

Drilling is to be conducted by large jumbos for long holes and by air trucks, with air legs to be used for under cut. In case of sublevel stoping, a long hole is to be drilled vertically and radially from the two sublevels in the middle of the face. The pattern thus produced should have the size of 2.5 x 4 m. In case of open stopes with supports, holes should be drilled in parellel upwardly and vertically in such a way as the size of each blasted section would be 2 x 2.5 m.

(e) Efficiency

| | Sublevel stoping | Open stope with supports | Under cut, etc. |
|---|---|---|---|
| Length of drilled hole per worker | 50 m | 40 m | 20 m |
| Tonnage per 1 m drilling | 17 t | 23 t | 2 t |

(2) Loading

(a) In case of sublevel stoping, scrapers (100 - 125 hp) are to be used, and in open stopes with supports, transloaders and small scrapers (50 hp) should be utilized.

In case of drifting, loading should be performed by rocker shovels and small scrapers (50 hp).

(b) Efficiency

| Equipment: | 100 hp scraper | 50 hp scraper | Trans-loader | Rocker shovel |
|---|---|---|---|---|
| Efficiency: | 150 tons | 75 tons | 75 tons | 35 tons |

(c) Transportation

Since the primary crusher is to be placed in the tunnel on 840 m level, ores mined by open pit as well as underground mining should be transported underground by trolly type locomotives (15 t or 12 t), with granvy type tubs concurrently utilized. In case of drifting, combination of the battery locomotives (6 t - 8 t) and 6 ton granvy type tubs is to be employed. Further, for the purpose of quick drifting, bunker trains are to be used.

(3) Other related items

(a) An incline with the dip of 13° is to be excavated from the end of the deposit for the purpose of transporting personnel, equipment and materials; and a winding machine of 300 hp should be installed.

(b) 4 stationary compressors, 2 each of 500 hp and 25 hp, are to be installed near the pit mouth on 900 m level.

(c) Ventilation should be dependent on natural air ventilation. In case the drifting is performed for a long distance or at places where the lack of proper ventilation occurs, local fans (5 - 20 hp) and air tubes of vinyl material should be installed.

(d) Drainage should be free draining. The water gushing out at each level is to be led to the inclines and discharged into the pit mouth on 900 m level.

4-1-12 Personnel Composition

| | Staff | Worker | Total |
|---|---|---|---|
| Prospecting | 2 | 8 | 10 |
| Open pit mining | 10 | 69 | 79 |
| Underground mining | 16 | 180 | 196 |
| TOTAL: | 28 | 257 | 285 |

The above personnel composition can be further broken up as follows.

| Prospecting | Open pit mining | Underground mining | Total |
|---|---|---|---|
| | 1 Chief engineer | | 1 |
| 1 Engineers | 2 Engineers | 6 Engineers | 9 |
| 1 Ass't engineer | 3 Ass'tenginners | 10 Ass't engineers | 14 |
| | 4 Clerks | | 4 |
| 8 Boring men | 10 Drillers | 20 Drifters<br>36 Miners | 74 |
| | 17 Heavy machinery operators | 40 Loading workers | 57 |
| | 6 Carriers | 14 Carriers | 20 |
| | 26 Other workers | 62 Other workers | 88 |
| | 10 Handy men | 8 Handy men | 18 |
| 10 | 79 | 196 | 285 |

4-1-13 Initial Expenses (In thousand yen)

| Facilities for Open pit mining | Amount | Remarks |
|---|---|---|
| Mechanical facilities | 381,985 | |
| Road construction | 132,100 | |
| Housing | 12,390 | (Office, warehouse, powder magazine, machine shop) |
| Haulage facilities | 63,300 | |
| Others | 82,265 | (Tools, equipment, gasoline tank, etc.) |
| Total: | 674,040 | (US$ 1.87 million) |

| Facilities for Underground mining | Amount | Remarks |
| --- | --- | --- |
| Mechanical facilities | 663,185 | |
| Drifting | 360,245 | |
| Construction works affiliated to drifting | 85,695 | (Wiring works for trolly type locomotives, pit mouth dressing, drainage, etc.) |
| Others | 91,350 | (Compressor chamber, electric works, telephone line installation, powder magazine, winding engine room) |
| Total: | 1,200,475 | (US$ 3.33 million) |
| GRAND TOTAL: | 1,874,515 | (US$ 52 million) |

Number & Specifications of Major Mechanical Facilities

| Kind | Specification | No. |
| --- | --- | --- |
| Shovels | P & H Diesel | 2 |
| Trucks | Athey PR619C 30 t | 3 |
| Angle dozer | Cat D-8 | 3 |
| Traxcavator | Cat D-977H | 1 |
| Air trac drill | Dember PR-123 | 3 |
| Loader | EIMCO - 4DH | 3 |
| Scraper | Joy 125 hp, 100 hp, 50 hp | 8 |
| Transloader | Joy - TL - 55 | 3 |
| Jumbo | Buk-22, BBC-54RFL | 2 |
| Compressor | 500 hp (2), 250 hp (2) | 4 |
| Trolly type locomotive | 15 t (2), 12 t (4) | 6 |
| Tub | 12 t granvy type | 60 |
| Battery locomotive | 6 t | 5 |
| Tub | 2.5 $m^3$ | 50 |
| Train loader | 35 $m^2$ | 1 |
| Alimak climber | | 3 |
| Trucks & jeeps | 4 trucks, 5 jeeps, 2 other kind of vehicles | 11 |
| Other facilities | | 1 set |

Major Roads

| Extension | Width (m) | Dip | Distance (m) |
|---|---|---|---|
| Main office - mine office | 8 | 1/10 | 7,700 |
| mine office 1,400 m level | 7 | 1/7 | 2,500 |
| Communication roads for shovels leading to faces | 8 | 1/10 | 2,000 |
| Communication roads for angle dozers leading to faces | 5 | 1/4 | 1,200 |
| Other communication roads | 5 | 1/10 | 1,000 |
| mine offce Pit mouth on 900 m level | 7 | 1/10 | 2,000 |
| Other roads | | | 2,000 |

Major Tunnels

| Kind | Size (m) | Dip | Distance (m) |
|---|---|---|---|
| Tunnel for velt conveyor, 700 m level | 2.3 x 2.8 | 1/50 | 1,500 |
| Communication tunnel, 820 m level | 3.0 x 4.0 | 1/150 | 550 |
| Haulage tunnel, 900 m level | 2.8 x 3.5 | 1/200 | 2,400 |
| Haulage tunnel, 1,000 m level | 2.8 x 3.5 | 1/200 | 800 |
| Haulage tunnel, 1,100 m level | 2.8 x 3.5 | 1/200 | 700 |
| Cross cut, etc. | 2.5 x 3.0 | 1/150 | 1,300 |
| Main incline | 2.5 x 3.0 | $13^{o}$ | 1,300 |
| Sub incline | 2.5 x 2.5 | $25^{o}$ | 400 |
| Shaft for open pit | 2.5 x 2.5 x 3.5 | | 1,140 |
| Shaft for underground | 3.5 x 3.5 | | 700 |
| Shaft, 700 - 800 m | 4.0 x 4.2 | | 240 |
| Shaft, 820 - 900 m | 4.0 x 4.0 | | 160 |

4-1-15 Operation Cost

| | Open pit mining (Thousand yen/ton) | Under-ground mining (Thousand yen/ton) | Total (Thousand yen/ton) | Cost per ton of crude ore (Yen) | Cost per ton of concen-trate (Yen) |
|---|---|---|---|---|---|
| Material Cost | | | | | |
| Gunpowder | 26,208 | 32,573 | | | |
| Steel materials | 13,085 | 32,725 | | | |
| Fuel, oil & grease | 4,692 | 1,310 | | | |
| Others | 37,200 | 38,780 | | | |
| Total: | 81,180 | 105,388 | 186,568 | 103 | 155 |
| Labour Cost | 75,320 | 126,800 | 202,120 | 113 | 168 |
| Other Costs | | | | | |
| Reparing | 51,334 | 36,000 | | | |
| Electricity | - | 14,537 | | | |
| Others | 9,900 | - | | | |
| Total: | 61,234 | 50,537 | 111,771 | 62 | 93 |
| TOTAL: | 217,724 | 282,725 | 500,459 | 278 | 416 |
| Cost per ton of crude ore | ¥242/t | ¥314/t | ¥278/t | | |
| Cost per ton of concentrates | ¥363/t | ¥471/t | ¥416/t | | |

Remarks: Cost of open pit mining includes stripping cost.
" " underground " " drifting cost.

4-2 Beneficiation Section

The beneficiation plan was drawn up based on the results of the tests conducted on Ore C which is most similar to the crude ores proposed to be mined (See Table 2-1, 9-1 --- 9-5, Flow Sheet No.3). As indicated in the attached flow sheet, the all sliming magnetic separation process was adopted in order to maintain the P content below 0.05%. It was decided, in view of relevant conditions and situations, to locate the beneficiation plant in Milan district about 2 km from the mine. The beneficiation would result in the elevation of grade, i.e., from Fe 50% of crude ore to Fe 67% of concentrates, Fe 13% of tailing. In this case, the yield percentage is 68.5% and the recovery percentage 91.8%.

The capacity of the beneficiation plant is set at 1.75 million tons of crude ore and 1.2 million tons of concentrates per year (Fe 67%, -325 mesh 85%).

Amount of tailing (dry tons) is 552 thousand tons annually, and the accumulated tonnage of tailing is about 9 million tons.

4-2-1 Outline of Beneficiation Plan

(1) Grades of crude ore, concentrates and of tailing are as given above with the beneficiation capacity and efficiency.

(2) Working days are as follows.
Working days will be 360 days a year, with 2 shifts per day adopted for primary and secondary crushing, 3 shifts for grinding and dehydration, and 10 hours a day for designing and 22 hours a day for operation.

(3) The beneficiation capacity is set at 900 t/h for primary crushing, 500 t/h for secondary crushing, and 230 t/h for grinding and processes which follow the grinding. The true specific gravity of crude ore, concentrates and tailing are 4.1, 4.6 and 1.5 respectively.

(4) Crushing is to be conducted over 3 stages, and the grain size by the final crushing should be -25 mm (-1").

(5) 20 mesh grinding will be conducted by Rod Mill utilizing open circuit, and -200 mesh grinding by Ball Mill utilizing the combination of cyclones and closed circuit.

(6) Ores ground by Rod Mill will be separated by high magnetic drum separator. Crude ores and concentrates will be classified by cyclones, and tailing will be classified and thickened by means of hydro separator.

The underflow of cyclones will be led to the secord grinding process, and the overflow to the 3 drum type separator.

(7) Stock pile will be about 6,000 dry tons.

(8) Tailing will be thickened and led to the tailing dam by slurry transport.

(9) Supernatent water will be used for beneficiation and the river water will be utilized when the supernatent water is not sufficiently available.

(10) The dehydration section of the pelletizing plant is included in this beneficiation plan.

4-2-2 Designing

(1) Refer to the attached drawings for the outline of the design.

(2) Electric power, rod, water, etc. to be consumed are as listed below.

| Item | Per ton of crude ore | Per ton of concentrate |
|---|---|---|
| Electricity | 21.3 KWH | 31.1 KWH |
| Rod | 0.4 kg | 0.6 kg |
| Ball | 0.6 kg | 0.9 kg |
| Water | 6.0 $m^3$ | 8.8 $m^3$ |
| Personnel | 0.013 | 0.018 |

(3) Voltages of electric appliances will be as follows.

| Item | Standard voltage |
|---|---|
| Motor, 50 hp & up | 3,300 V |
| Motor, 5 - 40 hp | 440 V |
| Motor, 4 hp and less | 220 V |
| Lighting equipment | 220 - 125 V |

(4) Tailing dam

Enbankment will be performed utilizing earth, sand and rock materials produced at the outset of the construction work. The concrete dam will be constructed , when need arises, after commencing production. See the attached drawing.

(5) Concrete aggregate

Gravels produced when drifting will be sieved and utilized, together with river gravels, as coarse aggregate. For fine aggregate, sand will be collected from the sea shore or from appropriate river banks.

4-2-3 Initial Expenses (In thousand yen)

| Item | Cost of equipment & materials | Freight | Installation & Construction | Total |
|---|---|---|---|---|
| Mechanical facilities | 695,832 | | 18,453 | 714,285 |
| Civil engineering work | 58,364 | | 134,179 | 192,543 |
| Housing | 25,344 | | 103,616 | 128,960 |
| Belt conveyor facilities | 90,705 | | 36,716 | 127,431 |
| Power receiving & distributing facilities | 49,000 | | 20,000 | 69,000 |
| Dehydration facilities | 107,020 | | 18,348 | 125,368 |
| Tailing dam | 50,385 | | 121,664 | 172,049 |
| Misecellaneous works | 46,980 | | 24,340 | 71,320 |
| TOTAL: | 1,114,640 | 277,909 | 477,316 | 1,869,865 |
| In thousand dollars | (3,096) | (772) | (1,326) | (5,194) |

4-2-4 Operation Cost (In yen)

| Item | Annual cost | Cost per ton of crude ore | Cost per ton of concentrate |
|---|---|---|---|
| Material cost | 175,343,000 | 100.10 | 146.10 |
| Labour cost | 50,502,000 | 28.00 | 42.10 |
| Other costs | 242,372,000 | 138.60 | 202.20 |
| TOTAL: | 468,217,000 (US$ 1,300,000) | 267.00 (US$ 0.74) | 390.00 (US$ 1.08) |

4-2-5 Outline of Facilities

| Major facilities | Quantity | Specification |
|---|---|---|
| (Primary Crushing) | | |
| Crude ore bin | 1 | Capacity - 200 t (for one freight train) |
| Apron feeder | 1 | 1.8 m x 8.0 m, 900 t/h |
| Gyratory crusher | 1 | 42" x 65", 300 hp, 900 - 1,000 t/h |
| Belt conveyor | 1 | 48" 20 m, 900 x 1,000 t/h |
| Overhead crane | 1 | 20 t |
| Ore bins | 2 | 2,500 t x 2 |
| Apron feeder | 2 | 1.2 m x 4.0 m, 500 t/h |
| Belt conveyor | 1 | 92" x 1,430 m (long distance), 500 t/h, -1/50 |
| (Secondary Crushing) | | |
| Storage bin | 1 | Capacity - 250 t |
| Apron feeder | 1 | 1.2 m x 3.0 m, 500 t/h |
| Belt conveyor | 78.5 m | 42", 500 t/h |
| " | 78.0 m | 40", 400 t/h |
| " | 7 m | 18", 100 t/h |
| Vibrating screen | 2 | 6' x 14', 2 decks, top - 2", lower - 1-3/4" |
| Metal detector | 1 | |
| Weighing equipment | 1 | Used for weighing 500 t/h |
| Overhead crane | 1 | 20 t |
| Ore bin | 1 | 5,000 t |
| (Grinding and Magnetic Separation) | | |
| Belt conveyor | 2 sets | 120 t/h |
| Rod mill | 2 | $10\frac{1}{2}$ x 12', overflow type, 700 hp/set |
| Ball mill | 7 | $10\frac{1}{2}$ x 16', overflow type, 900 hp/set |

| Major facilities | Quantity | Specification |
|---|---|---|
| Slurry pump | 12 | 6", 6 pumps to be kept in reserve |
| Cyclones | 20 | 12" Ø |
| Distributor | 6 | |
| Drum separator | 24 | 1 drum type, 0.6 x 1.7 m |
| " | 24 | 3 drum type |
| De-magnetizer | 8 | 5" Ø |
| Overhead crane | 4 | 10 t - 2 units, 5 t - 2 units |
| Water feed meter | 12 | |
| Sampler | 4 | Dry type 2, wet type 2 |

(a) Feeding of ore to the rod mill will be automatically controlled by constant feed meter which is to be used in combination with the weighing equipment.

(b) Feeding of water to the mill, drum separator and pump will be automatically controlled by water feed meter.

(c) The pulp density of the ore to be fed to the drum separator will be 45% at the primary separation and 20% at the secondary separation.

(d) Rods of 4" Ø and balls of 1 - 2" Ø will be properly selected and used. Rods and balls will be supplied by rail transport.

| Major facilities | Quantity | Specification |
|---|---|---|
| (Waste and Water) | | |
| Hydro-separator | 2 | 22" Ø |
| Thickener | 1 | 160' Ø |
| Slurry pump | 3 | 4" |
| Cyclones | 3 | 12 " Ø |
| Volute pump | 5 | 4.5 $m^3$/min set for repeatedly used water, 1 set to be kept in reserve |
| Turbine pump | 3 | 3.5 $m^3$/min set for fresh water, 1 set to be kept in reserve |
| Vertical pump | 4 | 2.5 $m^3$/min set for fresh water, 1 set to be kept in reserve |
| Water tank level gauge | 2 | For automatic operation |
| (Dehydration) | | |
| Thickener | 2 | 60' Ø |
| Slurry pump | 4 | 4", 2 sets to be kept in reserve |
| Disk filter | 6 | 8' Ø x 6 disk, 1 set to be kept in reserve |

| Major facilities | Quantity | Specification |
|---|---|---|
| Vacuum pump | 5 | Water-tight rotary type |
| Compressor | 2 | 20 $m^3$/min, 2 $kg/cm^2$, 1 set for spare |
| Filtrate pump | 2 | 2.0 $m^3$/min |
| Merric scale | 1 | |
| Sampler | 1 | |
| Belt conveyor | 200 m | 20" |
| Vertical pump | 1 | 2.5 $m^3$/min |
| Testing equipment | 1 set | Equipment for sample adjustment, chemical analysis, and beneficiation test |

(a) Water tank will have the capacity for one hour both for fresh water and repeatedly used water.

(b) Water pump will be automatically driven both for fresh water and repeatedly used water.

(c) The waste will be transported by 4" pump to the tailing dam and classified by cyclones into coarse grain waste and slime. The coarse grain waste will be used for enbankment, and the slime will be discharged into the dam.

The coarse sand in the waste will be carried up on the dam body by means of angle dozers.

(d) Concentrates transported by pipe transportation will be thickened by 50'Ø thickener, and de-watered through the filter.

4-2-6 Personnel Composition (of actually working personnel)

Staff - 8 : 2 engineers & 6 ass't engineers

Worker - 61 : 37 for mining,
13 for safety control,
9 for analysis, and
2 for clerical work

Total - 69

4-3 Mechanical and Electrical Facilities Section

4-3-1 General

(1) Personnel

Staff 8 : 3 engineers &
5 ass't engineers

Worker 28 : 5 mechanics,

6 electricians,
3 draftsmen,
2 carpenters,
10 handy men, and
2 clerical workers

Total - 36

(2) Initial Expenses (In Thousand yen)

| Item | Cost of equipment and materials | Freight | Installation & Construction | Total |
|---|---|---|---|---|
| Facilities for mechanical factory | 18,500 | 4,625 | 3,075 | 26,200 |
| Faciltles for electrical factory | 3,490 | 870 | 950 | 5,310 |
| Power receiving equipment | 52,000 | 13,000 | 10,000 | 75,000 |
| TOTAL: | 73,990 | 18,490 | 14,015 | 106,510 |

(3) Operation Cost (In yen)

| Item | Annual cost | Cost per ton of crude ore | Cost per ton of concentrate |
|---|---|---|---|
| Material cost | 7,700,000 | 4 | 6 |
| Labour cost | 29,498,000 | 16.8 | 24.6 |
| Other cost | 7,861,000 | 4.5 | 6.6 |
| TOTAL: | 45,059,000 | 25.7 | 37.5 |
| | (US$ 125,000) | (US$ 0.07) | (US$ 0.11) |

4-3-2 Outline of the Plan

Repairing of machines and equipment in the mining section is to be undertaken by each individual sub-section in charge. In this plan, therefore, the capacity and personnel were planned mainly for the purpose of maintaining the safety and security of the surface plant facilities, disregarding the repair of machines and equipment in the mining section. It is intended to utilize the small scale repair shop (privately owned) and the Mexican Navy's repair shop in Manzanillo, thereby to redue, to the minimum possible extent, the scale of the facilities at the mine.

With regard to the power receiving facilities, a substation will be established near the beneficiation plant which consumes the electric power most heavily, and electricity will be distributed from this substation. Expenses for the transmission facilities for the power receiving station will be borne by the electric company, and no initial expenses were estimated. Repair and maintenance of the transmission line wi ll also be undertaken by the electric company, and the expenses incurred by such repair or maintenance are not included in the operation cost.

4-3-3 Outline of Facilities, and Particulars Relative to Power Consumption

(1) Major facilities for mechanical factory

| Item | Q'ty | Specification |
|---|---|---|
| Lathe | 1 | 8' |
| " | 1 | 6' |
| Shaper | 1 | 24" |
| Milling machine | 1 | |
| Drilling machine | 1 | |
| Electric welder | 1 | |
| Air hammer | 1 | |
| Compressor | 1 | 100 rp |
| Factory building | 1 | 250 $m^2$, steel structured |

(2) Major facilities for electrical factory

| Item | Q ty | Specification |
|---|---|---|
| Dryer | 1 | |
| Trolly hoist | 1 | Capacity - 3 t |
| Factory building | 1 | 150 $m^2$, steel structured |

(3) Major facilities for power receiving station

| Item | Q'ty | Specification |
|---|---|---|
| Disconnecting switch | 1 | 69,000 V, 200 A |
| Air circuit breaker | 1 | w/compressor |
| Transformer | 1 | 3 ϕ 60/3 KVA on load |
| Switch board | 6 | |

Particulars relative to power consumption:

| | | |
|---|---|---|
| Power receiving voltage | : | 60,000 V |
| Total capacity | : | 7,600 KW |
| Diversity factor | : | 1.2 |
| Demand factor | : | 6.75 |
| Maximum demand power | : | 4,750 KW |
| Power receiving equipment capacity | : | 6,000 KVA |

4-4 Slurry Transporting Section

As a means of transporting ores from the mine to the port (pelletizing plant), there are 3 different methods, i.e., railway transport, land transport by trucks and slurry transport. With the view to developing the local industries, the Government of Mexico desired to transport the ores by constructing a railway line. However, since the district between the beneficiation plant and the port is quite steep, it is considered that the desired railway construction would incur a huge sum of money and the repayment therefor would not be possible by exploiting the Peña Colorada mine.

The Mexican authorities estimate the construction cost for the railway at about ¥50,000 (US$ 140) per meter or ¥3.5 billion (US$ 9.7 million) in total. Judging from the various conditions of the proposed route, however, the cost per meter is justifiably estimated to reach about ¥70,000. (US$ 190)

It is the opinion of the Survey Team that if the expenses for locomotives, freight cars and other necessary facilities are added, the total investment amount required for the railway construction would be as much as 6 - 7 billion yen (US$ 16~17 million). As regards the overland transportation utilizing big trucks, it is disadvantageous because of the high running cost.

As clarified by the beneficiation tests, all sliming magnetic separation process should be adopted for the Peña Colorada mine, and this process demands the slurry transporting of ores which is reviewed in the following sub-sections.

4-4-1 Preconditions for Slurry Transporting Plan

(1) The slurry transportation for pellet feed which is performed by International Nickel Company (INCO), Canada was observed, and their data on slurry transportation were utilized.

(2) In this plan, the gradient in natural flow transport was set at 5% and that in slurry transport at 0.5%, and the flow velocity was set at 1.56 m/sec., though these factors should of course be reviewed and determined by slurry transport tests.

(3) One route of wooden pipe (10" dia.) line is to be established, with spare pumps to be stored in reserve.

(4) Transmission line was assumed to be laid along the pipe line by the Mexican Electric Co. Cost estimation was therefore made only for the power receiving and distributing facilities.

(5) The pipe line way should be plotted on the drawing (scale : 1/10,000). Construction cost of the road required for the pipe line way was estimated at about ¥7,000 (US$ 17) per meter, and it was assumed that the reserve funds would be utilized to meet with any further requirements of expenses.

(6) The pipe line way should, in principle, be laid on one side of the road. A part of the expenses for constructing suspension bridges and the loading pier was also included in the cost estimation.

(7) For road construction, efforts were made towards reducing the initial expenses. This should be accomplished by constructing the road, where and as far as possible, by utilizing earth moving machinery prepared for open pit mining, and by letting out to a contractor only that part of road construction which cannot be covered by such direct work by the mine side.

(8) Reconnaissance and observation should be made on the proposed pipe line route. It is possible that there will be a change in the construction cost of the road, suspension bridge and loading pier when such reconnaissance and review are made in the future.

4-4-2 Initial Expenses (In thousand yen)

| Item | Cost | Remarks |
|---|---|---|
| Pump facilities (motor inclusive) | 321,000 | TV control system inclusive |
| Sub-station & power distribution | 68,000 | |
| Freight | 97,500 | 389,000 x 0.25 |
| Total: | 486,500 | |
| Pipe (wooden) & wooden conduit | 325,700 | Materials for supports inclusive |
| Pipe line accessories | 71,700 | |
| Installation of pipe and pump | 200,000 | |
| Freight | 18,300 | |
| Total: | 615,700 | |
| Road | 498,800 | |
| GRAND TOTAL: | 1,600,000 | |

(In thousand dollers 4,444)

4-4-3 Operation Cost (exclusive of administration cost) - In Yen

| Item | Annual cost | Cost per ton of concentrate | Remarks |
|---|---|---|---|
| Cost of materials and equipment | 10,920,000 | 9.10 | |
| Labour cost | 22,200,000 | 18.50 | Repair cost included in the labour cost of pelletizing plant section |
| Power cost | 55,920,000 | 46.40 | $\frac{1,792 \text{ KWH} \times ¥4/\text{KW}}{2.56 \text{ t/min} \times 60 \text{ min}} = ¥46.40/\text{t}$ |
| TOTAL: | 89,040,000 (US$ 247,000) | 74.00 (US$ 0.21) | |

¥1.76/ton mile ≒ 0.49 ¢/ton mile

4-4-4 Personel Composition (mechanics to be made available from other sections)

| Job classification | No. | Cost per month |
|---|---|---|
| Engineer | 1 | ¥200,000 |
| Ass't engineer | 3 | 100,000 |
| Operator | 30 | 30,000 |

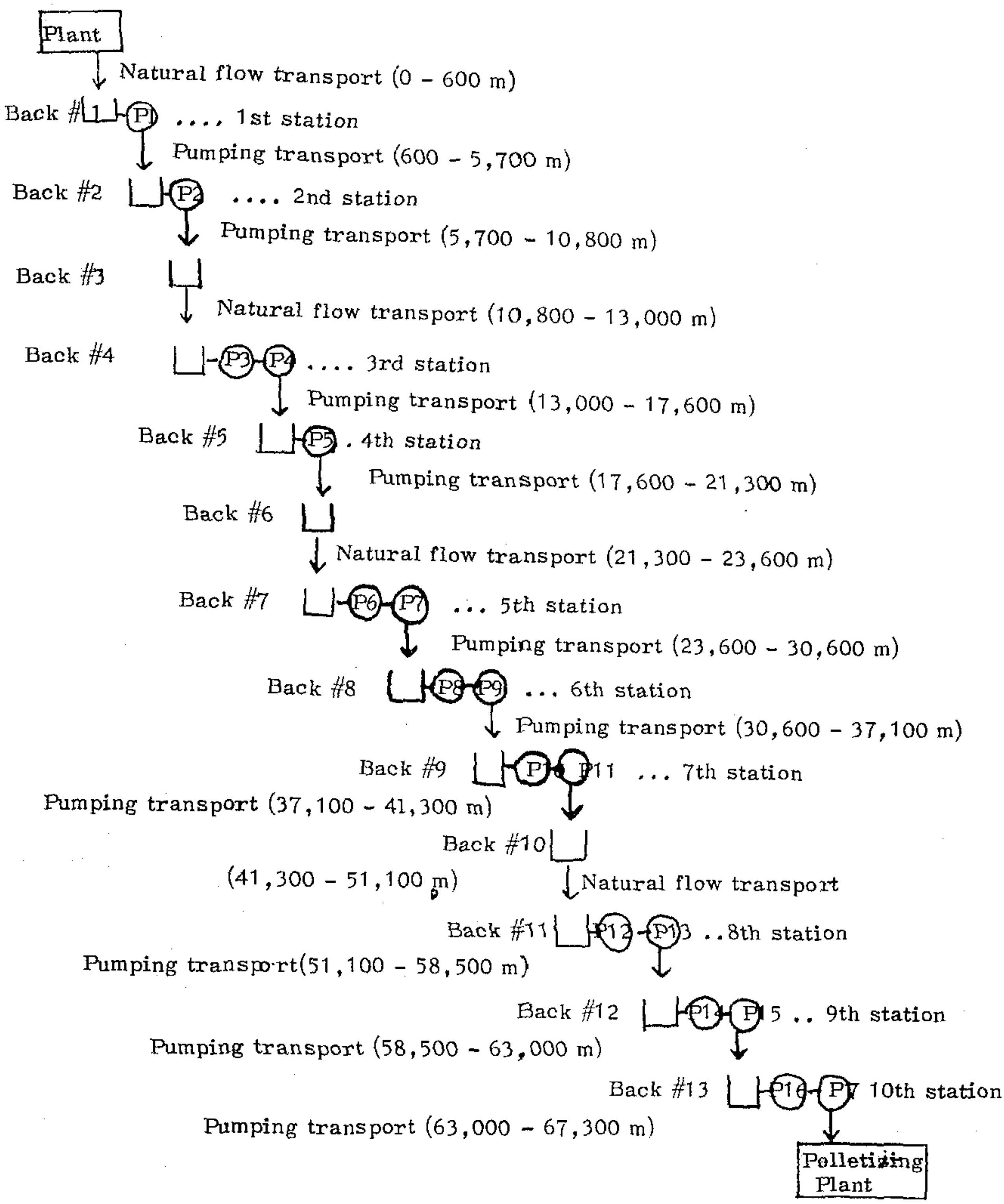
4-4-5 Slurry Transport Plan

| | |
|---|---|
| Transporting quantities (dry ton) | : 1.2 million tons/year |
| Working hours | : 24 hrs/day - 365 days/year |
| Specific gravity of solids | : 4.6 |
| Concentration by weight | : 40% |
| Specific gravity of slurry | : 1.456 |
| Ore transport quantities (dry ton) | : 2.56 t/min |
| Flow rate | : 4.6 $m^3$/min |
| Pipe diameter nominal | : 250 mm |
| Flow velocity | : 1.56 m/sec |

4-4-6 Particulars of Slurry Transporting

| Station | Distance | Transport method | Elevation at the starting point | Elevation at the end of distance | Difference in elevation | Pipe length | Friction head loss | Total head | Head per pump | No. of pumps |
|---|---|---|---|---|---|---|---|---|---|---|
| | Plant - - 1st | Natural flow transport | 630 m | 600 m | -40 m | 600 m | 8.4 m | -22.6 | - | - |
| 1st | 1st - 2nd | Pump transport | 595 | 565 | -30 | 5,100 | 71.4 | 41.4 | 42 | 1 |
| 2nd | 2nd - 2' | " " | 560 | 530 | -30 | 5,100 | 71.4 | 41.4 | 42 | 1 |
| | 2' - 3rd | Natural flow transport | 525 | 445 | -80 | 2,200 | 30.8 | -49.2 | - | - |
| 3rd | 3rd - 4th | Pump transport | 440 | 445 | -15 | 4,600 | 64.4 | 69.4 | 35 | 2 |
| 4th | 4th - 4' | " " | 440 | 430 | -10 | 3,700 | 51.8 | 41.8 | 42 | 1 |
| | 4' -5th | Natural flow transport | 425 | 375 | -50 | 2,300 | 32.2 | -17.8 | - | - |
| 5th | 5th - 6th | Pump transport | 370 | 340 | -30 | 7,000 | 98.0 | 68.0 | 35 | 2 |
| 6th | 6th - 7th | " " | 335 | 310 | -25 | 6,500 | 91.0 | 66.0 | 35 | 2 |
| 7th | 7th - 7' | " " | 305 | 310 | +5 | 4,200 | 58.8 | 63.8 | 35 | 2 |
| | 7' - 8th | Natural flow transport | 305 | 51 | -254 | 9,800 | 137.2 | -116.8 | - | - |
| 8th | 8th - 9th | Pump transport | 46 | 10 | -36 | 7,400 | 103.6 | 67.6 | 35 | 2 |
| 9th | 9th - 10th | " " | 5 | 8 | +3 | 4,500 | 63.0 | 66.0 | 35 | 2 |
| 10th | 10th - Plant | " " | 3 | 10 | +7 | 4,300 | 60.2 | 67.2 | 35 | 2 |
| | | | | | | 67,300 | | | | 17 |

4-4-7 Arrangement of Pumps



## 4-4-8 Specifications of the Pump

| Item | Unit | Specification |
|---|---|---|
| Model | | SP II - 200 |
| Kind of material contacting slurry | | *Rubber lining* |
| Slurry | | Iron ore slurry |
| Specific gravity of solids | | 4.6 |
| Density of slurry | % | 40 |
| Specific gravity of slurry | | 1.456 |
| Screen analysis | | -325 mesh 85% |
| Flow rate | $m^3/mm$ | 4.6 |
| Pipe diameter nominal | mm | 250 |
| Flow velocity | m/s | 1.56 |

| Station | | 1st | 2nd | 3rd | 4th | 5th | 6th | 7th | 8th | 9th | 10th |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Elevation at starting point | m | 595 | 560 | 440 | 440 | 370 | 335 | 305 | 46 | 5 | 3 |
| Elevation at the end of distance | m | 565 | 530 | 445 | 430 | 340 | 310 | 310 | 10 | 8 | 10 |
| Difference in elevation | m | *-30* | *-30* | *+5* | *-10* | *-30* | *-25* | *+5* | *-36* | *+3* | *+7* |
| Pipe length | m | 5100 | 5100 | 4600 | 3700 | 7000 | 6500 | 4200 | 7400 | 4500 | 4300 |
| Friction head loss | m | 71.4 | 71.4 | 64.4 | 51.8 | 98.0 | 91.0 | 58.8 | 103.6 | 63.0 | 60.2 |
| Total left head | m | 41.4 | 41.4 | 69.4 | 41.8 | 68.0 | 66.0 | 63.8 | 67.6 | 66.0 | 67.2 |
| No. of pumps | | 1 | 1 | 2 | 1 | 2 | 2 | 2 | 2 | 2 | 2 |
| Total lift head per pump | m | 42 | 42 | 35 | 42 | 37 | 37 | 37 | 35 | 35 | 35 |
| Pump revolution | rpm | 980 | 980 | 900 | 980 | 900 | 900 | 900 | 900 | 900 | 900 |
| Efficiency (fresh water) | % | 52 | 52 | 52 | 52 | 52 | 52 | 52 | 52 | 52 | 52 |
| Efficiency (slurry) | % | 41.6 | 41.6 | 41.6 | 41.6 | 41.6 | 41.6 | 41.6 | 41.6 | 41.6 | 41.6 |
| Motor for pump | kw & p | 150, 6p | 150, 6p | 110, 6p | 150, 6p | 150, 6p | 150, 6p | 150, 6p | 110, 6p | 110, 6p | 110, 6p |
| V belt | D x | 12 | 12 | 10 | 12 | 10 | 10 | 10 | 10 | 10 | 10 |
| V belt spped | m/s | 20.5 | 20.5 | 18.9 | 20.5 | 18.9 | 18.9 | 18.9 | 18.9 | 18.9 | 18.9 |

Bearing on impeller side 22226K

Bearing on belt side 32324DB25

| Item | Unit | Specification | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Bearing lubrication | | | | Oil bath | | | | | | | |
| (Station) | | (1st) | (2nd) | (3rd) | (4th) | (5th) | (6th) | (7th) | (8th) | (9th) | (10th) |
| Pump axis power | KW | 110.2 | 110.2 | 91.9 | 110.2 | 97.2 | 97.2 | 97.2 | 91.9 | 91.9 | 91.9 |

## 4-5 Pelletizing Plant Section

The pelletizing plant should be designed on the basis of the results of the pellet test and pilot test now being conducted. However, since these two tests are not yet completed, the trial calculation of the initial expenses has been made based on the following preconditions and of data provided by Hitachi Shipbuilding Company.

### 4-5-1 Preconditions

(1) The concentrates will be fine magnetite containing 5% of hematite which is to be transported by means of slurry transporting. Size will be -325 mesh 85%, Fe grade 67%, and P grade 0.03%.

(2) For convenience's sake, cost of thickening and filtering equipment was added to the initial expenses of the beneficiation plant, and is not, therefore, included in the initial expenses of the pelletizing plant section.

(3) The pelletizing plant will have the annual productive capacity of 1.2 million tons. The type of the machine to be installed is tentatively decided to be the Horizontal Gate with Hearth and Side Layer manufactured by Lurgi Gessellshaft, Germany.

(4) The stock of feed ores at the pelletizing plant is set at 6,000 wet tons.

(5) Electric power will be purchased at ¥4/KW (US$ 001/Kw), and the power receiving facilities only will be constructed.

### 4-5-2 Initial Expenses (In thousand yen)

| Item | Quantity | Cost | |
|---|---|---|---|
| Equipment of bins and stocks | 1 set | 40,000 | |
| Equipment of pelletizing dises | 1 set | 72,000 | |
| Firing machinery | 1 set | 1,530,000 | |
| Luminous indicator | 1 set | 36,500 | |
| Electrical equipment | 1 set | 392,000 | |
| Sub-station | 1 set | 50,000 | 4,000 KVA |
| Sub-total: | | 2,120,500 | |

| Item | Quantity | Cost |
|---|---|---|
| Construction of steel structure for building | | 565,000 |
| Construction of chimneys | | 56,500 |
| Installation cost | | 190,000 |
| Sub-total | | 811,500 |
| Freight | | 480,000 |
| Other costs | | 88,000 |
| Sub-total | | 568,000 |
| GRAND TOTAL: | | 3,500,000 |
| | (In thousand dollers | 9,722) |

4-5-3 Personnel Composition

| Job classification | No. | Cost per month |
|---|---|---|
| Plant superintendent | 1 | ¥300,000/month |
| Engineer | 2 | 250,000 |
| Chief clerk | 1 | 200,000 |
| Clerical worker | 6 | 100,000 |
| Mechanic | 6 | 100,000 |
| Foreman | 1 x 3 shifts | 100,000 on the average |
| Operator | 9 x 3 shifts | |
| Handy man | 3 x 3 shifts | |

Staff : 13
Worker : 42
Total: 55 (Staff members will be concurrently in charge of clerical work of loading and slurry transporting sections)

4-5-4 Operation Cost (Yen/ton)

| Item | Cost |
|---|---|
| Material & Other cost | 144.00 |
| Cost for repair, safety control and fuel of pelletizing plant | 190.20 |
| Labour cost | 51.00 |
| Electricity (28 KWH/t) | 100.10 |
| Ground rent @ ¥100 x 250,000 $m^2$ | 20.40 |
| Other cost | 119.30 |
| TOTAL: | 625.00 |
| | (US$ 1.74) |

## 4-6 Port and Loading Section

### 4-6-1 Outline of the Plan

Construction of loading facilities and shore protection works only will be undertaken by the mine side. The channel and drainage works are to be performed by the Mexican Navy.

The annual shipping volume is set at 1.2 million tons. The freighter for marine transportation of ores will be 45,000 - 50,000 tons. The stock pile yard will be 24,000 $m^2$, with the maximum storage capacity of 200 thousand tons.

Equipment for stocks and loading are as follows.

| Equipment | No. | Capacity |
|---|---|---|
| Stacker | 2 | 1,000 t/h |
| Jib loader | 2 | " |
| Belt conveyor | 2 | " |

Loading capacity nominal will be 2,000 tons per hour.

### 4-6-2 Cost for Facilities (In thousand yen)

| Item | Quantity | Cost |
|---|---|---|
| Stock facilities and ore transporting equipment | 1 set | 600,000 |
| Shore protection works | | 200,000 |
| Cost of land | 40,000 $m^2$ | 4,000 |
| Others | | 100,000 |
| Total: | | 904,000 |
| | (In thousand dollers | 2,511) |

### 4-6-3 Personnel Composition

| Job Classification | No. |
|---|---|
| Ass't engineer | 3 |
| Loading worker | 21 |
| Mechanics | 5 |
| Clerical worker | 3 |
| Handy man | 1 |
| TOTAL: | 33 |

### 4-6-4 Operation Cost (In thousand yean/year)

| Item | Cost |
|---|---|
| Cost for materials, repair and maintenance | 30,000 |

| Item | Cost |
|---|---|
| Other material & equipment cost | 10,000 |
| Total: | 40,000 |
| Labour cost | 18,000 |
| Other cost | |
| Electric power | 7,500 |
| Port charges | 18,000 |
| Others | 5,500 |
| Total: | 31,000 |
| GRAND TOTAL: | 89,000 |

Cost per ton of concentrate : ¥74
(US$ 0.21)

4-7 Administration Section

Main office and warehouse will be constructed west to the beneficiation plant. And on the flat land area further to the west of the beneficiation plant, dormitories, boarding houses, hopital, church, etc. will be constructed. Water will be supplied by the pipe line to be laid from the water source for beneficiation.

4-7-1 Personnel Composition

| Job classification | No. |
|---|---|
| Chief clerk | 1 |
| Secretary | 2 |
| Ass't secretary | 4 |
| Clerical worker | 34 |
| Handy man | 10 |
| Physician | 2 |
| Nurse | 4 |
| Teacher | 10 |
| TOTAL: | 68 |

4-7-2 Initial Expenses (In thousand yen)

| Item | Cost |
|---|---|
| Buildings | 235,250 |
| Construction works for facilities | 109,800 |
| Fixtures, etc. | 89,950 |
| TOTAL: | 435,000 |

(In thousand dollers 1,208)

Major Buildings:

| Item | Floor space ($m^2$) |
|---|---|
| Main office | 800 |
| Warehouse | 600 |
| Dormitory | 375 No. |
| Boarding house | 1,600 |
| Club | 200 |
| School | 850 |
| Hospital | 500 |
| Church | - |

Major facilities:

Water supply facilities

Drainage facilities

Electric distribution facilities

Telephone facilities

Roads

Others (Land, land readjustment, afforestation, etc.)

Fixtures:

| Item | Q'ty |
|---|---|
| Fixtures for office | 1 set |
| " " hosptial | 1 set |
| " " school | 1 set |
| Automobile | 3 trucks, 2 buses & 2 jeeps |

4-7-3 Operation Cost (In thousand yen/year)

| Item | Cost |
|---|---|
| Cost of materials & equipment | 7,080 |
| Labour cost | 46,440 |
| Other cost | 60,750 |
| Sub-total | 114,270 |
| Other cost | |
| Amount to be alloted to enbankment and tailing dam, & tax payable | 112,730 |
| GRAND TOTAL: | 227,000 |

Cost per ton of concentrate : ¥189 (US$ 0.52)

4-8 Other Affiliated Items

4-8-1 Cost for Technical Guidance

It is expected that during the 5 year exploitation period (of which 2 years are for exploration and planning), technical guidance relating to exploitation and operation of the mine will be given by Japanese engineers.

No. of engineers to be despatched:

| | |
|---|---|
| Chief engineer | : 1 |
| Geologist | : 2 |
| Mining engineer | : 2 |
| Beneficiation engineer | : 2 |
| Civil engineer | : 2 |
| Electric engineer | : 2 |
| Mechanical engineer | : 2 |
| Assistant to engineer | : 5 - 10 |

Total cost for technical guidance during the 5 year period (In thousand yen): 725,000

In thousand dollers 2,014

4-8-2 Cost for Test and Designing (In thousand yen)

Cost for test

| | |
|---|---|
| Test and analysis of ores | : 5,000 |
| Beneficiation test | : 3,000 |
| Slurry test | : 15,000 |
| Pellet test | : 5,000 |
| Total: | 28,000 |

Cost for designing

| | |
|---|---|
| Designing of beneficiation plant | : 30,000 |
| " " slurry transport facilities | : 45,000 |
| " " pelletizing plant | : 30, 000 |
| " " loading facilities | : 10,000 |
| Total: | 115,000 |

GRAND TOTAL: 143,000

In thousand dollers 397

4-8-3 Expenses for Exploration (In thousand yen)

| | | |
|---|---|---|
| Expenses for geophysical survey | : 36,000 | ... Expenses already spent by the Government of Mexico |
| " " boring test | : 273,000 | |
| " " designing | : 23,040 | |
| " " establishing camps | : 72,000 | |

# 5. CONCLUSION

| | | |
|---|---|---|
| Investigation expenses | : 6,560 ... | Expenses borne by the Government of Japan for the investigations of this time. |
| Expenses for investigations to be conducted in FY 1964 and in subsequent years | : 158,800 | |
| GRAND TOTAL: | : 570,000 | |
| | In thousand dollers 1,583 | |

4-8-4 Reserve Funds (In thousand yen)

About 10% of the investment amount, ¥1,250,000 thousand, is alloted. In thousand dollers 3,472

Total cost required for items 4-8-1 --- 4-8-4 is as follows. (In thousand yen)

| | | | In thousand dollers |
|---|---|---|---|
| Cost for technical guidance | : | 725,000 | 2,014 |
| Cost for tests and investigations | : | 143,000 | 397 |
| Expenses for exploration | : | 570,000 | 1,583 |
| Reserve funds | : | 1,250,000 | 3,472 |
| TOTAL: | : | 2,688,000 | 7,466 |

## 5. CONCLUSION

Results of the study and review made on different questions, given in the preceding pages of this Report, indicate that if various preconditions submitted could be met satisfactorily, the Peña Colorada mine may become the object of mining.

Given hereunder are a few items which were considered important for the exploitation of the mine.

1. Ore Reserves and Grades

Explorations made in the past for the Peña Colorada mine were far from being accurate and precise. It is therefore a matter of utmost importance to conduct, in the future, more diamond drilling tests, thereby to confirm the distribution of deposits, to increase the ore reserves and to re-check the ore grades.

Since the ores contain phosphorus minerals, it was found necessary to grind them to -200 mesh. This calls for the establishment of a pelletizing plant which requires far more than the estimated present ore reserves. Consequently, increase in the ore reserves is indeed an important matter.

It is therefore considered quite urgent to conduct explorations for ore deposits at the Pena Colorada mine as well as in its vicinity so that sufficient ore reserves may be secured for the pelletizing plant.

2. Mining and Beneficiation

Though there exist no outstanding problems at present, it is conceivable that the underground mining, when compared with the open pit mining, would incur far more production cost and require far larger object ore reserves when in future the production amount increases. Efforts should therefore be directed in the future towards locationg deposits capable of open pit mining.

3. Slurry Transporting

No slurry transporting covering a distance of 70 km is being practised in the world. Slurry tests should therefore be conducted in full detall before the exploitation.

4. Electric Power

In case the electric power consumption exceeds 5,000 KW, the transmission and other facilities are to be constructed by the Mexican Electric Co. The mine side will be responsible only for the power receiving and distributing facilities.

5. Interests

An interest rate of 10% per annum was set in this Report. If funds were available at lower rate of interest, the management of the mine would naturally become easier. Further review in this respect will be necessary.

6. Port Facilities

Of various port facilities, the construction of the channel and drainage was assumed to be undertaken by the Mexican Navy. The mine side would therefore be responsible for the shore protection works and loading facilities only.

7. Repayment of the Total Investment Amount

Repayment of the invested amount inclusive of interests was assumed to be completed over a 10 year depreciation period.

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## SUPPLEMENT I

### DETAILED ORE RESERVES CALCULATION
### OF THE PEÑA COLORADA MINE

| Sectional line | Front section | Rear section | Average section | Intervals of sections | Volume | S.G. | Distribution percentage | Ore reserves | (Grade) Fe | P | S |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | ($m^2$) | ($m^2$) | ($m^2$) | (m) | ($m^3$) | | ( % ) | (ton) | (%) | (%) | (%) |
| La Encantada, North. (A - C) (Massive Ore), Proved | | | | | | | | | | | |
| A | | 960 | 480 | 20 | 9,600 | 4 | 84 | | | | |
| A - B | 960 | 2,480 | 1,720 | 49 | 84,280 | " | " | | | | |
| B - C | 2,480 | 2,560 | 2,520 | 53 | 133,560 | " | " | | | | |
| C | 2,560 | | 1,280 | 20 | 25,600 | " | " | | | | |
| | | | | | 253,040 | 4 | 84 | 850,214 | 53.01 | 0.262 | |
| La Encantada. (E - H) (Massive Ore), (Proved + Probable) | | | | | | | | | | | |
| E | | 6,770 | 3,385 | 36 | 121,860 | 4.2 | 80 | | | | |
| E - F | 6,770 | 11,980 | 9,375 | 63 | 590,625 | " | " | | | | |
| F - G | 11,980 | 6,920 | 9,450 | 65 | 614,250 | " | " | | | | |
| G - H | 6,920 | 4,720 | 5,820 | 62 | 360,840 | " | " | | | | |
| H | 4,720 | | 2,360 | 80 | 188,800 | | | | | | |
| | | | | | 1,876,375 | 4.2 | 80 | 6,304,620 | 56.83 | 0.253 | |

| Sectional line | Front section ($m^2$) | Rear section ($m^2$) | Average section ($m^2$) | Intervals of sections (m) | Volume ($m^3$) | S.G. | Distribution percentage (%) | Ore reserves (ton) | (Grade) Fe (%) | P (%) | S (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| La Encantada. (E - H) (Massive Ore), (Proved) | | | | | | | | | | | |
| E | | 5,690 | 2,845 | 36 | 102,420 | 4.2 | 80 | | | | |
| E - F | 5,690 | 10,560 | 8,125 | 63 | 511,875 | " | " | | | | |
| F- G | 10,560 | 6,120 | 8,340 | 65 | 542,100 | " | " | | | | |
| G - H | 6,120 | 4,720 | 5,420 | 62 | 336,040 | " | " | | | | |
| H | 4,720 | | 2,360 | 30 | 188,800 | " | " | | | | |
| | | | | | 1,681,235 | 4.2 | 80 | 5,648,949 | 56.83 | 0.253 | |

Remarks:

Probable ore reserves of La Encantada:

Probale = (Proved + Probable)- (Proved ) : 6,304,620 ( Proved + Probable)- 5,468.949 ( Proved ) = 655.671 t

| Sectional line | Front section ($m^2$) | Rear section ($m^2$) | Average section ($m^2$) | Intervals of sections (m) | Volume ($m^3$) | S.G. | Distribution percentage (%) | Ore reserves (ton) | Fe (%) | P (%) | S (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Chin Forinazo, North. (6 - 12) (Massive Ore), ( Proved + Probable) | | | | | | | | | | | |
| 6 | | 12,120 | 6,060 | 50 | 303,000 | 4 | 80 | | | | |
| 6 - 7 | 12,120 | 9,230 | 10,675 | 40 | 427,000 | " | | | | | |
| 7 - 8 | 9,230 | 7,580 | 8,405 | 100 | 840,500 | " | | | | | |
| 8 - 9 | 7,580 | 5,410 | 6,495 | 51 | 331,245 | " | | | | | |
| 9 - 10 | 5,410 | 5,830 | 5,620 | 47 | 264,140 | " | | | | | |
| 10 - 11 | 5,830 | 5,350 | 5,590 | 61 | 340,990 | " | | | | | |
| 11 - 12 | 5,350 | 5,120 | 5,235 | 41 | 214,635 | " | | | | | |
| | | | | | 2,721,510 | 4 | 80 | 8,708,832 | 54.24 | 0.073 | |

| Sectional line | Front section ($m^2$) | Rear section ($m^2$) | Average section ($m^2$) | Intervals of sections (m) | Volume ($m^3$) | S.G | Distribution percentage (%) | Ore reserves (ton) | (Grade) Fe (%) | P (%) | S (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Chinforinazo, North. (6 - 12) (Massive Ore), (Proved)** | | | | | | | | | | | |
| 6 | | 7,920 | 3,960 | 50 | 198,000 | 4 | 80 | | | | |
| 6 - 7 | 7,920 | 5,600 | 6,760 | 40 | 270,400 | " | " | | | | |
| 7 - 8 | 5,600 | 6,860 | 6,230 | 100 | 623,000 | " | " | | | | |
| 8 - 9 | 6,860 | 5,120 | 5,990 | 51 | 305,490 | " | " | | | | |
| 9 - 10 | 5,120 | 5,360 | 5,240 | 47 | 246,280 | " | " | | | | |
| 10 - 11 | 5,360 | 3,920 | 4,640 | 61 | 283,040 | " | " | | | | |
| 11 - 12 | 3,920 | 3,320 | 3,640 | 41 | 149,240 | " | " | | | | |
| | | | | | 2,075,450 | 4 | 80 | 6,641,440 | 54.24 | 0.073 | |

**Remarks:**

Probable ore reserves of Chinforinazo—

Probable = ( Proved + Probable )- ( Proved ) : 8,708,832 ( Proved + Probable )- 6,641,440 ( Proved ) = 2,067,392 t

| Sectional line | Front section ($m^2$) | Rear section ($m^2$) | Average section ($m^2$) | Intervals of sections (m) | Volume ($m^3$) | S.G | Distribution percentage (%) | Ore reserves (ton) | (Grade) Fe (%) | P (%) | S (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Chinforinazo, South. (12 - 18) (Massive Ore), ( Proved + Probable )** | | | | | | | | | | | |
| 12 - 13 | 5,120 | 11,080 | 8,100 | 67 | 542,700 | 4.2 | 80 | | | | |
| 13 - 14 | 11,080 | 14,900 | 12,990 | 55 | 714,450 | " | " | | | | |
| 14 - 15 | 14,900 | 16,250 | 15,575 | 45 | 700,875 | " | " | | | | |
| 15 - 16 | 16,250 | 14,830 | 15,540 | 47 | 730,380 | " | " | | | | |
| 16 - 17 | 14,830 | 11,610 | 13,220 | 53 | 700,660 | " | " | | | | |
| 17 - 18 | 11,600 | 1,880 | 6,745 | 100 | 674,500 | " | " | | | | |
| 18 | 1,800 | | 940 | 42 | 39,480 | " | " | | | | |
| | | | | | 4,103.045 | 4.2 | 80 | 13,786,231 | 61.15 | 0.076 | |

| Sectional line | Front section ($m^2$) | Rear section ($m^2$) | Average section ($m^2$) | Intervals of sections (m) | Volume ($m^3$) | S.G. | Distribution percentage (%) | Ore reserves (ton) | (Grade) Fe (%) | P (%) | S (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| *Chinforinazo*, South. (12 - 18) (Massive Ore), ( Proved ) | | | | | | | | | | | |
| 12 - 13 | 3,360 | 7,200 | 5,280 | 67 | 353,760 | 4.2 | 80 | | | | |
| 13 - 14 | 7,200 | 11,780 | 9,480 | 55 | 521,950 | " | " | | | | |
| 14 - 15 | 11,780 | 14,490 | 13,135 | 45 | 591,075 | " | " | | | | |
| 15 - 16 | 14,490 | 13,560 | 14,025 | 47 | 659,175 | " | " | | | | |
| 16 - 17 | 13,560 | 10,960 | 12,260 | 53 | 649,780 | " | " | | | | |
| 17 - 18 | 10,960 | 1,880 | 6,420 | 100 | 642,000 | " | " | | | | |
| 18 | 1,880 | | 940 | 42 | 39,480 | " | " | | | | |
| | | | | | 3,457,220 | 4.2 | 80 | 11,616,259 | 61.15 | 0.076 | |

**Remarks:**

Probable ore reserves of Chinforinazo South -

Probable =( Proved + Probable) - ( Proved ): 13,786,231 ( Proved + Probable) - 11,616,259( Proved ) = 2.169,972 t

| Sectional line | Front section | Rear section | Average section | Intervals of sections | Volume | S.G. | Distribution percentage | Ore reserves | (Grade) Fe | P | S |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Espinazo (1 - 11) (Massive Ore), (Confirmed) | | | | | | | | | | | |
| 1 - 2 | 1,290 | 1,710 | 1,500 | 81 | 121,500 | 4.2 | 80 | | | | |
| 2 - 3 | 1,710 | 1,900 | 1,805 | 30 | 54,150 | " | " | | | | |
| 3 - a | 1,900 | 1,720 | 1,810 | 50 | 90,500 | " | " | | | | |
| a - 4 | 1,720 | 1,220 | 1,470 | 20 | 29,400 | " | " | | | | |
| 4 - b | 1,220 | 3,800 | 2,510 | 35 | 87,850 | " | " | | | | |
| b - 5 | 3,800 | 2,200 | 3,000 | 65 | 195,000 | " | " | | | | |
| 5 - 6 | 2,200 | 1,890 | 2,045 | 59 | 120,655 | " | " | | | | |
| 6 - c | 1,890 | 400 | 1,145 | 84 | 96,180 | " | " | | | | |
| c - 8 | 400 | 760 | 580 | 55 | 31,900 | " | " | | | | |
| 8 - 9 | 760 | 2,090 | 1,425 | 51 | 72,675 | " | " | | | | |
| 9 - 10 | 2,090 | 2,100 | 2,095 | 47 | 98,465 | " | " | | | | |
| 10 - 11 | 2,100 | 390 | 1,245 | 61 | 75,945 | " | " | | | | |
| 11 | 390 | | 195 | 43 | 10,335 | " | " | | | | |
| | | | | | 1,084,555 | 4.2 | 80 | 3,644,105 | 55.48 | 0.268 | |

| Sectional line | Front section ($m^2$) | Rear section ($m^2$) | Average section ($m^2$) | Intervals of sections (m) | Volume ($m^3$) | S.G. | Distribution percentage (%) | Ore reserves (ton) | (Grade) Fe (%) | P (%) | S (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| La Encantada, North. (A – D) (Disseminated Ore), ( Proved ) | | | | | | | | | | | |
| A | | 340 | 170 | 20 | 3,400 | 3.2 | 80 | | | | |
| A – B | 340 | 1,320 | 830 | 49 | 40,670 | " | " | | | | |
| B – C | 1,320 | 2,120 | 1,720 | 53 | 91,160 | " | " | | | | |
| C – D | 2,120 | 870 | 1,495 | 60 | 89,700 | " | " | | | | |
| | | | | | 224,940 | 3.2 | 80 | 575,820 | 23.59 | 0.259 | |
| La Encantada. (D – H) (Disseminated Ore), ( Proved + Probable) | | | | | | | | | | | |
| D – E | 870 | 2,480 | 1,675 | 80 | 134,000 | 3.2 | 80 | | | | |
| E – F | 2,480 | 2,520 | 2,500 | 63 | 157,500 | " | " | | | | |
| F – G | 2,520 | 2,770 | 2,645 | 65 | 171,925 | " | " | | | | |
| G – H | 2,770 | 11,280 | 7,025 | 62 | 435,550 | " | " | | | | |
| | | | | | 898,975 | 3.2 | 80 | 2,301,376 | 31.12 | 0.186 | |

| Sectional line | Front section ($m^2$) | Rear section ($m^2$) | Average section ($m^2$) | Intervals of sectinns (m) | Volume ($m^3$) | S.G. | Distribution percentage (%) | Ore reserves (ton) | (Grade) Fe (%) | P (%) | S (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **La Encantada (D - H) (Disseminated Ore), ( Proved )** | | | | | | | | | | | |
| D - E | 870 | 2,480 | 1,675 | 80 | 134,000 | 3.2 | 80 | | | | |
| E - F | 2,480 | 2,520 | 2,500 | 63 | 157,500 | " | " | | | | |
| F - G | 2,520 | 2,720 | 2,620 | 65 | 170,300 | " | " | | | | |
| G - H | 2,720 | 11,280 | 7,000 | 62 | 434,000 | " | " | | | | |
| | | | | | 895,800 | 3.2 | 80 | 2,293,248 | 31.12 | 0.186 | |

Remarks:

Probable ore reserves of La Encantada -

Probable = ( Proved + Probable ) - ( Proved ) : 2,301,376 ( Proved + Probable) - 2,293,248 ( Proved ) = 8,128 t.

| Sectional line | Front section ($m^2$) | Rear section ($m^2$) | Average section ($m^2$) | Intervals of sectinns (m) | Volume ($m^3$) | S.G. | Distribution percentage (%) | Ore reserves (ton) | Fe (%) | P (%) | S (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Chinforinazo (H - 16) Disseminated Ore, ( Proved + Probable)** | | | | | | | | | | | |
| H - 4 | 11,280 | 11,040 | 11,160 | 95 | 1,060,200 | 3.2 | 80 | | | | |
| 4 - 5 | 11,040 | 11,600 | 11,320 | 100 | 1,132,000 | " | " | | | | |
| 5 - 6 | 11,600 | 2,720 | 7,160 | 59 | 422,440 | " | " | | | | |
| 6 - 7 | 2,720 | 3,600 | 3,160 | 40 | 126,400 | " | " | | | | |
| 7 - 8 | 3,600 | 4,470 | 4,035 | 100 | 403,500 | " | " | | | | |
| 8 - 9 | 4,470 | 2,240 | 3,355 | 51 | 171,105 | " | " | | | | |
| 9 | 2,240 | | 1,120 | 47 | 52,640 | " | " | | | | |
| 14 | | 560 | 280 | 40 | 11,200 | " | " | | | | |
| 14 - 15 | 560 | 2,240 | 1,400 | 45 | 63,000 | " | " | | | | |
| 15 - 16 | 2,240 | 2,640 | 2,440 | 47 | 114,680 | " | " | | | | |
| 16 | 2,640 | | 1,320 | 26 | 34,320 | " | " | | | | |
| | | | | | 3,591,485 | 3.2 | 80 | 9,194,201 | 34.70 | 0.141 | |

| Sectional line | Front section ($m^2$) | Rear section ($m^2$) | Average section ($m^2$) | Intervals of sections (m) | Volume ($m^3$) | S.G. | Distribution percentage (%) | Ore reserves (ton) | (Grade) Fe (%) | P (%) | S (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Chinforinazo (H - 16) (Disseminated Ore), | | | | | | | | | | | |
| ( Proved ) | | | | | | | | | | | |
| H- 4 | 11,280 | 9,000 | 10,140 | 87 | 882,180 | 3.2 | 80 | | | | |
| 4 - 5 | 9,000 | 7,900 | 8,450 | 100 | 845,000 | " | " | | | | |
| 5 - 6 | 7,900 | 1,280 | 4,590 | 59 | 270,810 | " | " | | | | |
| 6 - 7 | 1,280 | 2,520 | 1,900 | 40 | 76,000 | " | " | | | | |
| 7 - 8 | 2,520 | 3,840 | 3,180 | 100 | 318,000 | " | " | | | | |
| 8 - 9 | 3,800 | 2,240 | 3,040 | 51 | 155,040 | " | " | | | | |
| 9 | 2,240 | | 1,120 | 47 | 52,640 | " | " | | | | |
| 14 | | 560 | 280 | 40 | 11,200 | " | " | | | | |
| 14 - 15 | 560 | 1,680 | 1,120 | 45 | 50,400 | " | " | | | | |
| 15 - 16 | 1,680 | 2,120 | 1,900 | 47 | 89,300 | " | " | | | | |
| 16 | 2,120 | | 1,060 | 26 | 27,560 | " | " | | | | |
| | | | | | 2,778,130 | 3.2 | 80 | 7,112,012 | 34.70 | 0.141 | |

**Remarks:**

Probable ore reserves of Chinroinazo -

Probable = ( Proved + Probable ) – ( Proved) : 9,194,201 ( Proved + Probable) - 7,112,012 ( Proved ) = 2,082,180 t.

| Sectional line | Front section ($m^2$) | Rear section ($m^2$) | Average section ($m^2$) | Intervals of sections (m) | Volume ($m^3$) | S.G. | Distribution percentage (%) | Ore reserves (ton) | (Grade) Fe (%) | P (%) | S (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Espinazo (1 - 11) (Disseminated Ore), ( Proved )** | | | | | | | | | | | |
| 1 - 2 | | | | | | | | | | | |
| 2 - 3 | | 760 | 380 | 30 | 11,400 | 3.2 | 80 | | | | |
| 3 - a | 760 | 3,840 | 2,300 | 50 | 115,000 | " | " | | | | |
| a - 4 | 3,840 | 360 | 2,100 | 20 | 42,000 | " | " | | | | |
| 4 - b | 360 | | 180 | 7 | 1,260 | " | " | | | | |
| b - 5 | | | | | | | | | | | |
| 5 - 6 | | 270 | 135 | 15 | 2,025 | " | " | | | | |
| 6 - c | 270 | 860 | 565 | 84 | 47,460 | " | " | | | | |
| c - 8 | 860 | 940 | 900 | 55 | 49,500 | " | " | | | | |
| 8 - 9 | 940 | 600 | 770 | 51 | 39,270 | " | " | | | | |
| 9 - 10 | 600 | 130 | 365 | 48 | 17,520 | " | " | | | | |
| 10 - 11 | 130 | | 65 | 20 | 1,300 | " | " | | | | |
| 11 | | | | | | | | | | | |
| | | | | | 326,735 | 3.2 | 80 | 836,442 | 47.91 | 0.250 | |

| Sectional line | Front section ($m^2$) | Rear section ($m^2$) | Average section ($m^2$) | Intervals of sections (m) | Volume ($m^3$) | S.G. | Distribution percentage (%) | Ore reserves (ton) | (Grade) Fe (%) | P (%) | S (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Primorosa, ( Probable ) | | | | | | | | | | | |
| I | | 1,480 | 740 | 43 | 31,820 | 4.2 | 80 | | | | |
| I - J | 1,480 | 1,240 | 1,360 | 50 | 68,000 | " | " | | | | |
| J - K | 1,240 | 720 | 980 | 50 | 49,000 | " | " | | | | |
| K - L | 720 | 400 | 560 | 50 | 28,000 | " | " | | | | |
| L - M | 400 | 170 | 285 | 50 | 14,250 | " | " | | | | |
| M | 170 | | 85 | 35 | 2,975 | " | " | | | | |
| | | | | | 194,045 | 4.2 | 80 | 651,991 | (55.00) | | |
| La Chula, North ( Probable ) | | | | | | | | | | | |
| 18 | | 80 | 40 | 12 | 480 | 4.2 | 80 | | | | |
| 18 - 19 | 80 | 380 | 230 | 50 | 11,500 | " | " | | | | |
| 19 - 20 | 380 | 250 | 315 | 30 | 9,450 | " | " | | | | |
| 20 | 250 | | 125 | 28 | 3,500 | " | " | | | | |
| | | | | | 24,930 | 4.2 | 80 | 83,765 | (54.00) | | |

Remarks: Fe grade in parentheses is presumed percentage.

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# SUPPLEMENT II

## MICROSCOPIC TEST ON IRON ORES OF THE PEÑA COLORADA MINE

Contents:



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## 1. Purpose of Test

Microspic and other tests, results of which are herein contained, were conducted in order to provide basic data for the beneficiation test which aims at the elevation of Fe grade and the removal of phosphorus minerals. Tests were performed mainly by observation of reflecting and petrographic miscroscopes, with X-ray diffraction test and fluorescent X-ray analysis currently conducted.

2. Test Samples

From each of the six different ores given in Table No. 1 below, one piece of sample considered to best represent each kind was selected. And from each six samples thus chosen, 2 pieces each of polish and thin section were prepared, and utilized as test samples. It must be made clear, therefore, that these test samples do not have the average mineral composition of the ores they represent.

Table No. 1 - Values by Chemical Analysis of Ore Components

| (Sample) | | (Value by Chemical Analysis) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| No. | Ore | Fe | FeO | $SiO_2$ | P | S | Cu | $Al_2O_3$ | CaO | MgO |
| 1. | Massive ore (Trench #3) | 58.73 | 23.62 | 6.94 | 0.243 | 2.039 | | 2.88 | 3.74 | 2.00 |
| 2. | Disseminated ore ( " ) | 28.41 | 7.27 | 33.02 | 0.083 | 1.957 | | 13.40 | 5.53 | 4.10 |
| 3. | Massive ore (Trench #4) | 49.92 | 14.60 | 13.87 | 0.284 | 0.866 | | 4.52 | 6.38 | 3.08 |
| 4. | Disseminated ore (Upper zone) | 26.64 | 8.96 | 36.60 | 0.160 | 0.943 | 0.021 | 6.98 | 5.57 | 2.53 |
| 5. | Massive ore (Middle zone) | 58.34 | 22.40 | 8.56 | 0.190 | 3.133 | 0.031 | 1.01 | 1.86 | 1.46 |
| 6. | Disseminated ore (Lower zone) | 33.94 | 12.12 | 29.48 | 0.137 | 2.306 | 0.024 | 8.10 | 4.28 | 2.95 |

(Elements detected by fluorescent X-ray analysis)

| | As | Ti | Mn | Zn | Cu | Cd | Sr | Sn | Zr | Pd | Mo |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. | - | - | tr | tr | tr | tr | tr | * | - | tr | tr |
| 2. | - | - | tr | tr | tr | - | * | - | tr | tr | - |
| 3. | - | - | - | tr | tr | - | tr | tr | - | - | - |
| 4. | - | - | - | tr | tr | - | o | tr | tr | tr | tr |
| 5. | - | - | - | tr | * | tr | tr | tr | - | tr | tr |
| 6. | - | - | - | tr | tr | - | * | tr | tr | tr | tr |

Remarks: Elements with atomic numbers larger than that of Ti could only be detected.

o = detected in some quantity    * = detected in extremely small q'ty.

3. Outline of Test Results

3-1 Mineral assemblage

Ore minerals consist chiefly of magnetite, with small quantities of pyrite, limonite, and extremely small quantities of hematite, chalcopyrite, sphalerite, bornite and chalcocite. Gangue minerals comprise feldspar, chlorite, pyroxen (augite and hedenbergite), epidote, calcite, phlogopite and extremely small quantities of smaragdite, apatite, zircon, cassiterite, titanite, brushite and dufrenite-like mineral. Mineral composition of each test sample is as tabulated below.

Table No. 2 - Mineral Composition (In percentage)

(Ore Minerals)

| Sample No. | Magnetite | Hematite | Limonite | Pyrite | Chalcopyrite |
|---|---|---|---|---|---|
| 1. | 70± | tr - 0.1 | 1± | tr - 1 | tr - 0.1 |
| 2. | 25 - 55 | 0.1 | 0.5 - 1 | 0.5 - 8 | 0.1 - 0.2 |
| 3. | 17 - 65 | tr | 0.1 - 0.5 | 0.1 - 2 | tr |
| 4. | 10 - 15 | tr | 1 - 5 | tr - 0.5 | tr |
| 5. | 70 - 80 | tr | 0.1 - 1 | 0.5 - 8 | tr - 0.1 |
| 6. | 20 - 35 | tr - 0.1 | 0.3 - 0.5 | 1± | 0.1 - 0.5 |

.........................................

(Gangue Minerals)

| Sample No. | Albite | Orthoclase | Augite | Hedenbergite | Epidote | Phlogopite |
|---|---|---|---|---|---|---|
| 1. | 5± | 10± | - | 1± | 0.2 | - |
| 2. | 10 - 15 | 30 - 50 | - | 0.5 - 3 | 0.1 | - |
| 3. | 15 - 38 | 20 - 40 | 5 - 13 | - | tr | 0.2 - 0.5 |
| 4. | 14 - 15 | 40 - 45 | - | 14 - 18 | 3.5 - 3 | - |
| 5. | 1± | 4± | - | - | tr | 2± |
| 6. | 15± | 35± | - | 7± | 1± | - |

- To be continued -

(Gangue Minerals) - Cont'd -

| Sample No. | Smaragdite | Chlorite | Calcite | Zircon & Cassiterite | Apatite | Brushite | Dufrenite |
|---|---|---|---|---|---|---|---|
| 1. | tr | 5 ± | 5 ± | tr | 0.2 | tr - 0.1 | 0.1 |
| 2. | 0.1 - 0.5 | 1 - 10 | 3 - 5 | 0.1 | 1.0 | tr | tr |
| 3. | tr | 3 - 6 | 5 - 7 | tr | 1.5 | tr - 0.5 | tr |
| 4. | tr | 6 - 8 | tr | 1 | 0.5 | tr - 0.2 | tr |
| 5. | tr | 8 ± | tr | 0.1 | 0.5 | 1.5 - 3 | 0.5 |
| 6. | tr | 20 ± | tr | 0.5 | 0.5 | tr | tr |

*Remarks:* Besides the above-tabulated minerals, extremely small quantites of bornite and chalcocite were detected in Test Sample No. 6, and titanite in Test Samples No. 4 and 6.

Brushite = $CaHPO_4 \cdot 2H_2O$ ; Dufrenite = $2FeO.4Fe_2O_3.3P_2O_5.9H_2O$

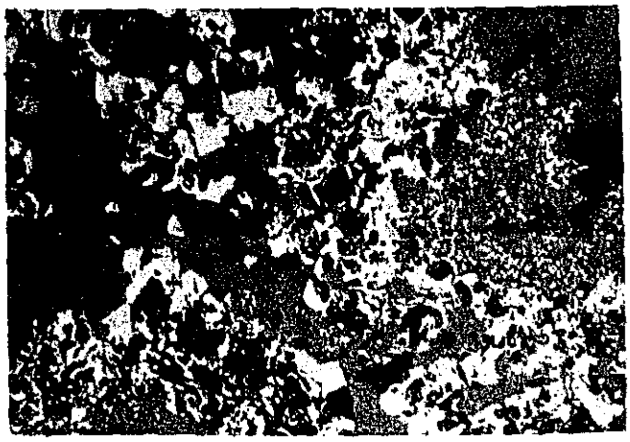
3-2 Texture, and Grain Size of Magnetite

Magnetite exists as single grains or aggregates, with the grain size ranging from the max. 1 mm to the minimum 5$\mu$. Single grains form, in one case, idiomorphic hexagonal and rhombus crystals, and in another case present hypidiomorphic - allotriomorphic granular or indeterminate shape.

Most of magnetite exists either as comparatively coarse grains of the size 0.6 - 0.2 mm in diameter or as fine grains with the size ranging from 0.1 - 0.01 mm in diameter; extremely fine grains of the size 5$\mu$ are found in a very limited quantity. (See Photo No. 1 & 2)

Photo No. 1
Porphyritic magnetite of coarse grain
(No. 2. reflect. x 102.5)


Photo No. 2
Magnetite of fine and extremely fine grain
(No. 1. reflect. x 102.5)



Mt = magnetite, Py = pyrite, Dark portion = gangue minerals

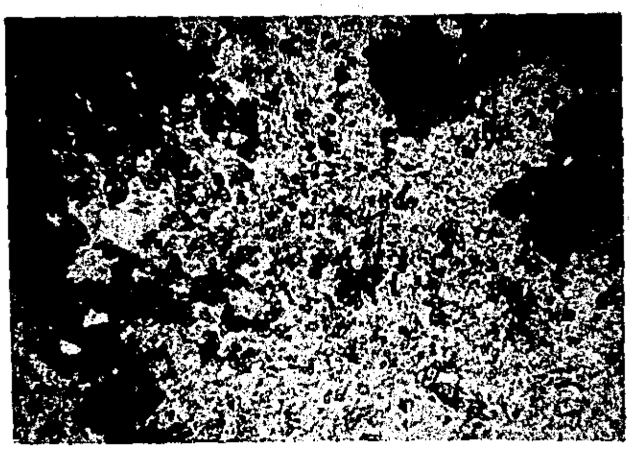
0 0.5 1.0 m/m

(Mag. x 102.5)

Disseminated ores are found scattered in the gangue minerals as single grains of magnetite of coarse grain and also as single grains or aggregate of magnetite of fine grain.

Massive ores are found as indeterminate aggregates of fine grains, causing the gaungue to present a porphyritic texture with the size ranging from 2 - 0.2 mm (See Photos No. 3 - No. 7)

Photo No. 3
Disseminated ore (coarse grain)
(No. 4. Petro. x 38)



0 0.5 1.0 m/m

Photo No. 4
Massive ore
(No. 1. petro. x 38)

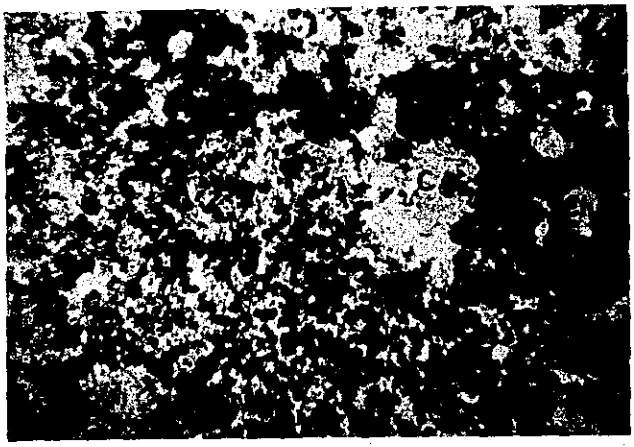
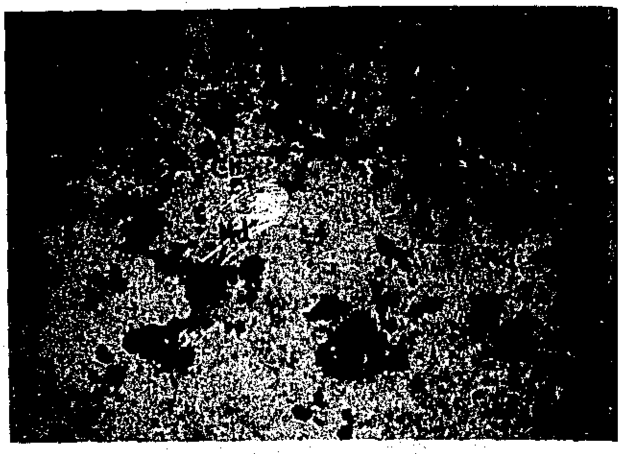


Photo No. 5
Disseminated ore (fine grain)
(No. 6. petro. x 38)



Dark portion = magnetite, Greyish white ground = feldspar,
C = calcite, Ch = Chlorite, Hd = hedenbergite

0 0.5 1.0 m/m

(Mag. x 38)

Photo No. 6
Massive ore
(No. 5, reflect. x 32)

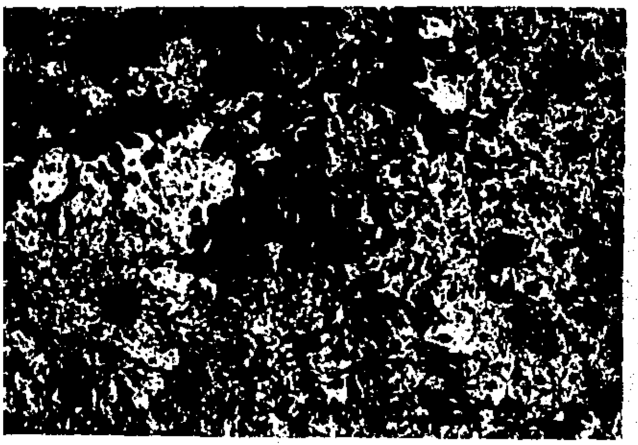
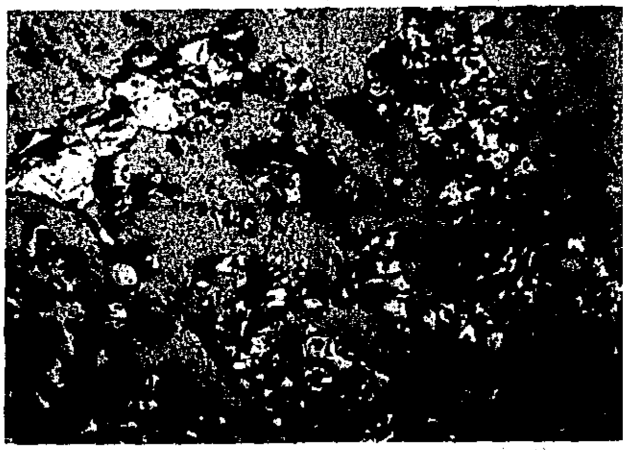


Photo No. 7
Disseminated ore
(No. 4, reflect. x 32)



White portion = magnetite, dark portion = gangue minerals

0 0.5 1.0 m/m

(Mag. x 32)

3-3 Phosphorus Minerals

It was found that such phosphorus minerals as apatite (probably Fluor-apatite), brushite ($CaHPO_4 \cdot 2H_2O$), monetite ($2CaO \cdot P_2O_2 \cdot H_2O$), Dufrenite ($2FeO \cdot 4Fe_2O_3 \cdot 3P_2O_5 \cdot 9H_2O$), etc. are existent.

**Apatite:** Apatite is idiomorphic prismatic and hexagoral plate in shape, with its size being 0.3 x 0.06 mm at maximum and 0.07 - 0.01 mm on the average. It is not widely distributed in the ore but is found concentrated. It tends to be located near magnetite, particularly when magnetite is in abundance. However, intrusion into magnetite grains is hardly noticed, and in most cases it exists in feldspar, chlorite, clacite, etc. which are near magnetite. Adhesion of apatite to magnetite is relatively often found particuarly in massive ores, in which case apatite is found as the ostensible inclusion of magnetite. (See Photos No. 8 - No. 11) Since it is discovered in linear arrangement of idiomorphic crystals, most of apatite is presumed to be associated with mineralization or post mineralization.

Photo No. 8
Pyroxen and apatite in feldspar
(No 2. petro. x 96)

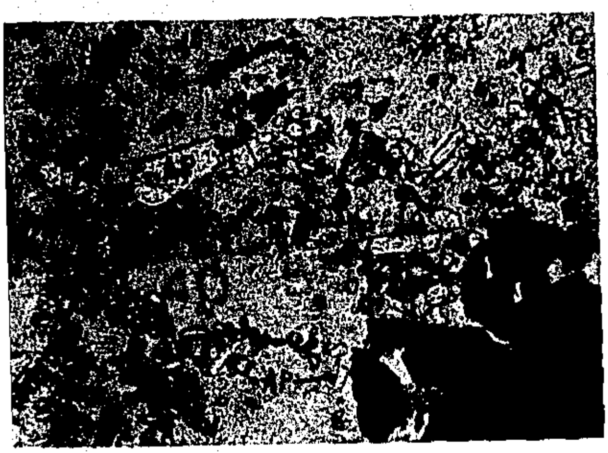


Photo No. 9
Apatite in feldspar around magnetite grains
(No. 3. petro. x 96)

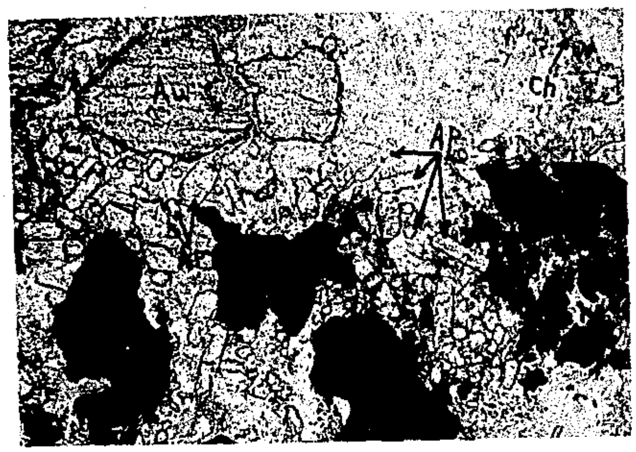


Photo No. 10
Apatite in calcite around magnetite grins
(No. 2. petro. x 96)

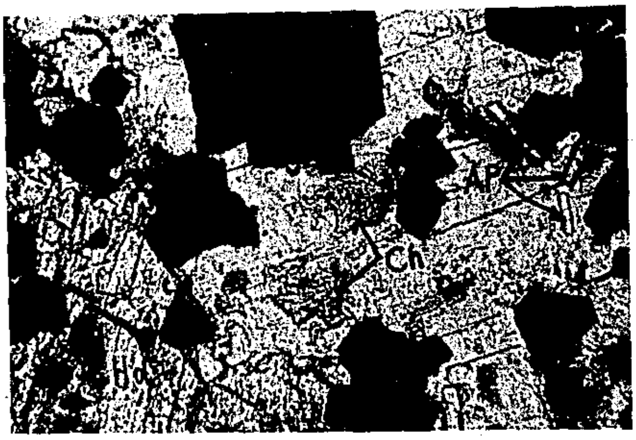
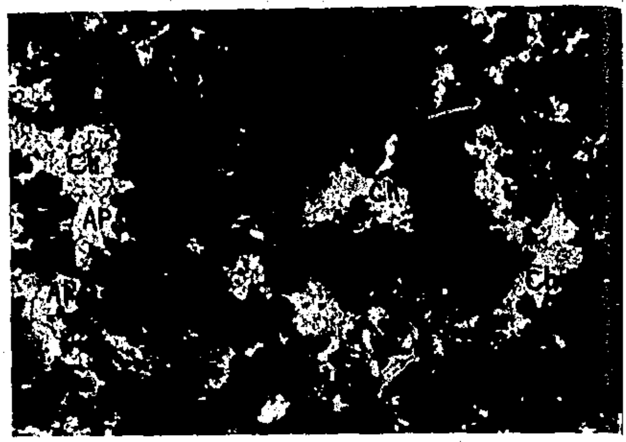



Photo No. 11
Apatite intruding into magnetite grains
(No. 5. petro. x 96)




Dark portion = magnetite, White ground = feldspar, Ap = apatite,
Hd = hedenbergite, Au = augite, C = calcite, Ch = chlorite

0 0.5 1.0 m/m

(Mag. x 96)

Photo No. 12
Apatitie in linear arrangement in feldspar
(No. 3. petro. x 96)

(Mag. x 96)

Photo No. 13
Ditto
(No. 3. petro. x 38)

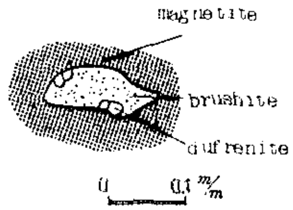
0 0.5 1.0 m/m

(Mag. x 38)

Dark portion = magnetite, White ground = feldspar, Ap = apatite,
Ch = chlorite

Brushite, Monetite and Dufrenite: It was discovered, as a result of X-ray diffraction test, that the earthy, yellow minerals filling the druse in the massive ore consist mainly of brushite. As indicated in Fig. No. 1, there exist yellow and granular minerals, together with brushite, in the druse of magnetite aggregate. High optical index and double refraction of these minerals denote that they are optically identical to dufrenite. Further, it was inferred from X-ray diffraction test, that monetite and dufrenite are existing besides brushite.

Fig. No. 1




It is therefore considered safe to conclude that these granular minerals are dufrenite.

As is clear from its composition, dufrenite is a phosphorus mineral with high iron content and exists, in paragenesis, with limonite as secondary mineral in the oxidized zone. It is easily decomposed by weathering. It is believed that dufrenite is subject to oxidation ($Fe^{2+} \longrightarrow Fe^{3+}$) which is followed by the dissociation of $P_2O_5$ and transformation into limonite.

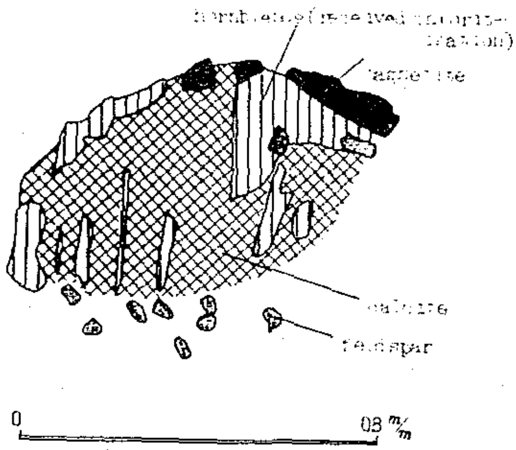
It is accordingly concluded that what should be crystallized into apatite where gangue minerals are abundant, was found in the massive ore as dufrenite, and that $P_2O_5$ was dissociated and combined with Ca, forming $CaHPO_4 \cdot 2H_2O$ (Brushite) or $2CaO \cdot P_2O_5 \cdot H_2O$ (Monetite), and dufrenite itself was either transformed into goethite or remained partly as it is in relic.

Brushite exists as dense aggregate of needle-like crystals of extremely fine grain ($5\mu \pm$) which presents greenish yellow colour. Brushite aggregates are found in irregular shape with the size below 1 mm, filling the interstice in between the magnetite aggregates. The optical index of brushite is little higher than that of balsam (1.53) and the double refraction is about 0.015. Dufrenite is found crystallized in the druse between magnetite aggregates in grains of about 0.03 mm.

3-4 Study into the science of ore deposits

mother rocks : Among the mineral assemblage, there exist so-called skarn minerals such as hedenbergite and epidote. However, these two minerals are found in samall quantities, i.e., about 20% at maximum and about 5% on the average. The predominant gangue mineral is feldspar. One of the features of the mineral composition is that hardly any quartz is found. The feldspar consists of orthoclase (kali-orthoclase) and plagioclase (the composition of which comes under the category of oligoclase optically). While the former is found polluted by dust, the latter is found not clear or in termittent in its albite-twin. As illustrated in Fig. No. 2, calcite which replaced large crystals of hornblende is found involved, and furhter, as shown in Photo No. 9, corroded augite is existent. This would lead to the reasonable conclusion that the mother rocks are the neutral plutonic rocks, It is therefore inferred that the primary mineral components of the plutonic rock were orthoclase, oligoclase, hornblende (as ferromagnesia mineral - Sample No. 2 and others), and the accessory minerals were zircon, cassiterite, apatite, etc.

Fig. No. 2



Order of Crystallization: Order of crystallization is *presumed to have been* roughly as follows.

Hedenbergite ——(1)——> Magnetite ——(2)——> Sulphide ——(3)——> Calcite
Epidote                                                   Chlorite
Phlogopite
Chlorite

(1) is conceivable by inferring that hedenbergite, epidote, etc. were involved *in magnetite as its fine inclusions.*

(2) is clear from Photo No. 14 which shows that pyrite surrounds granular magnetite and also fills the fissure in magnetite.

(3) is also clear because calcite and chlorite fill, and traverse like veinlet, the *openings left by grains of other minerals.*

Photo No. 14
Magnetite in pyrite
(No. 2. reflect. x 102.5)

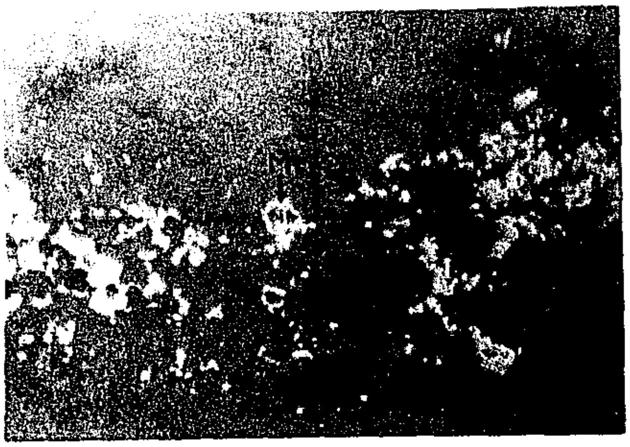

Mt = magnetite, Py = pyrite
(Mag. x 102.5)

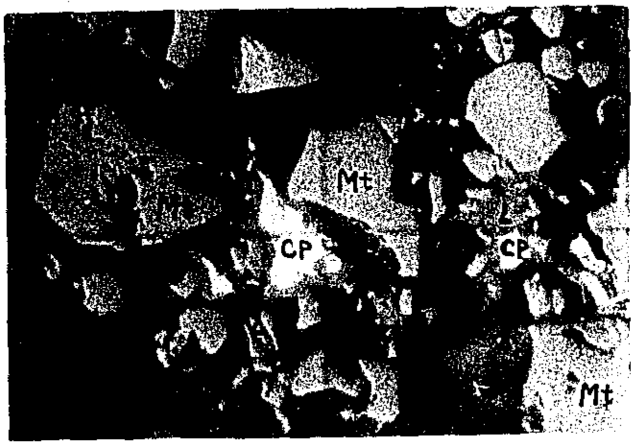
4. Description of ore

4-1 Sample No. 1 (Massive Ore, Trench No. 3)

Photo No. 15
Extremely fine grains of magnetite (reflect.)

Photo No. 16
Fine grains of magnetite and chalcopyrite (reflect.)




Mt = magnetite, Cp = chalcopyrite, L = limonite,
Dark portion = gangue minerals

0 0.05 0.1 m/m

(Mag. x 370)

Texture: Porphyritic texture as shown in Photo No. 4 was noticed.

Magnetite: Generally, magnetite exists as irregular aggregate of hypidiomorphic tetragonal or hexagonal crystals of the size ranging from 0.2 - 0.02 mm. It also exists, in limited quantities, as single grains, but few of such single grains present idiomorphic shape.

Extremely small grains of about 5$\mu$ are also found scattered in the gangue but not in quantities.

Hematite: Edges of magnetite, about 5$\mu$ in width, are found transformed into hematite in few cases.

Limonite: Limonite is found surrounding magnetite and sulphide, polluting feldspar into brown colour.

Pyrite: Indeterminate grains of the size 0.03 - 0.01 mm are found scattered forming aggregates of indeterminate shape which are below 0.2 mm in size.

Chalcopyrite: Indeterminate grains of the size ranging from 0.03 - 0.005 mm are found in the gangue, or exist with pyrite in paragensis, filling the openings left by magnetite grains. It is often noticed that the edges are transformed into limonite (See Photo No. 16).

Feldspar: Feldspar exists in two different conditions, i.e., the one which forms albite-twin and presents hypidiomorphic lath-like or prismatic shape, and the other which is polluted by brown dust, with the optical index equivallent to or lower than that of balsam, generally presenting feather-like extinction and allotriomorphic shape. The former is judged to be equivallent to oligoclase from the fact that its angle of maximum symmetric extinction (at 010 plane) is small and its opitcal index is sometimes higher than that of balsam. The latter is orthoclase. Size of feldspar ranges from 0.2 - 0.1 mm. Since magnetite presents idimorphic shape when compared to feldspar with irregular replacement, the feldspar aggregate shows wide fluctuation in size which ranges from 0.6 - 0.04 mm.

Calcite: Calcite is found filling the interstice left by magnetite and feldspar, and presents irregular shapes ranging in size from 1 - 0.01 mm.

Chlorite: Light green in colour, and extremely low in its dobule refraction, chlorite is found in fibrous state, and the length of the fibre is shorter than 0.04 mm. Found as irregular aggregate, it often exists with calcite in paragenesis and occasionally intersects calcite in veinlet-like form. It also exists as aggregate of the size 0.2 - 0.01 mm intruding into magnetite aggregate.

Hedenbergite: Hypidiomorphic and allotriomorphic prism in shape, hedenbergite exists in calcite and chlorite. $C \wedge Z = 34 - 37^{\circ}$. In feldspar, it exists with chlorite in paragenesis but not alone.

Epidote: Hypidiomorphic and allotriomorphic prism in shape, epidote shows peculiar yellow pleochroism of 0.03 x 0.02 - 0.01 mm. It is found in calcite, chlorite and feldspar, and most frequently in calcite.

Smaragdite: Accompanying calcite, smaragdite is found as idiomorphic prism of the size 0.1 x 0.07 mm.

Apatite: Apatite is idiomorphic and hypidiomorphic hexagon or prism in shape, with the size of 0.2 x 0.05 mm at maximum and 0.02 mm on the average. It intrudes into magnetite aggregate, but rarely into magnetite grain. Its concentrated intrusion into magnetite aggregate is found forming an approximate linear arrangement, though intermittently.

4-2 Sample No. 2 (Disseminated Ore, Trench No. 3)

Texture: Magnetite grains are generally of large size. Coarse grains of magnetite are found scattered in the gangue as single grains without forming aggregates. Pyrite is also found scattered in grains of large size.

Magnetite: About one third of magnetite is found scattered in the gangue presenting idiomorphic and hypidiomorphic shape of rhomb, hexagon or trigon. Size ranges from 0.2 - 0.1 mm generally, and from 0.5 - 0.1 mm in coarse grains. Some of these grains have substantial inclusions of hedenbergite of the size 0.03 - 0.005 mm.

About two thirds of magnetite are fine grains, ranging in size from 0.08 - 0.02 mm, and are scattered as single grain or aggregate, Hematite & Limonite: Hematite is found in lattice shape of about 2$\mu$ width around the edges of magnetite. As for limonite, its condition is the same as in Sample No. 1.

Pyrite & Chalcopyrite: P$_o$rphyritic pyrite of large grain, generally forming veinlet-like arrangment and presenting idiomorphic and hypidiomorphic square shape, is found in quantities. The grain size ranges from the maximum of 1.4 x 1.0 m to the minimum of 0.07 mm, averaging 0.4 - 0.2 mm. Pyrite envelopes and occasionally intersects magnetite grains. Further, pyrite aggregate consisting of extremely small grains, 0.02 - 0.006 m in size, is found included in the gangue or enclosing magnetite.

Chalcopyrite is found between magnetite grains or in the gangue, and presents irregular shapes of the size ranging from 0.14 - 0.02 mm.

It is noticed that the feldspar near these two minerals are often polluted into brown colour.

Feldspar: Most of feldspar presents feather-like extinction and is polluted by dust. Though the clear albite-twin is not found excepting carlsbad twin, there exists comparatively fresh feldspar which is considered to be plagioclase. Excepting the idiomorphic prismatic shape likely to have been formed by plagioclase, it presents allotriomorphic shape, with the size ranging from 0.2 - 0.1 mm generally. Magnetite and apatite are idiomorphic when compared to feldspar.

Calcite: Allotriomorphic calcite of the size ranging from 0.4 - 0.1 mm forms irregular aggregates filling the interstice left by feldspar and magnetite.

Hedenbergite: Most are found as extremely small grains of the size 0.04 - 0.02 mm, widely scattered in feldspar.

Epidote: Indeterminate epidote of the size 0.05 - 0.02 mm is found forming aggregates, existing with calcite in paragenesis.

Smaragdite: Fibrous smaragdite, 0.4 mm in length and 0.04 mm in width, is found in feldspar. It is often found accompanying calcite.

Chlorite: Extremely short fibrous chlorite, 0.05 mm in size, forms aggregates, exsiting with calcite in paragenesis. Large porphyritic hornblende is found to have been replaced by calcite, with its small remainder having been transformed into chloride. (See Fig. No. 2)

Phlogopite: Lath-like idiomorphic phlogopite, size below 0.1 x 0.05 mm, is found in feldspar in paragenesis with calcite.

Cassiterite: Cassiterite presents indeterminate shape of the approximate size of 0.05 mm, and is found intruding mainly in the edges of magnetite.

Apatite: Presenting needle-like or hexangonal idiomorphic shape, apatite grains, size ranging from 0.2 x 0.06 - 0.04 x 0.01 mm, are found scattered in feldspar in paragenesis with pyroxene. A small quantity of apatite is noted to be stuck to magnetite. As in Sample No. 1, adhesion to magnetite is found concentrated.

4-3 Sample No. 3 (Massive and Disseminated Ore, Trench No. 4)

Sample No. 3 is the mixture of disseminated ore and massive ore. The disseminated ore exists in the gangue as single grains or as aggregates of coarse grain. Massive ore exists as irregular aggregates of coarse and fine grain, presenting porphyritic texture (1 - 0.1 mm in size) of the gangue.

Magnetite: The maximum size observed reaches 1 mm. In general, however, magnetite is found either as coarse grains of 0.5 - 0.2 mm or as extremely fine grains of less than 0.05 mm. Coarse grains constitute about 3/4 of the entire magnetite grains, and are found as single grains or aggregates presenting hypidiomorphic and allotriomorphic shapes with a small quantity found in idiomorphic rhombus or hexangonal shapes. Grains of large size, about 1 mm, are found to possess lots of inclusions which are in many cases indeterminate feldspar of the size ranging from 0.1 - 0.01 mm.

Limonite & Hematite: Hardly any hematite is found. Limonite is polluting the edges and invirons of sulfide as well as gangue minerals near sulfide.

Pyrite & Chalcopyrite: Chalcopyrite is almost non-existent. Pyrite is usually found as coarse grains, with the maximum size reaching 2.8 x 1.6 mm. As a rule, however, it is of the size 1 - 0.2 mm, presenting hypidiomorphic rectagonal or hexagonal shape. As shown in Photo No. 17, some grains present the shape likely to have been formed by replacing ferromagnesia minerals. Besides these, indeterminate or granular pyrite, 0.1 - 0.01 mm in size, is found scattered as single grains in the gangue, or filling the interstice between magnetite grains in the form of aggregate.

Photo No. 17
Large crystal of pyrite
(reflect. x 32)

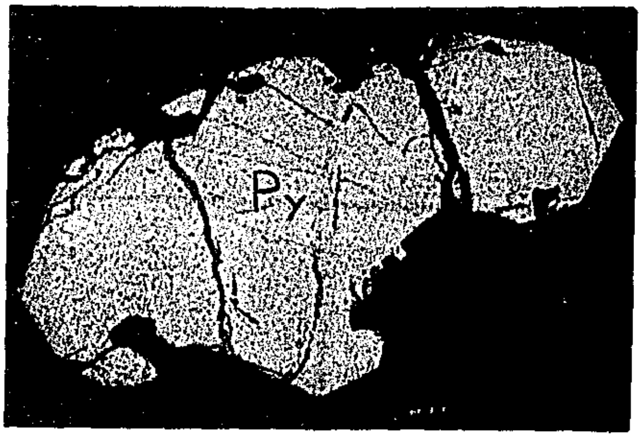



Photo No. 18
Idiomorphic magnetite and pyrite
(reflect. x 32)


Mt = magnetite, Py = pyrite, Dark portion = gangue minerals

0 0.5 1.0 m/m

(Mag. x 32)

Augite: Presenting hypidiomorphic prismatic shape of short size, augite is found corroded in its edges, and chloritized along the edges and fissure. (See Photo No. 9) $C \wedge Z = 40 - 52^{\circ}$. Being larger than hedenbergite, it has the maximum size of 1.4 x 2.0 mm but averages 0.6 - 0.1 mm, and presents idiomorphic shape when compared to feldspar in which it is included. It is also found occasionally intruding into magnetite, and sometimes envelopes apatite as inclusion. Some are found impregnated by limonite along the cleavage.

Phlogopite: Presenting wide lath-like shape with the length of 0.6 mm, phlogopite is found chloritized along the cleavage, and in some cases envelopes augite.

Chlorite: Besides being found as the chloritized edges of augite and mica, chlorite exists in feldspar, intermittently or forming veinlets as fibrous aggregates of the size below 0.4 x 0.2 mm.

Calcite: About 0.6 - 0.2 mm in size, calcite is found to irregularly intrude into grains of, and fill the interstice left by, magnetite, feldspar and augite.

Cassiterite: Presenting irregular shapes of the size approximately 0.04 mm, cassiterite is found adherred to magnetite grains.

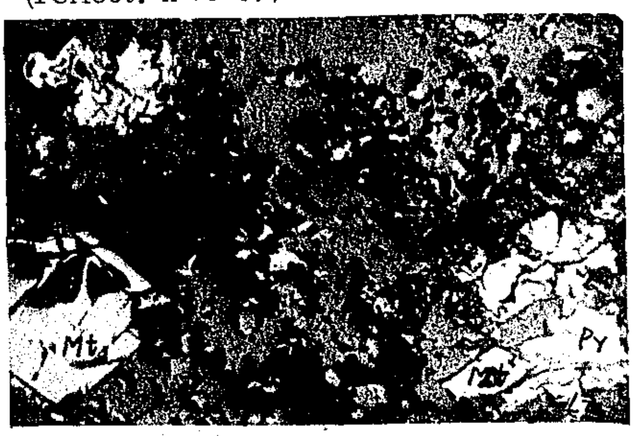
Feldspar: Indeterminate in shape, feldspar has the size of 2 mm at maximum, averaging 0.6 mm. Twins are mostly not clear, but what appears like albite-twins are found in small quantities. Feldspar is generally found polluted by dust, and presents feather-like extinction and is shaped like the tip of a broom.

Apatite: Apatite presents idiomorphic prismatic or hexagonal shape and has the size of 0.2 x 0.06 mm at maximum and 0.06 - 0.02 mm on the average. Though some are found scattered in feldspar, most are concentrated particularly around the edges of magnetite. Intrusion into magnetite is hardly noted. It also forms linear arrangement which is 5 mm in length and 0.2 - 0.04 mm in width. (See Photo No. 12 and No. 13)

4-4 Sample No. 4 (Disseminated Ore, Upper Zone)

Texture: Single grains of coarse grain magnetite and aggregates of fine grain magnetite are found scattered in the gangue. (See Photo No. 3 and No. 7)

Photo No. 19
Pyrite remaining as relic in limonite
(reflect. x 102.5)




Mt = magnetite, Py = pyrite, Lm = limonite

0 0.5 m/m

(Mag. x 102.5)

Magnetite: Hypidiomorphic and allotriomorphic in shape, magnetite has the average size of 0.4 - 0.1 mm , with the size of corase grains being below 0.7 mm. It exists as single grains where gangue minerals are found in quantities and also as aggregates where gangue minerals are scanty. It is found in few cases in idiomorphic hexagonal or rhombus shape. Fine grains of less than 0.1 mm are found in feldspar as single grains or irregular aggregates. And extremely small grains of hedenbergite are found included in such irregular aggregates.

Limonite: Hematite is not found in quantities. and a substantial quantity of hematite is found to have been transformed into limonite. As shown in Photo No. 19, pyrite is mostly transformed into limonite and exists in paragenesis with magnetite or intrudes irregularly among gangue minerals. Pyrite transformed into limonite is found as grains of the size ranging from 0.1 - 0.04 mm, and it is noted that feldspar near such limonite grains is polluted into brown colour.

Pyrite: Pyrite is found as fine grains. Transformation of pyrite into limonite is noted to be substantially developed. Forming irregular aggregates of about 0.1 mm, pyrite intrudes in between the grains of magnetite and gangue minerals. The size of relic pyrite is about 0.05 x 0.01 mm.

Feldspar: Less than 0.1 mm in size, feldspar presents feather-like extinction and is mostly polluted by dust. A small quantity of albite-twins is seen though not cearly. Excepting a small quantity which presents hypidiomorphic lath-like shape, feldspar is allotriomorphic in shape.

Hedenbergite: With the size below 0.2 mm, generally ranging from 0.1 - 0.04 mm, hedenbergite presents hypidiomorphic and allotriomorphic lath-like shape and is found enclosed by chlorite in feldspar. $C \wedge Z = 34 - 41^{\circ}$.

Epidote: 0.3 X 0.15 at maximum and generally 0.2 - 0.1 mm in size, epidote presents hypidiomorphic and allotriomorphic prismatic shape, and exists in paragenesis with hedebergite in feldspar.

Chlorite: Besides filling the interstice left by magnetite and hedenbergite, it is occasionally found in feldspar forming veinlets of 0.01 mm width or hypidiomorphic lath-like aggregates of less than 0.2 mm length.

Zircon: Prismatic and tetragonal zircon, size averaging 0.07 - 0.009 mm and 0.15 mm at maximum, is found in comparatively large quantities around hedenbergite.

Titanite: Titanite is shaped like an arrowhead and has the maximum size of 0.4 mm and average size of 0.06 - 0.1 mm. It exists in paragenesis with magnetite.

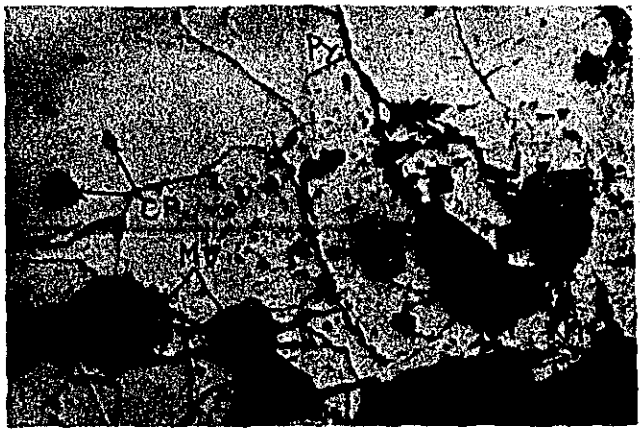
Apatite: Prismatic apatite, maximum size 0.15 and average size 0.07 - 0.01 mm, is found forming groups comprising several grains, and these groups are scattered in feldspar.

4-5 Sample No. 5 (Massive Ore, Middle Zone)

Texture: Magnetite is found irregularly aggregated, leaving the irregular and porphyritic texture of the gangue.

Magnetite: Since magnetite is aggregated, individual grains cannot be clearly identified. However, the size ranges from the maximum of 1 mm to the minimum of $5\mu$. Generally, grains of 0.2 - 0.06 mm are found irregularly aggregated. Chlorite and mica are found intruding in magnetite aggregate of the size below 0.3 mm in such way as is influenced by the shape and condition of interstice in between magnetite grains.

Photo No. 20
Magnetite and extremely small grains of chalcopyrite in limonite (reflect. x 102.5)



Cp = chalcopyrite, Mt = magnetite,
Py = pyrite

0 — 0.5 m/m
(Mag. x 102.5)

Limonite: Limonite is found to be polluting the gangue minerals.

Pyrite: Pyrite exists as coarse grains of the size averaging 0.1 mm and up with the maximum size of 1.4 x 0.8 mm, and fills the interstice left by magnetite grains, also enveloping hypidiomorphic magnetite grains. (See Photo No. 20) Occassionally, it has the inclusion of chalcopyrite of the size 0.05 - 0.015 mm. (See Photo No. 20)

Feldspar: Feldspar is seen left in between the magnetite grains, forming irregular shapes with the size below 0.2 mm.

Hedenbergite: Hedenbergite exists as single grains of the size ranging from 0.2 - 0.005 mm or as aggregates, and both intrude into magnetite grains.

Phlogopite: Phlogopite shows pleochroism ranging from bluish-green to transparent, and can be distinguished from biotite by its large optical axial angle. It is found in between magnetite grains, forming lath-like shape of the approximate size 0.2 mm.

**Apatite:** Apatite exists in between magnetite grains, presenting prismatic and granular shapes, with the size below 0.05 mm.

**Brushite:** Presenting indeterminate shape of the size below 1 mm, brushite intrudes in the intersitce left by ore minerals. Light yellowish green in colour, it exists as aggregates of needle-like crystals which are $5\mu \pm$ in size, and has almost no pleochroism. Overlapped crystals show ostensibly high double refraction, which is considered attributable to the monetite content. Double refraction of a single crystal on the edge is about 0.015. Elongation is positive.

**Dufrenite-like mineral:** Presenting granular appearance with the size of 0.03 mm $\pm$, it intrudes into the drusy opening in magnetite aggregate. The colour is yellow, and both its optical index and double refraction are extremely high.

4-6 Sample No. 6 (Disseminated Ore, Lower Zone)

**Texture:** Magnetite of coarse and fine grain is found scattered in the gangue as single grains or aggregates.

**Magnetite:** Most of single grains are idiomorphic and hypidiomorphic hexagon and tetragon in shape, ranging in size from 0.2 - 0.02 mm. They are often found lining around the edges of feldspar (See Fig. No. 3) or accompanied by chlorite. In some cases, they present corona texture (See Fig. No. 4).

Fig. No. 3

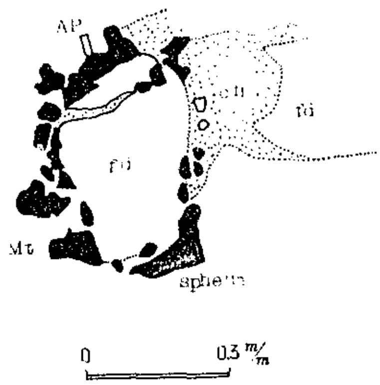
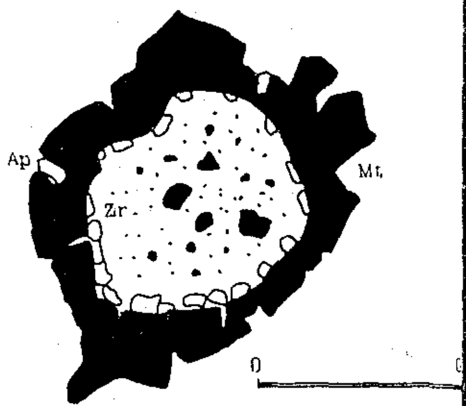



Fig. No. 4



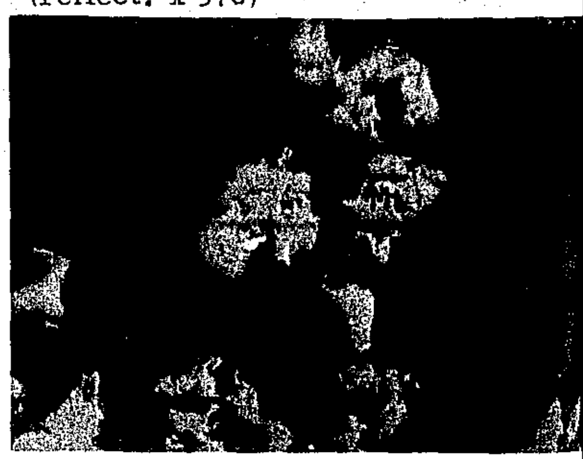

Mt = magnetite, Fd = feldspar, Ch = chlorite, Zr = zircon, Ap = apatite

Hematite: Hematite intrudes into magnetite forming lattice shape which is $2\mu$ in width. (See Photo No. 21) It is found in small quantities.

Pyrite: Size of pyrite ranges from the maximum of 0.8 x 0.4 mm (hypidiomorphic to 0.1 mm, but in general it exists as fine grains of the size below 0.02 mm which intrude in the gangue forming indeterminate veinlets. Also, in very few cases, pyrite of indeterminate shape of the size 0.01 mm - $5\mu$ is found intruding into magnetite. (See Photo No. 22)

Phono No. 21
Hematite intruding in lattice-like shape
(reflt. x 370)

Photo No. 22
Extremely small pyrite grain in magn
(reflect. x 370)



Mt = magnetite, Py = pyrite, **Dark portion** = gangue minerals

0 0.1 m/m

(Mag. x 370)

Chalcopyrite: Chalcopyrite is found in the gangue in indeterminate shapes of about 0.1 - 0.05 mm. It is noted that its edges are partially oxidized and transformed into bornite and chalcocite.

Feldspar: Less than 0.4 mm in size and indeterminate in shape, feldspar presents feather-like extinction and is often found polluted by dust. A small quantity shows albite-twin, though not clearly.

Chlorite: Besides enveloping magnetite and intruding in the gangue irregularly, chlorite is found occasionally intruding into feldspar, forming veinlet of less than 0.1 mm width.

Epidote: Hypidiomorphic and allotriomorphic prism of epidote, with the length ranging from 0.3 - 0.1 mm, is found scattered. It is found in quantities in feldspar and around magnetite. It is noted in the gangue that there are points where epidote or hedenbergite is concentrated.

Hedenbergite: Generally presenting granualr shape of 0.1 - 0.04 mm, and partially presenting hypidiomorphic prismatic shape, hedenbergite is found on the edges of magnetite and often accompanied by chlorite. $C \wedge Z = 35 - 39^{\circ}$.

Phlogopite: Usually presenting lath-like shape with 0.2 mm length, phlogopite exists in paragenesis with magnetite. Most of it are found chloritized.

Zircon: Generally below 0.1 mm in size, zircon adhers to, and intrudes into magnetite. An unusual type of zircon, as illustrated in Fig. No. 5, is also noticed.

Smaragdite: Smaragdite exists as long prismatic and needle-like crystals of the approximate size 0.05 x 0.005 mm.

Calcite: Calcite is found intruding in the gangue with the size below 0.4 mm.

Apatite: The size is below 0.3 mm, averaging 0.05 - 0.02 mm. Apatite intrudes in the gangue, presenting idiomorphic hexagonal and prismatic shape. It is found mostly in feldspar and chlori[te] around magnetite. A limited quantity is noticed to be intruding into magnetite grain.

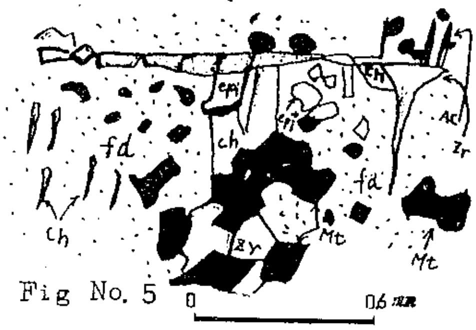



Fig No. 5

4-7 X-Ray Diffraction Test on Brushite

Since the test sample, which is yellow and earthy, was not sufficiently available, the diffreaction test was conducted by spreading it thinly on the glass plate. The test indicated that there are peaks which are not clear. Conditons for X-Ray were as follows.

Cu target; Ni-filter used; 30 KV - 20 mA; Scale factor 16; Multiplier 1; Time constant 2 sec.; Scanning speed and chert speed $2^{\circ}$ - 2 cm/min; Slit $1^{\circ}$ - 0.4 mm.

When compared to the data of ASTM card, it was noted that the test results of brushite are in excellent conformity, whereas those of dufrenite showed, though found in fairly good conformity, certain problems relative to intensity, etc. Further review in this respect should therefore be made together with the clarification of the peaks that are not clear.

| Sample | | ASTM 11 -293 Brushite | | ASTM 8 - 155 Dufrenite | |
|---|---|---|---|---|---|
| d | I/Io | d | I/Io | d | I/Io |
| 12 | 3 | | | 12.33 | 30 |
| 7.6 | 100 | 7.62 | 100 | | |
| 7.1 | 6 | | | 6.90 | 10 |
| 6.6 | 3 | | | 6.54 | 10 |

| Sample | | Brushite | | Dufrenite | |
| --- | --- | --- | --- | --- | --- |
| d | I/Io | d | I/Io | d | I/Io |
| 5.96 | 2 | | | 6.10 | 10 |
| 5.75 | 13 | | | | |
| 5.43 | 4 | | | 5.59 | 10 |
| 5.12 | 11 | | | 5.05 | 90 |
| 4.4 | 2 | | | 4.40 | 30 |
| 4.29 | 8 | 4.27 | 2 | | |
| 4.15 | 2 | | | 4.15 | 40 |
| 3.814 | 19 | 3.80 | 30 | | |
| 3.63 | 4 | | | 3.67 | 20 |
| 3.56 | 3 | | | | |
| 3.351 | 9 | | | 3.42 | 90 |
| 3.13 | 9 | | | 3.17 | 100 |
| 3.081 | 18 | 3.06 | 8 | 3.01 | 40 |
| 2.968 | 5 | | | | |
| 2.873 | 15 | | | 2.88 | 50 |
| 2.794 | 7 | | | 2.81 | 20 |
| 2.769 | 5 | | | | |
| 2.535 | 14 | 2.53 | 6 | | |

***********

SUPPLEMENT III

# BENEFICIATION TEST ON IRON ORES OF PEÑA COLORADA MINE

The magnetic separtion test and other relevant tests, results of which are herein contained, were conducted on the magnetite bearing phosphorus minerals and sulphide minerals of the Peña Colorada mine at the Mitaka Laboratory of Nettetsu Consultants Co., Ltd.

## 1. Outline of Test Results

### (1) Qualities of Ores

As shown in Table No. 1, there are 3 kinds of test samples. Test samples, generally noted to be brittle, could be crushed with relatively little difficulty. Results of complete analysis of the sample ores, as shown in Table No. 2, indicate that S and P contents generally increase in proportion to Fe content.

### (2) Test Results

(a) Chemical Analysis of Ores

Results of chemical analysis are as shown in Table No. 2-1. No particular problems were noted excepting the existence of deleterious S and P contents.

(b) Sizing-Assay

For Ores A and B, sizing-assay was conducted over 5 stages of grain size ranging from 25 mm to -20 mesh. As a result, it was discovered that there are very few grade fluctuations by the size of grain, particularly in Ore A. Results of sizing-assay are given in Table No. 3.

(c) Magnetic Separtion Test on Various Sizes

Magnetic separation test on Ore A resulted in the conclusion that the beneficiation would not be very effective on grains of the size exceeding 100 mesh and that it starts to be effective on grain size -200 mesh. Grades and other particulars of final concentrate of Ore A with the grain size of -200 mesh are as given in Table No. 6-4.

With regard to Ore B, it was revealed, as a result of the magnetic separation test, that it consits of grains more or less rough when compared to Ore A and is subject to isolation. This leads to the relatively easy separation of S and P contents. By beneficiation on grain size -100 mesh, Fe grade of concentrate marked 57%, and it is expected that the grade can be further elevated on grain size -200 mesh.

Results of test on Ore C (Mixture of Ore A and B), shown in Table No. 9, indicated that scalping effects can only be expected on size -20 mesh. With the grain size -200 mesh, however, grades of Fe and P contents of the final concentrates registered 69.65% and 0.023% respectively, nearly meeting the expectation.

(3) Comments and Suggestions

Tests on the above 3 kinds of ores have led to the following comments and suggestions.

(a) In order to obtain concentrates with the grade of P content below 0.05%, it is necessary to set the grain size of the feed ore at -200 mesh at the last stage of magnetic separation.

(b) Cleaning was conducted twice on the concentrates obtained by magnetic separation, and it was noticed the cleaning has remarkable effects in all cases. P content, in particular, was notably degraded by the cleaning. It would therefore be advisable to perform at least more than two cleanings.

(c) The grain size of concentrate marked, in the case of the final concentrate of Ore C with the grain size -200 mesh, -325 mesh 58%. Whether or not this size is suitable for pellet will have to be determined by further tests.

2. Test Method, Purpose, etc.

(1) Test Sample

Table No. 1

| Kind | Test Sample | Sampling Place |
|---|---|---|
| A | Massive Ore | Trench No. 3 |
| B | Disseminated Ore | " " |
| C | Massive Ore + Disseminated Ore | " No. 4 |

(2) Purpose of Tests

(a) Complete analysis and fluorescent X-ray analysis of ores.

(b) Study into grades by grain size

(c) Magnetic separation on various grain sizes, with importance placed upon beneficiation efficiency and separation of P content according to the grain size.

(3) Test Method

25 - 0.3 mm : Dry magnetic separation

-3 mm : Wet magnetic separation

Separator : Gröndel separator

(4) Process of Test

See the attached flow sheets.

3. Test Results

(1) Complete Analysis and Fluorescent X-Ray Analysis of Ores

Table No. 2-1: Chemical Analysis

| Sample | Fe | FeO | S | P | Cu | MgO | $SiO_2$ | CaO | $Al_2O_3$ | Sn | Zn | Mn |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A | 58.73 | 23.62 | 2.039 | 0.206 | 0.024 | 2.00 | 6.94 | 3.74 | 2.88 | 0.01 | 0.01 | 0.13 |
| B | 28.41 | 7.27 | 1.957 | 0.071 | 0.022 | 4.10 | 33.02 | 5.53 | 13.40 | tr | 0.01 | 0.11 |
| C | 49.92 | 14.61 | 0.866 | 0.241 | 0.013 | 3.08 | 13.87 | 6.38 | 4.52 | 0.01 | 0.01 | 0.05 |

Table No. 2-2: Fluorescent X-Ray Analysis

| Sample | As | $TiO_2$ | Cd | Mn | Zn | Cu | Sr | Sn | Zr | Pd | Mo |
|---|---|---|---|---|---|---|---|---|---|---|---|
| A | - | - | tr | tr | tr | - | tr | tr | - | tr | tr |
| B | - | - | - | tr | tr | - | - | - | tr | tr | - |
| C | - | - | - | - | tr | - | tr | tr | - | - | - |

Table No. 3: Results of Sizing-Assay

| Sam-ple | Grain size | (Weight %) % | Accumulated % | (Assay %) Fe | S | P | (Distribution %) Fe | S | P |
|---|---|---|---|---|---|---|---|---|---|
| A | 25-15 mm | 28.31 | 28.21 | 59.74 | 1.425 | 0.215 | 28.48 | 21.55 | 28.94 |
| | 15-6 mm | 48.24 | 76.55 | 59.35 | 1.900 | 0.209 | 48.21 | 46.97 | 47.94 |
| | 6 - 3 mm | 8.31 | 84.36 | 58.54 | 2.715 | 0.202 | 8.19 | 11.56 | 7.98 |
| | 3- 20 mesh | 6.57 | 91.43 | 58.75 | 2.444 | 0.203 | 6.50 | 8.23 | 6.34 |
| | -20 mesh | 8.57 | 100.00 | 59.74 | 2.661 | 0.216 | 8.62 | 11.69 | 8.80 |
| B | 25-15 mm | 46.08 | 46.08 | 27.54 | 1.988 | 0.072 | 45.31 | 45.55 | 44.37 |
| | 15-6 mm | 31.26 | 77.34 | 28.06 | 1.924 | 0.077 | 31.32 | 29.91 | 32.21 |
| | 6-3 mm | 6.89 | 84.23 | 27.84 | 2.036 | 0.074 | 6.85 | 6.98 | 6.82 |
| | 3-20 mesh | 2.55 | 91.78 | 26.75 | 2.156 | 0.077 | 7.21 | 8.09 | 7.78 |
| | -20 mesh | 8.22 | 100.00 | 31.74 | 2.318 | 0.080 | 9.21 | 9.47 | 8.80 |

9.21

(3) Magnetic Separation on Various Sizes - Ore A

| Grain size | Magnetic power (Gauss) | Product | Weight % Wt.% | Weight % ΣWt.% | Assay % Fe | Assay % S | Assay % P | Distribution % Fe | Distribution % S | Distribution % P |
|---|---|---|---|---|---|---|---|---|---|---|
| **Table No. 4-1** | | | | | | | | | | |
| | | F | 100.00 | | 59.04 | 2.255 | 0.266 | 100.00 | 100.00 | 100.00 |
| 15-6 mm | 500 | C | 99.35 | | 59.10 | 2.249 | 0.206 | 99.46 | 99.07 | 99.35 |
| | 1,000 | M | 0.64 | | 49.71 | 3.215 | 0.207 | 0.54 | 0.91 | 0.64 |
| | " | T | 0.01 | | 13.96 | 4.677 | 0.150 | 0 | 0.02 | 0.01 |
| **Table No. 4-2** | | | | | | | | | | |
| | | F | 100.00 | | 59.36 | 2.196 | 0.208 | 100.00 | 100.00 | 100.00 |
| 6-3 mm | 500 | C | 99.2 | | 59.47 | 2.095 | 0.208 | 99.39 | 94.64 | 99.25 |
| | 1,000 | M | 0.6 | | 50.88 | 10.638 | 0.218 | 0.51 | 2.91 | 0.63 |
| | " | T | 0.2 | | 29.05 | 26.947 | 0.129 | 0.10 | 2.45 | 0.12 |
| **Table No. 4-3** | | | | | | | | | | |
| | | F | 100.00 | | 58.29 | 2.572 | 0.192 | 100.00 | 100.00 | 100.00 |
| 3mm - 20 mesh | 500 | C | 97.6 | | 58.81 | 1.844 | 0.194 | 98.51 | 70.00 | 98.18 |
| | 1,000 | M | 0.8 | | 38.91 | 26.546 | 0.183 | 0.50 | 7.74 | 0.76 |
| | " | T | 1.6 | | 35.73 | 35.345 | 0.127 | 0.99 | 22.26 | 1.06 |
| **Table No. 4-4** | | | | | | | | | | |
| | | F | 100.00 | | 60.13 | 2.624 | 0.215 | 100.00 | 100.00 | 100.00 |
| -20 mesh | 500 | C | 92.7 | | 62.45 | 1.064 | 0.155 | 96.29 | 39.04 | 66.99 |
| | 1,000 | M | 1.0 | | 45.45 | 11.019 | 0.332 | 0.77 | 4.45 | 1.55 |
| | " | T | 0.3 | | 28.22 | 22.748 | 1.071 | 2.94 | 56.51 | 31.46 |

(3) Magnetic Separation on Various Sizes - Ore A - Cont'd -

Table No. 5-1

| Grain size | Magnetic power | Product | Weight % | | Assay % | | | Distribution % | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | (Gauss) | | Wt.% | ΣWt% | Fe | S | P | Fe | S | P |
| | | F1 | 100.0 | 100.0 | 59.91 | 1.850 | 0.199 | 100.00 | 100.00 | 100.00 |
| -20 mesh | 1,000 | C1 | 93.9 | 93.9 | 61.95 | 1.198 | 0.139 | 97.10 | 60.79 | 65.72 |
| | " | T1 | 6.1 | 6.1 | 28.51 | 11.893 | 0.948 | 2.90 | 39.21 | 34.28 |

Table No. 5-2

| Grain size | Magnetic power | Product | Wt.% | ΣWt% | Fe | S | P | Fe | S | P |
|---|---|---|---|---|---|---|---|---|---|---|
| | | F2 =(C1) | 100.0 | 93.9 | 61.95 | 1.198 | 0.139 | 100.00 | 100.00 | 100.00 |
| -100 mesh | 500 | C2 | 93.4 | 87.7 | 64.77 | 0.393 | 0.097 | 97.24 | 38.10 | 65.25 |
| | " | T2 | 6.6 | 6.2 | 25.98 | 9.035 | 0.905 | 2.76 | 61.90 | 34.75 |

Table No. 6-1

| Grain size | Magnetic power | Product | Weight % | | Assay % | | | Distribution % | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Gauss | | % by test | Ore % set at 100 | Fe | S | P | Fe | S | P |
| | | F1 | 100.00 | 100.00 | 59.76 | 2.078 | 0.206 | 100.00 | 100.00 | 100.00 |
| -20 mesh | 1,000 | C1 | 92.97 | 92.97 | 62.32 | 1.388 | 0.158 | 96.96 | 62.10 | 72.04 |
| | | T1 | 7.03 | 7.03 | 25.89 | 11.211 | 0.819 | 3.04 | 37.90 | 27.96 |

Table No. 6-2

| Grain size | Magnetic power | Product | % by test | Ore % set at 100 | Fe | S | P | Fe | S | P |
|---|---|---|---|---|---|---|---|---|---|---|
| | | F2 (=T1) | 100.00 | 7.03 | 25.89 | 11.211 | 0.819 | 3.04 | 37.90 | 27.96 |
| -20 mesh | 1,000 | C2 | 4.98 | 0.35 | 46.97 | 5.997 | 0.227 | 0.27 | 1.00 | 0.38 |
| | | T2 | 95.02 | 6.08 | 24.79 | 11.483 | 0.850 | 2.77 | 36.90 | 27.58 |

(3) Magnetic Separation on Various Sizes - Ore A - Cont'd -

Table No. 6-3

| Grain size | Magnetic power (Gauss) | Product | Weight % | | Assay % | | | Distribution % | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | % by test | ore % set at 100 | Fe | S | P | Fe | S | P |
| | | F3 (=C1) | 100.00 | 92.97 | 62.35 | 1.388 | 0.159 | 96.96 | 62.10 | 72.04 |
| -200 mesh | 500 | C3 | 88.37 | 82.16 | 67.04 | 0.550 | 0.076 | 92.18 | 21.76 | 30.44 |
| | | T3 | 11.63 | 10.81 | 26.41 | 17.751 | 0.791 | 4.47 | 40.34 | 41.60 |

Table No. 6-4

| Grain size | Magnetic power (Gauss) | Product | % by test | ore % set at 100 | Fe | S | P | Fe | S | P |
|---|---|---|---|---|---|---|---|---|---|---|
| | | F4(=C2) | 100.00 | 82.16 | 67.04 | 0.550 | 0.076 | 92.18 | 21.76 | 30.44 |
| -200 mesh | 500 | C4 | 95.61 | 78.55 | 68.68 | 0.155 | 0.050 | 90.29 | 5.86 | 19.09 |
| | | T4 | 4.79 | 3.61 | 31.40 | 9.167 | 0.648 | 1.89 | 15.90 | 11.35 |

Table No. 6-5

| Grain size | Magnetic power (Gauss) | Product | % by test | ore % set at 100 | Fe | S | P | Fe | S | P |
|---|---|---|---|---|---|---|---|---|---|---|
| | | F5(=T3) | 100.00 | 10.81 | 26.46 | 7.751 | 0.791 | 4.47 | 40.34 | 41.60 |
| -200 mesh | 500 | C5 | 15.84 | 1.71 | 64.64 | 0.824 | 0.098 | 1.85 | 0.68 | 0.82 |
| | | T5 | 84.16 | 9.10 | 19.28 | 9.054 | 0.922 | 2.93 | 39.66 | 40.78 |

(3) Magnetic Separation on Various Sizes - Ore B

Table No. 7-1

| Grain size | Magnetic power | Product | Weight % | | Assay % | | | Distribution % | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Gauss | | Wt.% | $\sum$Wt.% | Fe | S | P | Fe | S | P |
| | | F | 100.0 | | 27.31 | 1.986 | 0.070 | 100.00 | 100.00 | 100.00 |
| 25-15 mm | 500 | C | 91.6 | | 27.77 | 2.036 | 0.068 | 93.14 | 93.73 | 89.14 |
| | 1,000 | M | 7.9 | | 23.13 | 1.515 | 0.086 | 6.69 | 6.03 | 9.72 |
| | " | T | 0.5 | | 9.55 | 0.978 | 0.159 | 0.17 | 0.24 | 1.14 |

Table No. 7-2

| Grain size | Magnetic power | Product | Wt.% | $\sum$Wt.% | Fe | S | P | Fe | S | P |
|---|---|---|---|---|---|---|---|---|---|---|
| | | F | 100.0 | | 28.27 | 1.696 | 0.072 | 100.00 | 100.00 | 100.00 |
| 15-6 mm | 500 | C | 93.7 | | 28.94 | 1.652 | 0.070 | 95.91 | 91.26 | 91.68 |
| | 1,000 | M | 6.1 | | 18.63 | 2.347 | 0.092 | 4.02 | 8.44 | 7.84 |
| | " | T | 0.2 | | 10.49 | 2.561 | 0.172 | 0.07 | 0.30 | 0.48 |

Table No. 7-3

| Grain size | Magnetic power | Product | Wt.% | $\sum$Wt.% | Fe | S | P | Fe | S | P |
|---|---|---|---|---|---|---|---|---|---|---|
| | | F | 100.0 | | 27.36 | 1.814 | 0.071 | 100.00 | 100.00 | 100.00 |
| 6 - 3 mm | 500 | C | 93.0 | | 28.38 | 1.705 | 0.068 | 96.46 | 87.42 | 89.62 |
| | 1,000 | M | 5.3 | | 15.33 | 3.400 | 0.097 | 2.97 | 9.93 | 7.29 |
| | | T | 1.7 | | 9.14 | 2.825 | 0.128 | 0.57 | 2.65 | 3.09 |

Table No. 7-4

| Grain size | Magnetic power | Product | Wt.% | $\sum$Wt.% | Fe | S | P | Fe | S | P |
|---|---|---|---|---|---|---|---|---|---|---|
| | | F | 100.0 | | 25.63 | 2.274 | 0.070 | 100.00 | 100.00 | 100.00 |
| 3 mm - 20 mesh | 500 | C | 60.4 | | 32.62 | 1.707 | 0.061 | 76.95 | 45.38 | 52.32 |
| | 1,000 | M | 24.1 | | 18.28 | 2.611 | 0.075 | 17.15 | 27.62 | 25.67 |
| | | T | 15.5 | | 9.75 | 3.960 | 0.100 | 5.90 | 27.00 | 22.01 |

(3) Magnetic Separation on Various Sizes - Ore Be - Cont'd -

Table No. 7-5

| Grain size | Magnetic power | Product | Weight % | | Assay % | | | Distribution % | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Gauss | | Wt.% | ΣWt.% | Fe | S | P | Fe | S | P |
| | | F | 100.0 | | 31.41 | 2.267 | 0.079 | 100.00 | 100.00 | 100.00 |
| -20 mm | 500 | C | 55.1 | | 48.14 | 0.835 | 0.043 | 84.46 | 20.29 | 29.89 |
| | 1,000 | M | 3.5 | | 18.00 | 2.745 | 0.074 | 2.00 | 4.24 | 3.27 |
| | | T | 41.4 | | 10.27 | 4.133 | 0.128 | 13.54 | 75.47 | 66.84 |

Table No. 8-1

| Grain size | Magnetic power | Product | Wt.% | ΣWt.% | Fe | S | P | Fe | S | P |
|---|---|---|---|---|---|---|---|---|---|---|
| | | F1 | 100.0 | 100.0 | 31.72 | 1.876 | 0.088 | 100.00 | 100.00 | 100.00 |
| -20 mesh | 1,000 | C1 | 64.3 | 64.3 | 40.25 | 1.116 | 0.053 | 81.59 | 38.25 | 38.75 |
| | | T1 | 35.7 | 35.7 | 16.36 | 3.245 | 0.114 | 18.41 | 61.75 | 61.25 |

Table No. 8-2

| Grain size | Magnetic power | Product | Wt.% | ΣWt.% | Fe | S | P | Fe | S | P |
|---|---|---|---|---|---|---|---|---|---|---|
| | | F2(=C1) | 100.0 | 64.3 | 40.25 | 1.116 | 0.051 | 100.00 | 100.00 | 100.00 |
| -100 mesh | 500 | C2 | 65.0 | 41.8 | 57.02 | 0.308 | 0.026 | 88.07 | 17.99 | 31.91 |
| | | T2 | 35.0 | 22.5 | 14.34 | 2.608 | 0.096 | 11.93 | 82.01 | 68.09 |

(3) Magnetic Separation on Various Sizes - Ore C

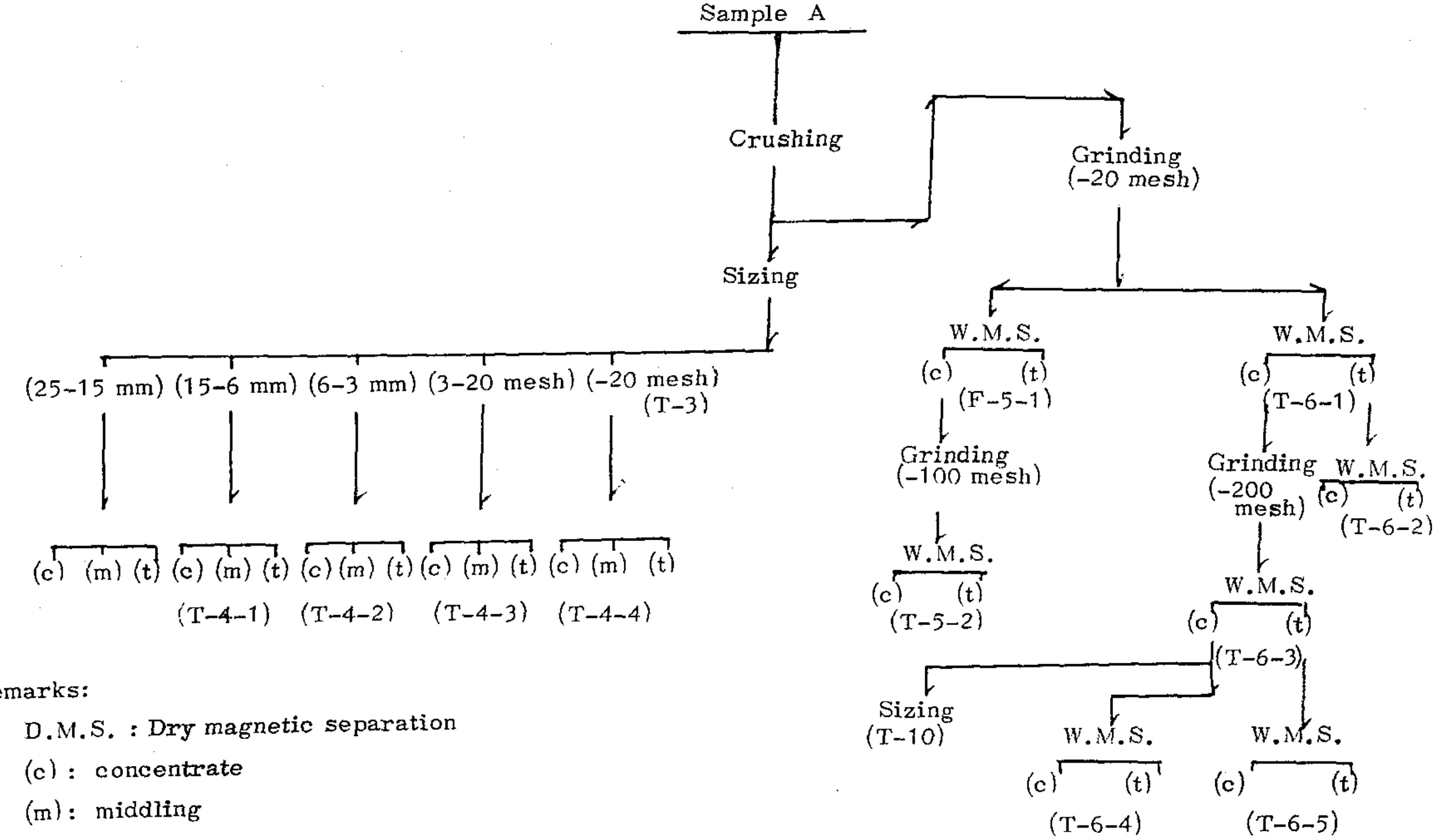
| Grain size | Magnetic power | Product | Weight % | | Assay % | | | Distribution % | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Mesh | Gauss | | % by test | ore % set at 100 | Fe | S | P | Fe | S | P |
| **Table No. 9-1** | | | | | | | | | | |
| | | F1 | 100.00 | 100.00 | 51.14 | 0.963 | 0.234 | 100.00 | 100.00 | 100.00 |
| -20 | 1,000 | C1 | 84.91 | 84.91 | 58.29 | 0.537 | 0.148 | 96.79 | 46.52 | 53.60 |
| | | T1 | 15.09 | 15.09 | 10.87 | 3.413 | 0.719 | 3.21 | 53.48 | 46.40 |
| **Table No. 9-2** | | | | | | | | | | |
| | | F2(=T1) | 100.00 | 15.09 | 10.87 | 3.413 | 0.719 | 3.21 | 53.48 | 46.40 |
| -20 | 1,000 | C2 | 1.52 | 0.23 | 28.37 | 3.783 | 0.335 | 0.13 | 0.90 | 0.33 |
| | | T2 | 98.48 | 14.86 | 10.60 | 3.407 | 0.725 | 3.08 | 52.58 | 46.07 |
| **Table No. 9-3** | | | | | | | | | | |
| | | F3(=C1) | 100.00 | 84.91 | 58.29 | 0.527 | 0.148 | 96.79 | 46.52 | 53.60 |
| -200 | 500 | C3 | 81.39 | 69.11 | 66.99 | 0.126 | 0.047 | 90.54 | 8.26 | 13.76 |
| | | T3 | 18.61 | 15.80 | 20.24 | 2.332 | 0.590 | 6.25 | 38.26 | 39.84 |
| **Table No. 9-4** | | | | | | | | | | |
| | | F4(=C3) | 100.00 | 69.11 | 66.99 | 0.115 | 0.047 | 90.54 | 8.26 | 13.76 |
| -200 | 500 | C4 | 94.70 | 65.45 | 69.65 | 0.028 | 0.023 | 89.15 | 1.90 | 6.44 |
| | | T4 | 5.30 | 3.66 | 19.45 | 1.670 | 0.467 | 1.39 | 6.36 | 7.32 |
| **Table No. 9-5** | | | | | | | | | | |
| | | F5(=T3) | 100.00 | 15.80 | 20.24 | 2.332 | 0.590 | 6.25 | 38.26 | 39.84 |
| -200 | 500 | C5 | 17.50 | 2.77 | 66.66 | 0.250 | 0.055 | 3.60 | 0.72 | 0.65 |
| | | T5 | 82.50 | 13.03 | 10.40 | 2.773 | 0.703 | 2.65 | 37.54 | 39.19 |

(4) Grade by Grain Size of concentrate

Table No. 10

| Ore | Grain size | Weight % | | Assay % | | | Distribution % | | |
|---|---|---|---|---|---|---|---|---|---|
| | Mesh | % | Σ% | Fe | S | P | Fe | S | P |
| A (Table No. 5-2) | 100 - 150 | 18.29 | 18.29 | 60.27 | 0.882 | 0.126 | 17.11 | 34.27 | 25.89 |
| | 150 - 200 | 18.96 | 37.25 | 62.10 | 0.663 | 0.105 | 18.27 | 26.70 | 21.93 |
| | 200 - 270 | 12.95 | 50.20 | 65.06 | 0.415 | 0.077 | 13.08 | 11.42 | 10.99 |
| | -270 | 49.80 | 100.00 | 66.69 | 0.261 | 0.076 | 51.54 | 27.61 | 41.69 |
| B (Table No. 8-2) | 100 - 150 | 23.22 | 23.22 | 53.17 | 0.459 | 0.026 | 21.88 | 28.09 | 21.42 |
| | 150 - 200 | 23.85 | 47.07 | 56.08 | 0.396 | 0.033 | 23.70 | 24.89 | 27.93 |
| | 200 - 270 | 13.62 | 60.69 | 59.51 | 0.297 | 0.024 | 14.36 | 10.66 | 11.60 |
| | -270 | 39.31 | 100.00 | 57.52 | 0.351 | 0.028 | 40.06 | 36.36 | 39.05 |
| C (Table No. 9-4) | 200 - 270 | 20.63 | 20.63 | 69.35 | 0.022 | 0.024 | 20.82 | 19.97 | 20.76 |
| | 270 - 325 | 21.36 | 41.91 | 68.90 | 0.020 | 0.026 | 21.41 | 18.79 | 23.29 |
| | -325 | 58.01 | 100.00 | 68.45 | 0.024 | 0.023 | 57.77 | 61.24 | 55.95 |

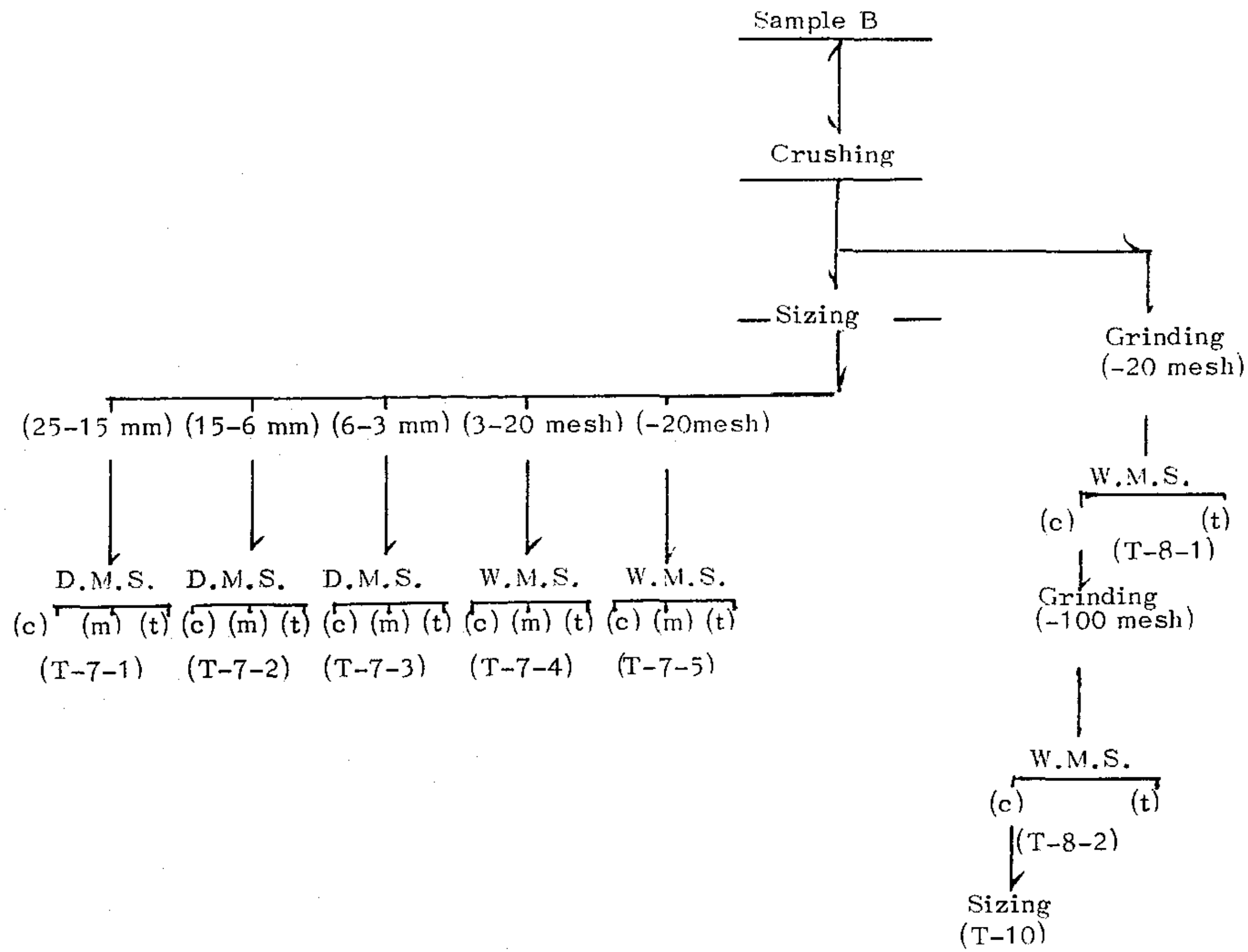
## FLOW SHEET (No. 1)



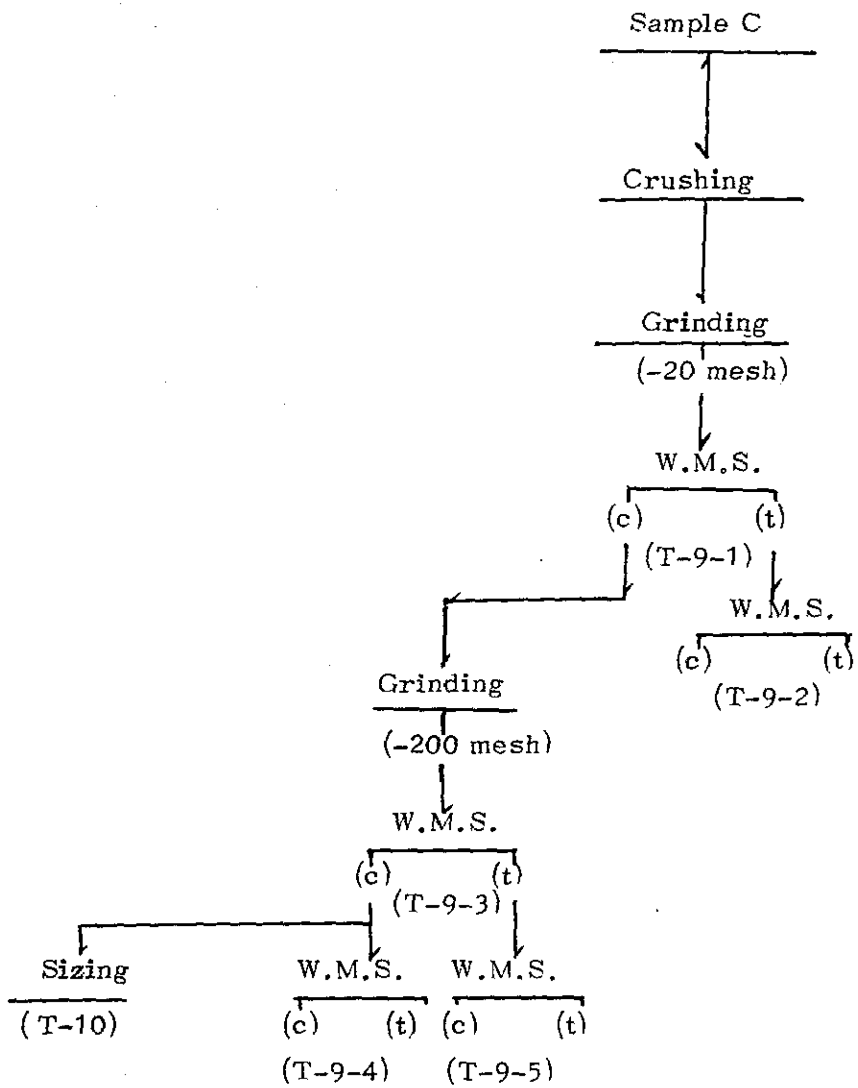

Remarks:

1. D.M.S. : Dry magnetic separation
2. (c) : concentrate
   (m) : middling
   (t) : tailing
3. (T-1-...) : Table No.

## FLOW SHEET (No. 2)



## FLOW SHEET (No. 3)



Drawings for Development Plan

of

Peña Colorada Mine in Mexico

1) Location Map of Peña Colorada Mine
2) Claim Map ( 1:20,000 )
3) Plan of Deposit Peña Colorada Mine ( 1:2,000 )
4) Map of Ore Deposit ( 1:2,000 )
5) Cross section of Ore Deposits ( 1:2,000 )
6) Diamond Drilling Logs of Peña Colorada
7) Diamond Drilling Logs of Peña Colorada
8) Diamond Drilling Logs of Peña Colorada
9) General Plan of Peña Colorada Mine ( 1:5,000 )
10) Mining Plan of Peña Colorada Mine ( 1:2,000 )
11) The Mining Plan of Angledozer Bench Cutting
12) The Mining Plan of Angledozer Bench Cutting
13) The Mining Plan of Shovel Bench Cutting ( 1:2,000 )
14) The Mining Planangledozer and Shovel Bench Cutting
15) Showing of the Cutting Section of Road
16) Stoping Method
17) Layout of Stopes
18) Flow Sheet of Dressing Plant
19) Machine Arrangement of the Dressing Plant (1:200)
20) The Balance Sheet of the Mill Section
21) The Location Map of Dressing Plant and Waste Dam (1:10,000)
22) Tailing Dam & Concrete Dam (1:1,000)
23) Section of Primary Crusher and Conveyor ( 1:200)
24) Route of Rail Way & Pipe Line at Peña Colorada Mine
25) Hitachi Zosen Lurgi Type Pelletizing Plant
26) Crushing & Washing Plant at el Encino Mines

REPORT ON INVESTIGATIONS OF IRON ORE DEPOSIT AT PEÑA COLORADA MINE

## CORRIGENDA

| Page | Line | Error | Correct |
|---|---|---|---|
| 7 | 5 & 33 | A. Encantada | La Enchantada |
| 22 | 25 | US$ 11.58 | US$ 5.25 |
| | 27 | US$ 17.30 | US$ 10.97 |
| 34 | 14 | Number & Specifications ........ | 4-1-14 Number & Specification.. |
| | 29 | 35 $m^3$ | 3.5 $m^3$ |
| 43 | 26 | 3φ 60/3KVA on load | 3φ 60/3KV on load ; 6,000KVA |
| 49 | 12 | $m^3$/mm | $m^3$/min |
| Supplement III | | | |
| 7 | 8 | 26.41 17.751 | 26.46 7.751 |
| 9 | 13 | 0.051 | 0.053 |
| 10 | 11 | 0.126 | 0.115 |