3.9 Equipment Operation Rate

We have examined the current operation rate of equipment at the three beneficiation plants requiring survey. Results are shown below. Operation rates have been calculated on the basis of planned operating time covering the period from January to June, 1989.

(1) Parral Beneficiation Plant

Operation rate	65.5%
Reasons for shutdown	
Shutdown maintenance	16.3%
Sudden breakdown (repair)	16.3%
Ore shortage	12.3%
Other reasons	55.1%

The excessively high ratio of "other reasons" shows that the imbalance between the capacity of the crushing process and that of the grinding and subsequent processes causes the former process to discontinue its operation for many hours "pending the completion of grinding operation". That is, all systems in the plant do not discontinue their operation at the same time. The operation rate of equipment in the grinding to floatation alone is 71 to 75%. In addition, the shutdown due to the pure shortage of ore also accounts for only 12.3%. From these figures, it is undeniable that the ore treatment program is improper.

(2) Guanacevi Beneficiation Plant

Operation rate	54.2%
Reasons for shutdown	
Shutdown maintenance	14.1%
Sudden breakdown (repair)	14.6%
Ore shortage	57.6%
Other reasons	13.7%

The overwhelmingly high ratio of the reasons due to ore shortage seems to reflect current conditions of the plant and surrounding mines.

(3) Barones Beneficiation Plant

Operation rate	67.9%
Reasons for shutdown	
Shutdown maintenance	30.3%
Sudden breakdown (repair)	23.3%
Ore shortage	15.2%
Other reasons	31.2%

The majority of "other reasons" is occupied by the shortage of water for the beneficiation. At this plants, therefore, the procurement of necessary water has come into question.

The reason "ore shortage" means, correctly speaking, the waiting time at switchover of ore types and the time lost due to unbalanced capacity of each process. In reality, ore has been stored in large quantities at the stockyard.

(4) Problems Common to Three Beneficiation Plants

In regard to reasons for shutdown at the three beneficiation plants, the common problem is the fact that the ratio of shutdown due to sudden breakdown is very high at 14% to 23%. The ratio of "shutdown maintenance" also shows that defects in equipment are found and the shutdown maintenance is unavoidably carried out during the planned operating period. Although this is somewhat more planned than coping with sudden breakdown, the reason should also be almost included in the item of sudden breakdown. When both ratios are totaled, the shutdown due to the repair of equipment accounts for about 30% to 50%, and constitutes a cause that checks the improvement of the equipment operation rate. Concerning the maintenance of equipment, no planning for shutdown maintenance prolongs the time required for repair of breakdowns and lowers the operation efficiency.

If it is considered that each plant treats, in a consignment or purchasing system, the ore produced at many surrounding mines, the inevitable idling during the switchover of ore types and the time lost between processes might be unavoidable. However, this certainly constitutes an important factor that brings about temporary ore shortage and lowers the overall operation rate of equipment. At the same time, the factor is also considered as one of the causes that increase recovery loss of valuable metal.

As reason why the capacity of equipment has not been adequately exhibited at each process of crushing, grinding and floatation, it can be cited that the ore feeding volume is not continuous and the plant is not operated with the treating ore volume maximizing the operation rate of each process, in the light of overall consideration covering each process. With this also, the separate treatment of many kinds of ore is related. In particular, this influence is very great when the operation is performed in the consignment system.

Problems such as the shortage of water, which are attributable to weather and local conditions, might not be settled easily with effort in the part of beneficiation alone. However, the problems concerning equipment maintenance mentioned so far and ore shortage attributable to the operational fluidity have left adequate room for improvement.

It has been judged that in order to raise the operational rate of equipment, considerable improvement can be achieved by tackling both of these problems.

3.10 Analysis Work

(1) Outline

1) Parral Beneficiation Plant

The analysis work at Parral Beneficiation Plant consists of sampling, pretreatment, wet method and dry method, and the manager of the laboratory serves concurrently as that of the analysis department. At the analysis department, the following samples are ordinarily analyzed.

(i) Ore stored at the stockyard
(ii) Plant ordinary samples 20 samples/day
(iii) Plant instantaneous samples 8 samples/day
(iv) Beneficiation test sample

Au and Ag in these samples are analyzed by the dry method, and Pb, Zn, Fe and (Cu) by the atomic absorption method.

2) Personnel and Years of Experience

	Number of personnel	Years of experience
Manager of analysis dept.	1	30 years
Wet method	2	3.5 years, 4 years
Dry method	2	10 years, 8 years
Sampling and pretreatment	4	10, 8, 5, 0.5 years

3) Major Equipment

Description of Equipment	Number of units installed	State of operation	Remarks
Primary jaw crusher	1	Satisfactory	
Secondary jaw crusher	1	Satisfactory	
Tertiary roll crusher	1	Satisfactory	
Dryer	2	Satisfactory	One unit leased
Mettler PC 8000	1	Satisfactory	Min. 0.1 g
Mettler H31A R	2	One unit damaged	Min. 0.1 mg
Mettler M3	2	One unit damaged	Min. 0.001 mg
Muffle furnace	2	One unit damaged	
Atomic absorption analyzer	1	Sometimes defective	PERKIN ELMER 560

4) Analysis

The ore received from each mine to the stockyard is sampled at a rate of 50 kgs from the lot of 50 tons, and further sampled again by 50 kgs from the lot of 300 tons received. These sampled groups of ore crushed with the primary and secondary jaw crushers and tertiary roll crusher. After that, the crushed ore is reduced and the sample of 1 kg is divided into 10 bags. Such samples are further crushed up to -100 mesh to make samples for the analysis of ore grade. Operation samples are reduced after crushing and crushed up to -100 mesh, and are analyzed by dry and wet methods. In the dry method, Au and Ag are analyzed, and in the wet method, Pb, Zn, Fe and (Cu) are analyzed using an atomic absorption analyzer. In addition, Ag is analyzed from the leaching solution of the cyanidation plant.

• Dry method

-100 mesh sample
← Flux
Heated for one hour
Fusion
- Slag
- Lead button
  - Cupelling 45 minutes
    - Lead is absorbed in a cupel
    - Gold, silver bullion granulation .. weighing
      - <--- HNO_3
      - Parting
        - Silver solution
        - Gold grain .. weighing

• Wet method .... Atomic absorption method

-100 mesh sample

<-- $KClO_4$ 0.2 g

<-- HNO_3 conc. 10 ml

<-- HCl conc. 10 ml

Boiling

Cooling

<-- HCl conc. 15 ml

Boiling

<-- HCl 20 ml; H7O 30 ml

Boiling

Hydro-cooling

Filtration

The filtrate is diluted and analyzed by atomic absorption photometer.

5) Diagnosis on Current Conditons

Although all equipments are arranged satsifactorily in the analysis department, many of them are out of order, and controversial points are followed:

- Many Metlers have been damaged and require repair.
- The atomic absorption analyzer sometimes become unstable, so that it requires maintenance.
- One muffle furnace has been damaged and requires repair.
- The suction power of the muffle furnace duct is insufficient.
- A pH meter for the laboratory is necessary.
- It is desirable to hold lecture classes for the improvement of analyzing techniques focusing on the work of the Tecamachalco Laboratory.

(2) Guanacevi Beneficiation Plant

1) Outline

The analysis work at Guanacevi Beneficiation Plant consists of the sampling at the stockyard, sampling of operation samples and dry method, and the general manager of the laboratory serves concurrently as that of the analysis department. At the analysis department, the following samples are ordinarily analyzed:

(i) Ore stored at the stockyard
(ii) Plant ordinary samples 12 samples/day
(iii) Beneficiation test samples

For these samples, Au and Ag are analyzed by the dry method, and no wet method is carried out.

2) Personnel and Years of Experience

	Number of personnel	Years of experience
Manager of analysis dept.	1	1 year
Wet method	2	10 years, 5 years
Sampling at stockyard	4	--
Sampling of operation samples	4	--

3) Major Equipment

Description of Equipment	Number of units installed	State of operation	Remarks
Primary jaw crusher	1	Satisfactory	
Pulverizer	1	Satisfactory	
Mettler H80	1	Satisfactory	
Mettler ME 80	1	Satisfactory	Min. 0.1 mg
Muffle furnace	2	Satisfactory	Min. 0.001 mg

4) Analysis

The ore received from each mine to the stockyard is sampled at a rate of 20 kgs from a lot of 10 tons. Next, these samples are reduced and crushed up to -200 mesh using a jaw crusher and pulverizer. After that, they are reduced further, and a sample of 1 kg is divided into 10 bags to make samples for the analysis of ore grate. Operation samples are reduced after drying and crushed up to -200 mesh to make samples for analysis.

In the dry method, Au and Ag are analyzed by basically the same way as that of Parral Beneficiation Plant. However, correction is performed for the quantity of Ag which is somewhat absorbed into the cupel at the time of cupelling. Correction factors are shown below.

Ag Grade	Correction Factor
+500 g/T	5%
500 - 400 g/T	4%
400 - 300 g/T	3%
300 - 200 g/T	2%
200 - 80 g/T	1%
-80 g/T	0%

5) Diagnosis on Current Conditions

Although the operation of equipment is almost satisfactory, there are the following problems:

- For crushing the ore stored at the stockyard, secondary crushers are required.
- The capacity of the pulverizer is inadequate.
- A distilled-water making equipment is required.
- The suction of ducts attached to the muffle furnaces is inadequate.
- The installation of an atomic absorption analyzer is desirable for the analysis of Pb and Zn.
- It is desirable to hold lecture classes for the improvement of analyzing techniques focusing on the work of the Tecamachalco Laboratory.

(3) Barones Beneficiation Plant

1) Outline

At Barones Beneficiation Plant, ore sampling and analysis are carried out by completely separate departments. The sampling department performs the weighing of received ore, sampling at the stockyard, sampling of plant operation samples, and pretreatment. On the other hand, the analysis department ordinarily analyzes the following samples:

(i) Ore stored at the stockyard
(ii) Plant operation samples 39 samples/day
(iii) Beneficiation test samples

For these samples, Au and Ag are analyzed by the dry method. The analysis of Cu, Pb, Zn and Fe had been carried out by the titration method, but it was discontinued because an atomic absorption analyzer was installed in September.

2) Personnel and Years of Experience

	Number of personnel	Years of experience
Manager of sampling dept.	1	9 years
Stockyard sampling and pretreatment	4	3, 6, 6 and 4 years
Sampling of operation samples	4	3, 2, 6 and 3 years
General manager of analysis dept.	1	24 years
Dry method	2	10 years, 5 years
Wet method	3	3, 1 and 0.5 years

3) Major Equipment

Description of Equipment	Number of units installed	State of operation	Remarks
Primary jaw crusher	1	Satisfactory	
Secondary jaw crusher	1	Satisfactory	
Pulverizer	2	Satisfactory	
Balance	1	Satisfactory	1 g - 100 g
Balance	1	Satisfactory	1 mg - 100 mg
Mettler H80	1	Damaged	
Muffle furnace	2	Satisfactory	One unit for spare
Atomic absorption analyzer	1	Satisfactory	PERKIN ELMER 3000

4) Analysis

The ore received from each mine to the stockyard is sampled at a rate of 30 kgs from every lot of 10 tons, the sample forming one unit of 300 kg. The unit is crushed up to -1" using a jaw crusher, reduced, and crushed further up to -10 mesh with a gyratory crusher and pulverizer. Out of this crushed product, a sample of 1 kg is ground further up -100 mesh to make a proper sample for the analysis of ore grade. Also, operation samples are reduced after drying and ground up to -100 mesh to make samples for analysis.

In the dry method, Au and Ag are analyzed by the basically same ways as those of Parral and Guanacevi beneficiation plants. However, no correction of Ag absorbed into the cupel, which is performed at the Guanacevi plant, is carried out.

On the other hand, in the analysis of sulfide ore, the influence of interferring elements is removed by putting nails into the crucible.

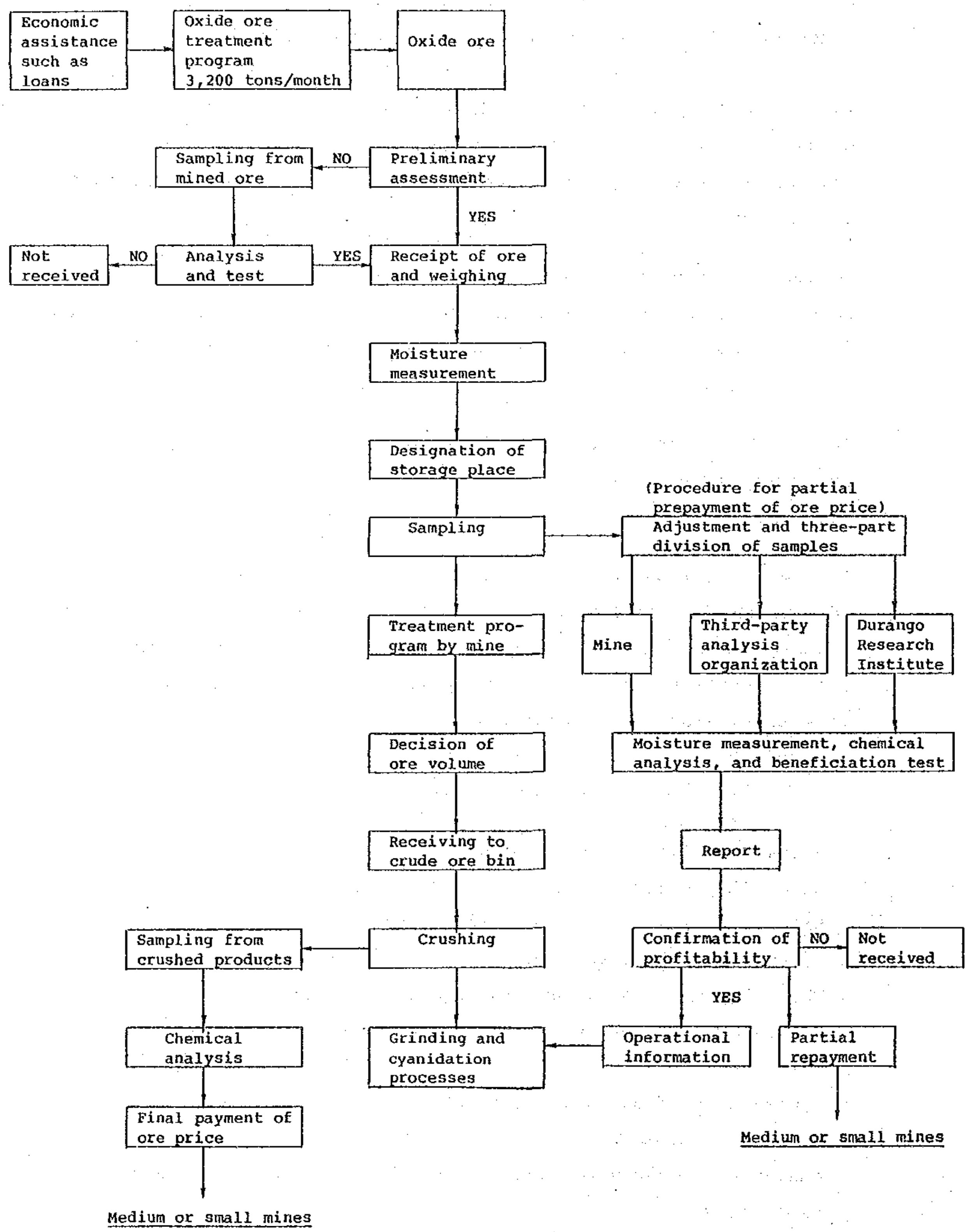
In the wet method, a atomic absorption analyzer has been installed, and the analysis of Cu, Pb, Zn and Fe in the ore and Ag in the leaching solution of the cyanidation plant has been commenced. The introduction of atomic absorption analyzer reduces analyzing time considerably. Accordingly, it is considered that the number of analyses will possibly be increased with a great contribution to the control of plant operations.

5) Diagnosis on Current Conditions

- Since the atomic absorption analyzer has been installed, practice is necessary for improving accuracy.
- Desks and shelves are necessary for arranging glassware.
- The enlargement of dryers is required for improving efficiency.
- The enlargement of the muffle furnaces is required for improving efficiency.
- The suction of ducts for the muffle furnaces is inadequate.
- It is desirable to hold lecture classes for the improvement of analyzing techniques focusing on the work of the Tecamachalco Laboratory.

3.11 Maquila and Ore-Purchasing Systems

Barones Beneficiation Plant: Ore-Purchasing Procedures (oxide ore)



Controversial points concerning current conditions are shown below.

(1) Shutdown-based loss of time

Since ore needs to be treated separately by mine, the shutdown-based loss of time is produced at the time when the ore from A mine is switched to that from B mine. This constitutes one of the main causes that lower the operation rate of equipment.

(2) Remaining-ore removal operation

To prevent the ore from A mine and B mine from mixing together, the remaining-ore removal operation becomes necessary for crude-ore bins and ground-ore. This is another cause that increases use of operating personnel. In addition, the working environment is bad because of dust.

(3) Separate dewatering of concentrates by mine

In the case of consignment treatment, emptying thickeners and switching filters due to the necessity of dewatering concentrates separately by mine, cause a loss of time and increase in workload. The loss of concentrates also amounts to a large quantity.

(4) Number of continuous operation days for the same ore

The small number of treating days for the same ore makes it impossible to continue stable conditions of operation. In addition, it is difficult to operate under the ideal conditions if factors such as the volume of reagents used and pH values are unknown. This is also one of causes that lower the beneficiation recovery and at the same time, brings about high production costs due to the excessive addition of reagent (collector) for fear of the decline of recovery, for example.

(5) High analysis costs

The necessity of analyzing ore and products (concentrates) separately by mine increase the numbers of sampling and analyses, and causes high production costs.

(6) Establishment of recovery through beneficiation test

It is considerably difficult to establish a beneficiation recovery of purchased ore through beneficiation tests for a small quantity of samples. In practice, many factors are decided in the negotiation between a private medium or small mine and CFM's beneficiation plant. This should be put to question.

(7) Calculation of recovery using sample analysis value obtained on the spot of operation

In regard to the method in which a recovery is determined by calculating balance on the basis of results obtained from the analysis conducted on the spot of actual operation, circulating ore volume in the system and ore retention in equipment such as tanks and thickeners come into question. Accordingly, such a recovery is not always accurate as that for each mine.

(8) Treating lot

Presently the ore received from a small mines whose tonnage is dozens to several-hundred tons, no treatment is being carried out until the ore volume at the stockyard reaches a prescribed amount (several hundred to a thousand tons), in order to comply with separate treatment by mine. This causes long delays in deciding the ore price to be paid, and should be put to question.

(9) Office management

Each beneficiation plant receives ore from many medium and small mines and must calculate ore prices in accordance with the separate condition of each mine. Therefore, each plant cannot help having a very complicated accounting system of office management. This also constitutes one of the causes for high production costs.

(10) Desire to improve results

In the case of consignment operation, the relevant mine receives the entire concentrate in untouched conditions, in accordance with the system. The outcome of recovery has no direct connection with the income and expenditure of the beneficiation plant. This seems to be one of causes that restrain the beneficiation operator's desire to improve the job.

3.12 Income and Expenditure

(1) As basic problems common to all three beneficiation plants which we visited, the following points can be cited:

1) The equipment has become very superannuated due to a lack of investment in equipment renewal for a long time and negligence in performing periodical maintenance and repair. This has caused the decline of operation rate and recovery.

2) In the case of not only the maquila system but also the ore-purchasing system, the ore is all controlled and beneficiated by lot (mine).

This seems to increase management expenses for ore and to worsen the operation rate of beneficiation.

3) For the ore volume treated, each plant has a considerably large number of employees. There might be some reason at each plant, but a substantial personnel reduction is considered possible.

4) No reevaluation of assets has been performed. Machines and equipment has been depreciated on the basis of prices at the time of purchase, but they are considerably different from current prices because of the former age of high inflation experiences.

5) Sales are all controlled by the head office, and necessary expenses are covered by remittance made from the office every week. Accordingly, each plant seems to lack the spirit of profit pursuance or sense of cost control. No budget control has been carried out. In order to improve conditions of income and expenditure, it will be necessary to implant in the employee's mind a sense of cost control and at the same time control of the real production by budget.

(2) The following are comments on the investigations on current conditions of the beneficiation plants which we visited and our impressions after the investigations. The profit and loss statement, sales item statement, and cost item statement (for 1988 and the first half of 1989) are attached.

1) Parral Beneficiation Plant (capacity: floatation 400 tons/day, cyanidation 240 tons/day, and employees 79 persons).

At this plant, sound operation is being carried out resulting in profit. At present, all the ore is treated by the purchasing system and no maquila beneficiation is carried out. Sulfide ore purchased is treated by floatation and oxide ore, by the cyaniding process after the floatation.

Procedures for the ore-purchasing system are as follows:

(i) For the ore received, sampling is performed (at the time of crushing), analytical and beneficiation tests are carried out, and then an advanced payment is paid after the calculation of estimated recovery.

The advanced payment is limited to the following
[ore price x (Estimated recovery - 10%)] x 80%

(ii) After an actual recovery has been decided by analyzing the concentrate and tailings produced in the beneficiation process, the payment of the ore price is settled (on the 15th day of the next month to the day when beneficiation is performed, deducting the beneficiation cost of 13 dollars/ton and smelting cost). Calculations are all carried out on steady basis so as not to be disadvantageous to the plant and furthermore, ore price is settled after the confirmation of actual recovery. This shows that considerable attention is paid to the prevention of loss.

The ore received is controlled by lot (mine), and put in the beneficiation process when the lot has reached 250 to 300 tons. Since ore is received from about 30 mines among which small mines with the output of some 20 tons/month exist, the control and beneficiation of the ore have become considerably complicated.

Sales are chiefly composed of those of three products such as Ag presipitates, lead concentrates and zinc concentrates (sold to Torreon Smeltery, Penoles Company), and in addition, (a small amount) earned by the sales of high grade non-teratment ore is included.

A provisional payment (80%) is received 15 days after the delivery to a smeltery and the final payment is settled one to two months later. The settlement of payment for the ore purchased is more often performed before that for the concentrates. However, no loss is suffered because the beneficiation recovery has been estimated on a steady basis.

The accounting procedures of sales amounts are as follows:

(i) In the relevant month, the settled amount of payment is booked.

(ii) For the unsettled portion, anticipated amount is booked temporarily.

(At the time of settlement, counter-booking is made to offset the above temporary amount and the total settled amount is booked.)

From about 30 mines which ore is purchased, nine mines have been given CFM's loans. Such loans are given by the Parral branch of CFM directly to the mine owners, the beneficiation plant having no relation to such decisions. (The CFM branch conducts the credit investigation on a mine concerned before giving the loan.) The loan is repaid through the offset with ore prices. That is, the plant delivers a check for ore prices to the CFM branch and the latter pays the balance, after deducting its repayment principal amount and interest, to the mine owner. The plant is being operated at surplus and has comparatively few problems under the ore-purchasing system alone. However, the following points should be examined.

a) The seniority of employees is very low and the number of skilled hands is small because the plant is located near the Maquila industrial area along the border between the United States and Mexico.

In addition, the superannuated equipment increases maintenance costs. Despite the above problems, for power supply and reagents used in the crushing, grinding and cyaniding processes, considerable cost reduction is considered to be possible by making operational devices. (See the section of beneficiation.)

b) Irrespective of the ore-purchasing system, the ore is beneficiated by lot without exception, which complicates the control of ores and the plant operation. Expenses for the ore received and stockyard control account for about 10% of operating costs, and personnel expenses for the above two sections account for as high as 24% of the total.

The operation seems to be streamlined considerably by treating purchased ore in a mixed state. However, the mixed treatment include delicate problems, which must be taken into consideration. The problems are, for example, how such treatment changes recovery in terms of technical phases and whether the payment of ore prices involves risk or not.

c) The plant has received comparatively high grade ore and the recovery is deemed to be satisfactory. Accordingly, sales are also very large. The level of operating costs is considerably high as well, but profit is gained because of the large amount (13 dollars/ton) of beneficiation costs, deducted from ore prices. The plant is located in an area with high mining potential and its stable operation can also be expected in the future.

2) Guanacevi Beneficiation Plant (Capacity: floatation 600 tons/day and employees 96 persons)

This plant is entirely different from the Parral Beneficiation Plant. That is, the operation is almost always performed at a deficit; only beneficiation by maquila is carried out and no ore is purchased; the beneficiation process is only floatation, no cyanide process being used. The plant produces bulk concentrates only. The ore is all controlled and beneficiated by lot because all concentrates are returned to each mine owner. (The concentrates are sold by mine owners to smelters.)

Sales of this plant are only the maquila fees. In January, 1989, the former fee (14,000 pesos/ton) was raised to 30,000 pesos/ton. Although the operation cost in 1988 was about 19,000 pesos/ton, the average cost in January to June, 1989 increased sharply to 35,000 pesos/ton. This has caused continued deficit despite the raising of the maquila fee. The factor which caused such rapid cost increase was chiefly a rise in material costs in the crushing, grinding, and filtering processes.

Since only the floatation in maquila system is carried out, procedures are simpler than those of Parral Beneficiation Plant. However, the following are problems at this plant:

a) The volume of the maquila beneficiation is decreasing and sales may decrease further in the future because if the current level of metal price continues, income will decrease. However, starting next year for the next two years, the maquila fees may increase (5,000 tons/month) due to prospecting at Penoles company's Cruz Mine is expected. Accordingly, current conditions can be maintained during that period. It is indispensable to carry out prospecting during this period. (See the section of mining potential.)

b) In spite of performing only floatation, beneficiation costs are very high. Since the plant is located in a remote corner of the country, certain high-cost factors such as transportation and welfare expenses are acceptable. However, the cost of electric power, personnel expenses, consumption of reagents, and expenses for dewatering and drying concentrates might be reduced. (See the section on beneficiation.)

c) In the past, the new installation of cyaniding equipment was planned and about 70% of the entire equipment installation has been completed.

   Since then, oxide ore has decreased in volume and the plan for its use has been left discountinued up to now. The decrease in output of oxide ore is considered to have been foreseeable even at the time the equipment was purchased. If such investment had been used for improvement of the floatation process, the effect would have been great. Examination should be made concerning a method for effectively utilizing even a part of this equipment in such a way as its removal or diversion to another beneficiation plant may be in the best interest of all concerned.

3) Barones Beneficiation Plant (capacity: floatation 300 tons/day, Cyanidation 120 tons/day, and employees 122 persons).

Medium and small mine owners are adamant in their rejection of raising the beneficiation fee, so the plant is compelled to be operated at a deficit. This plant operates by both ore purchasing (oxide ore - cyaniding treatment) and maquila system (sulfide ore - floatation). The ore received is controlled quantitatively in conformity with the capacity of the plant. The ore volume to be purchased from each mine every month is decided (Plan De Recepcion) separately for oxide ore (purchasing system) and sulfide ore (maquila system) through discussion between the plant and the relevant mine owner.

For purchased ore, samples extracted at the time of receiving are analyzed and tested at the laboratory, and then advance payment for the ore price is made based on results of the analysis and test. The advance payment is limited to the amount calculated using the following formula:
[(ore price x recovery rate - smelting cost - beneficiation fee) x 60%]
After crushing, samples extracted again are analyzed and tested at the laboratory to decide beneficiation recovery. The settlement of ore prices is performed on the basis of the recovery (not based on analysis results of concentrate and tailings).

The beneficiation fee to be deducted from the ore price is different from the actual cost of operation and is uniformly 17,500 pesos [17,000 pesos+500 pesos (conveying freight for ore)] per ton.

Products (Ag presipitates) are all sold to Penoles company's Torreon Smelter.

For the maquila beneficiation also, samples extracted at the time the ore is received are analyzed and tested at the laboratory.

An estimated recovery rate is calculated based on the results of the analysis and tests to settle advance payment of processed ore prices. However, the provisional payment is performed by CFM's branch, the plant having no connection with it.

In addition, after the beneficiation has been carried out, samples of concentrates and tailings are analyzed and tested at the laboratory to decide the actual recovery. The relevant mine owner is informed of the recovery rate (for reference).

The maquila fee is 16,500 pesos [15,500 peso + 1,000 peso (conveying freight of ore)].

All products (zinc, lead and copper concentrates) are returned to each mine owner, who sells them to a smelter.

Problems of the plant are as follows:

a) In addition to the inferior grade, the ore contains many minerals which are difficult to treat, and its recovery rate is low.

   Accordingly, ore treated (recorded in 1988) is almost as much as that of Parral Beneficiation Plant, sales are about half those of the above plant. The low level of sales exerts considerable influence on the income and expenditure.

b) Unlike the Parral Beneficiation Plant, the payment of purchased ore prices is settled on the basis of the recovery that has been decided through the analysis and test of samples extracted from crushed ore. That is, no procedures are taken for confirming the actual recovery.

The beneficiation cost considerably exceeds the Maquila fee (16,500 peso/ton) and the fee received at the time of purchasing ore (17,500 peso/ton), constituting a major cause of the deficit. However, raising of the beneficiation fee would result in a deep-seated and difficult regional problem which may cause the shut down of medium and small mines. Therefore, it is said that unless the recovery rate is improved so as to exceed the figure attained before the equipment of the beneficiation plant becomes obsolete, the cooperation of medium and small mine owners would be difficult to obtain.

c) The ore receiving is controlled in conformance with the capacity of the plant. However, some major mine owners have been making progress in their plans for constructing beneficiation plants for their own use, and it is forecasted that they will soon discontinue bringing their ore to the Barones Beneficiation Plant. It is unclear whether or not the volume of ore brought into the plant instead from small mine owners with small lots will increase. Even if the ore volume can be secured, the decline of grade and diversification of ore types have the possibility of lowering both recovery and operation rates further than at present.

d) In the surrounding area, there are beneficiation plants which perform maquila operations - CFM's El Bote Beneficiation Plant (maquila fee: 29.412 peso/ton) and the plant at Frisco company's Fresnillo Mine (maquila fee: 12 to 13 dollars/ton). Each maquila fee is considerably higher than that of Barones Beneficiation Plant, but the recovery rate seems to exceed that of the Plant. It is likely that comparatively high grade ore is brought in the former two plants and low grade ore is sent to the latter. In addition, since one of the small mine owners plants to construct a maquila beneficiation plant, the above tendency has a strong possibility of becoming increasingly conspicuous in the future.

In connection with the above item c) and d), some type of tie-up with El Bote beneficiation Plant for maquila operation is considered to be worth examining.

4. BENEFICIATION TEST

4.1 Beneficiation Test in Mexico

(1) Parral beneficiation plant

1) The current condition of the laboratory

The beneficiation test laboratory and the analysis room are in the same building. The chief of the laboratory is also the chief of the analysis section. Beneficiation test equipment includes ball mills, flotation machines, cyanidation test apparatus, reagents, etc. The pH meter, however, cannot be used as it doesn't work and should be repaired, or be changed for a new one. For beneficiation tests, only the standard test for received ores is routinely carried out. Tests for improvement of beneficiation are not carried out.

Table 4.1.1 shows the main equipment for beneficiation tests.

2) Analysis of CFM test data

Prior to our beneficiation tests, the test results obtained by CFM were taken into consideration. The beneficiation test conditions were determined after an investigation of the plant operation problems and on the test results, especially those of Pavoreal ore which is difficult to treat.

3) Beneficiation test

Beneficiation tests were performed with some operation problems being considered. Table 4.1.2 shows some operation problems, test objects, sample names, and test content.

a) Beneficiation test of Casale ore

Fig.4.1.1 shows from flow sheet for Casale ore test No.1.

The tests from No.2 to No.7 were performed under the various beneficiation conditions shows in Table 4.1.2. The results are given in Table 4.1.3, each result showing a total Ag recovery as low as 35%, with final tailings grade being not less than 230g/t. To understand the causes of this low recovery, therefore, the mineralogical studies of silver in flotation tailings and cyanidation tailings were carried out in Japan.

b) Washing and decantation test of Jose Galindo ore

The washing and decantation test result of Jose Galindo ore are shown in Fig.4.1.2, which indicate a high silver grade of the primary slime, so that the desliming effect of washing is not expected. Since the silver of fine particles and that of coarse particles after grinding do not show a marked difference, a desliming effect in the secondary slime is also unlikely. From these results it seems difficult to solve the problem of suspended solid in the cyanidation plant by means of desliming. Consequently, improvement of clarification equipment is required.

c) Mixed sample flotation test

(Sun Luis 2, Nochebuena and La Union)

To improve efficiency of plant operation, mixed treatment was intended. Mixed sample flotation tests were carried out in Tecamachalco laboratory for Sun Luis 2, Nochebuena and La Union ores, each being abundant throughput and having a similar head grade. Bulk flotation tests alone were carried out as beneficiation test. Firstly, the test was made with the individual ore samples and then with a mixed sample consisting of the three types of ores of the same quantity. The flotation conditions in individual ores were: Grinding, 20 min; AF31, 30 g/t; AP404, 15 g/t; AX350, 25 g/t; and ESMIN451, 30 g/t. In the mixed ore, addition of CC1065 by 60 g/t was added in place of ESMIN.

The test results are given in Tables 4.1.4 and 4.1.5, in which firstly the results of each individual ores, next the combined result calculated as the mean value of the three individual results, and finally the results of the mixed ore sample are shown.

Our comparison between individual ore test and mixed ore test was made by comparing the calculated result with the mixed sample results.

In the individual ore tests the silver grade of cleaners exceeds 10,000 g/t with the silver distribution rate ranging from 41.6 - 53.9 %. In the mixed ore test, the silver grade of cleaners indicated 406 g/t with the silver distribution rate being an approximately constant value of 1%. This may be attributed to errors in analysis. From the result, we consider it difficult to make a comparison between the flotation results of individual ore and mixed ore.

In the future, however, mixed ore tests may be necessary depending on the throughput, ore characteristics and grade of ores or mine owners. In this case, the mixed ore test result can be compared with the combined result calculated from the individual ore test results as mentioned above. The batch test results would be beneficial if they are applied to plant operation with some improvement being made. In the batch test the following should be taken into account:

- o Tests should be carried out more than once to confirm reproducibility.
- o Consider the type and amount of reagents and processes as applicable to the plant operation.

(2) Guanacevi Beneficiation Plant

1) The current condition of the laboratory

The beneficiation test laboratory and the analysis room are in the same building. The chief of the laboratory is also the chief of the analysis section. The laboratory is located on the mezzanine floor and is not equipped with ventilators. Such poor working conditions should be improved. Beneficiation test equipment includes ball mill, flotation machines, and some reagents. However, there is no pH meter and filter press and these should be supplied.

For beneficiation tests, only the standard test for received ore is carried out. Tests for improvement of beneficiation are not carried out.

Table 4.1.6 gives the main equipment for beneficiation tests.

2) Analysis of CFM test data

The ordinary cyanidation of silver ores co-existing with manganese ores brings about a low silver dissolution rate. According to a report on CFM test results, silver recovery has been greatly improved by cyanidation of the ore after preleaching of manganese by the addition of SO_2. Part of the results obtained are shown in the Table below:

Sample	Feed assay		SO_2 Kg/t	Improvement of Ag recovery
	Ag g/t	Mn %		
Ana Cristina	350	1.74	32.9	56.7% --> 94.6%
La Conception	190	4.65	unknown	39.6% --> 89.4%

In spite of the great improvement in silver recovery, the addition of a large amount of SO_2 is disadvantageous. The revenue and expenditure are estimated here when Ana Cristina ore is employed for example.

Silver price: 570 US cent/Toz

SO_2 cost : 1.1 US $/kg (in Japan)

Improvement of Ag recovery : 37.9%

Revenue: 5.7 US $/Toz 31.9 g/Toz x 100 x 0.35 Kg/t x 0.379

= 24 US $/t

Expenditure: 1.1 US $/Kg x 39.2 Kg/t = 43 US $/t

Balance: - 19 US $/t

The above estimation shows that this process does not pay on account of a large amount of SO_2 required.

In the CFM report, however, the test data for the amount of SO_2 added or the SO_2 leaching time are not mentioned. Therefore, by making detailed tests on these factors, the optimum amount of SO_2 to be added can be determined. Thus this process should be evaluated systematically from the viewpoints of economy, plant investment, SO_2 handling, etc.

3) Beneficiation test

Beneficiation tests were performed with some operation problems being considered. Table 4.1.7 gives some operation problems, test objects, sample names, and test content.

a) Flotation test of Rosario oxide ore

Fig. 4.1.3 shows the flow sheet for Rosario oxide ore test No. 1.

The test results from No. 2 to No. 4 obtained under the various flotation conditions given in Table 4.1.7 are shown in Table 4.1.8. The results are summarized as:

- o In tests No. 1 - 3 silver recovery was 72 - 75 % in rougher flotation with floatabity not so low.
- o Silver grade increased in cleaning (Test No. 3).
- o Accordingly, further investigation on the following items will probably improve operation efficiency:

  Ground particle size

  Flotation time

  Amount of collector addition

  Combination of various collectors

b) Mixed sample flotation test (Rosario oxide and sulfide)

As a mixed sample for use in Guanacevi Beneficiation Plant, Rosario oxide and sulfide ores belonging to the same mine owner were chosen according to a request from CFM. As beneficiation tests only flotation test was carried out in Tecamachalco laboratory. Firstly, individual flotation test for each ore and secondly mixed sample flotation test for a mixture of oxide and sulfide ores using an equal quantity, respectively, were carried out. The individual flotation tests for oxide ore and sulfide ore were carried under the appropriate conditions for each ore, bulk concentrates were got respectively. In the mixed sample flotation test, firstly sulfide ore concentrate and secondly oxide ore concentrate were got as bulk concentrate respectively.

An evaluation of the flotation test results was made by comparing the combined result calculated from the individual test results with the sum result of the sulfide ore concentrate and oxide ore concentrate obtained from the mixed sample test results.

Table 4.1.9 and 4.1.10 show these test results.

Flotation conditions

	Sulfide	Oxide	Mixed
Grinding	18 min.	14 mim.	18 min.
NaHS		60 g/T	300 g/T
AX 350	40 g/T	30 g/T	90 g/T
AF 31		25 g/T	25 g/T
AP 404		30 g/T	50 g/T
CC 1065	35 g/T	20 g/T	50 g/T

In the individual flotation test each minerals floated well and Ag recovery was 82.5%, while the same test with oxide ore showed recovery of as low as 55.3% in cleaner concentrate and 71.7% as the total recovery value. The mixed sample test showed Ag recovery of 80.8% as total recovery, which was 10% higher than that of the individual test results. Consequently, it is concluded that mixed ore flotation has the possibility of improving the silver recovery, though this is a conclusion from a test made only once. Further detailed investigation, therefore, may be required.

(3) Barones Beneficiation Plant

1) Current condition of the laboratory

The laboratory building stands next to the analysis building. As equipment for beneficiation test, ball mills, flotation machines, cyanidation test equipment, some reagents and a pH meter are available, but two flotation machines and pH meter electrode are out of order. They are fundamental equipment and therefore should be repaired immediately.

Ordinary, only standard beneficiation tests of received ore are carried out and development tests are not carried out. The main equipment for beneficiation test is shown in Table 4.1.11.

2) Analysis of CFM test data

Before beneficiation tests, results of CFM tests were analyzed. Many beneficiation tests were carried out especially on Vetalinda ore by CFM. Therefore, while avoiding overlapping of tests, we planned the test that seemed to be essential.

3) Beneficiation test

Beneficiation tests were carried out with plant problems being considered. Operation problems, object of tests, names of sample, and content of tests are shown in Table 4.1.12. Table 4.1.13 shows an assay of typical ore at Barones beneficiation plant.

a) Table 4.1 14 shows the result of cyanidation tests with regard to grinding time.

These results reveal that the rate of Ag dissolution is increased by reduction of particle size.

Table 4.1.15 shows the effect of agitation time on cyanidation tests. These results reveal that the rate of Ag dissolution is improved by increasing agitation time.

Table 4.1.16 shows the effect of Pb $(NO_3)_2$ addition on cyaniding test. These results reveal that the rate of Ag dissolution is improved by $Pb(NO_3)_2$ addition.

Here the revenue and expenditure when using lead nitrate is calculated, with an increment of 7% in silver recovery being considered:

Silver price 570 US cent/Toz
Lead nitrate cost 4.5 US $/Kg (in Japan)
Increment in silver recovery 7%

Revenue: $5.7 \div 31.1 \times 1000 \times 0.17 \times 0.07 = 2.2$ US $/t
Expenditure: $4.5 \times 0.2 = 0.9$ US $/t
Balance: 1.3 US $/t

Thus a profit is expected. Therefore, further detailed tests concerning the addition of lead nitrate, reproducibility, etc. are recommended.

Table 4.1.17 shows the effect of hot pulp agitation in the cyanidation test. These results indicate that there is no difference in Ag dissolution between normal agitation and hot pulp agitation.

b) The problem of dust at crushing plant and suspended solid at cyanidation plant.

Washing and decantation tests on crude ore with a high primary slime content were carried out. The results are shown in table 4.1.18.

With the silver grade of fine particles being high, a good effect of desliming by washing cannot be expected. The next problem on suspended solid in a cyanidation plant was investigated using Vetalinda ore. Sedimentation tests were carried out for cyanidation tailings, where a comparison between washed and deslimed sample and unwashed samples was made. No diferece in sedimentation speed was found between the two samples. It is considered secondary slime was made by grinding even after washing. This suspended solid problem, accordingly, is not solved by desliming, so that an improvement in clarification equipment is required.

c) Mixed sample beneficiation test
(Calicanto sulfide and oxide)

As a mixed sample for use in Barones beneficiation plant, Calicanto sulfide and oxide ores were chosen considering the throughput and the mine owner. In the beneficiation tests made in Tecamachalco laboratory, individual tests of sulfide ore were carried out by flotation and those of oxide ore were carried out by cyanidation. Next, mixed ore tests were carried out by using a mixture of sulfide and oxide in the ratios of 3:7 and 5:5. Firstly, flotation was carried out and then the flotation tailings went cyanidation. In the flotation test, untill primary cleaning was performed, and got bulk concentrate. An evaluation of the beneficiation test results was made by comparing the combined results calculated from the individual test results with the mixed ore test results as in the cases of Parral and Guanacevi. The results obtained are given in Tables 4.1.19 and 4.1.20.

Conditions of beneficiation tests

	Sulfide	Oxide	Mixed 5:5	Mixed 3:7
Grinding	8 min	12 min	12 min	12 min
$CuSO_4$	200 g/t			
AX 350	60 g/t		30 g/t	30 g/t
AF 31	50 g/t		32 g/t	32 g/t
AP 404	50 g/t		25 g/t	25 g/t
E 659			33 g/r	33 g/t
Conc. of CN		0.15%	0.15%	0.15%
Agitation time		48 hrs	48 hrs	48 hrs
CaO		12 kg/t	12 kg	12 kg

In the individual flotation tests for sulfide ore, each minerals floated well, Ag recovery of cleaner concentrate was 70.4% and the cyanidation test results for oxide ore showed Ag dissolution of 81.2%. The calcualted result from the above tests, therefore, provided Ag recovery of 75.9%. The mixed ore test result for the sulfide and oxide mixture at the ratio of 5:5 showed Ag recovery of 61.2% in flotation and Ag dissolution rate of 19.8% in cyanidation, these resulting in a total value of 81.0%. In the same test at a ratio of 3:7, Ag recovery was 57.5% in flotation with a dissolution of 22.1% in cyanidation, the total value being 79.5%.
From the above results the following may be concluded:

- o An improvement in recovery is possible when a mixture of sulfide and oxide ores is treated in a serial process of flotation-cyanidation through further tests may be necessary.
- o The cyanidation process is a requisite.
- o An increase in the mixing ratio of sulfide ore improves the Ag recovery in flotation, thereby it is possible to alleviate the load on the cyanidation process.

d) An investigation on the low recovery of Zn in Santa Marta ore.
The recovery of Zn in Santa Marta is low. For an investigation into the cause, batch tests were carried out. Samples of Zn flotation tailings were sent to Japan and EPMA analysis was carried out.

e) Sampling cyanidation plant
For the investigation of current conditions in the cyanidation plant, detailed sampling was carried out. The results are shown in Table 4.1.21.

4.2 Beneficiation Test in Japan

(1) Ore assay

Ore assay by complete analysis, X-ray diffraction, microscopic analysis, and EPMA analysis was carried out for sample ores from 18 mines under investigation. The summary of the results obtained is given in Tables 4.1.2 - 4.1.4, photographs from microscopic analysis and EPMA analysis are shown in the final pages. These samples, not always typical of the respective mine, observed some marked features as a result of our assay.

1) Complete analysis: Ore assays differ greatly according to mines, but some regional features were observed.
   - o Parral: Fe and CaO contents are relatively high.
   - o Guanacevi: MnO and Al_2O_3 contents are relatively high.
   - o Barones: Ag content is relatively low.

2) X-ray diffraction: Other than ordinary ores such as Chalcopyrite ($CuFeS_2$), Galena (PbS), Sphalerite (ZnS), Pyrite (FeS2) and Quartz (SiO_2); the following were characteristically identified in each region.
   - o Parral: Calcite ($CaCO_3$) and Fluorite (CaF2)
   - o Guanacevi: Chlorite ($(Mg,F11,Al)_{12}(Si,Al)8O20(OH)16$), Sericite ($K_2Al_4(Si6Al2)O20(OH,F)4$) and Orthoclase ($KAlSi_{13}O_8$)
   - o Barones: Ankerite ($Ca(Fe,Mg,Mn(CO_3)_2)$)

3) Microscopic analysis: Chalcopyrite, Tetrahedrite ($Cu_{12}Sb_4S_{12-13}$), Galena, Sphalerite and Pyrite were mostly Observed. In ores from Capsaya and San. Raphael mines, Marcasite (FeS_2) was found.

4) EPMA analysis: For Ag mineral, many Ag sulfide mineral such as Ag-Tetrahedrite $(Cu,Fe,Zn,Ag)_{12}\cdot Sb_4S_{13}$, Stromeyerite (CuAgS), Argentite (Ag_2S), Polybasite $8(Ag,Cu)_2S\cdot(Sb,As)_2S_3$ or Antimonpeaceite were observed, and regional features were not found. Other silver ores observed were Electrum in San. Josechico, Las Cumbres and San. Rafael ores and Matildite ($AgBiS_2$) in San. Robert ore. In Unificacion ore, Manganocalcite $(Ca,Mn)CO_3$ was found.

(2) Beneficiation test

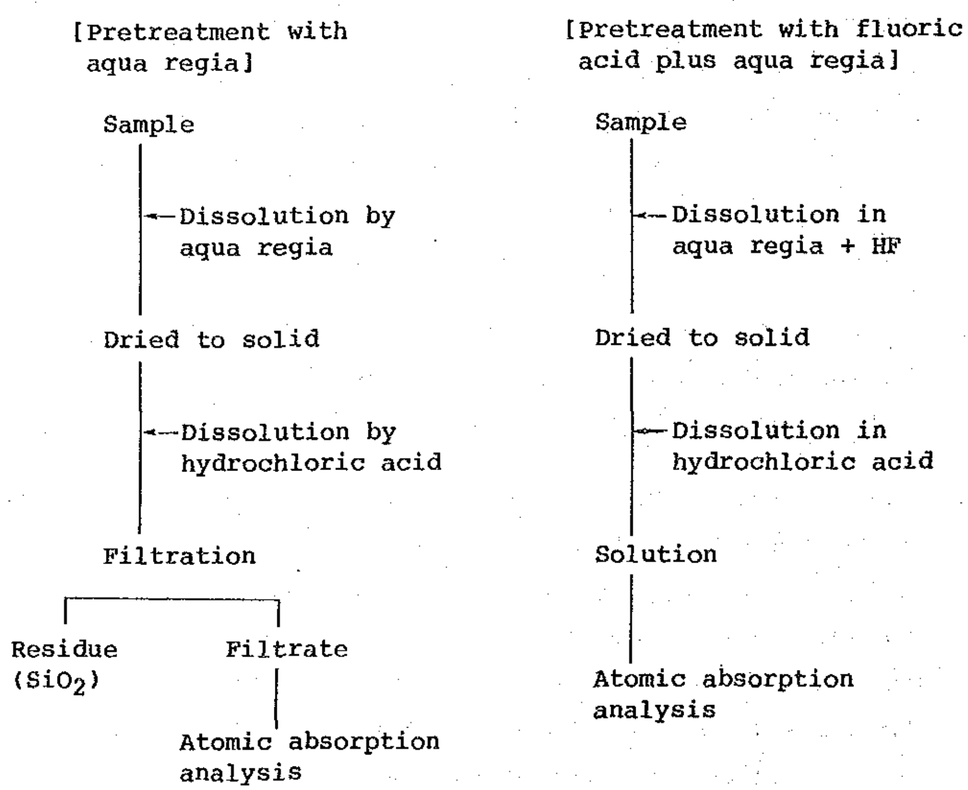
1) Parral beneficiation plant

a) Investigation on the cause of the low Ag recovery of Casale ore

A series of beneficiation tests on Casale ore made in Parral plant showed Ag recovery was low, Ag assay of the final tailings not being reduced to less than 230 g/t. To find the cause of low Ag recovery was considered to be more important than carrying out further beneficiation tests and the following method was employed:

1 Method of investigation

- EPMA analysis and microscopic analysis
- Wet chemical analysis employing different ore pretreatment: The flowsheets of analysis for the methods with aqua regia pretreatment and with aqua regia plus fluoric acid pretreatment are shown.



When ore is pretreated with aqua regia alone, sulfide mineral is dissolved while silicate mineral is left in the residue. Therefore, the mineral included in the silicate mineral is not dissolved, so that the metal assay results in a lower value than the actual value. On the other hand, when ore is pretreated with aqua regia plus fluoric acid the silicate mineral is also dissolved together with sulfide mineral, and the metal assay indicates the actual value. Accordingly, by comparing the two assays obtained by the above methods we can see if there is Ag in the silicate mineral.

2 Result of investigation

- EPMA analysis

  Photos of EPMA analysis are shown at the end of this report.

  Flotation tailings 1 : Quartz and Fe minerals were observed, Ag-S mineral was found in the quartz.

  Flotation tailings 2 : Quartz was observed, in which Ag mineral and Fe mineral were found.

  Cyanidation tailings 1 : Ca-F mineral (fluorite) and Ag-Sb-Pb-S mineral (tetrahedrite) were observed.

  Cyanidation tailings 2 : Quartz was observed, in which Ag mineral was found.

- Microscopic analysis

  The result of microscopic analysis is given in Table 4.2.5 and micrographs are shown at the end. From the analysis, pyrite was observed both in the flotation tailings and in cyanidation tailings.

2 Comparison of wet chemical analysis between aqua regia pretreatment and aqua regia plus fluoric acid pretreatment

The chemical analyses obtained are given below:

- Pretreatment with aqua regia

	Au g/t	Ag g/t	Pb%	Zn%	Fe%	S%
Flotation tailings	0.1	63	0.17	0.16	3.42	0.24
Cyanidation tailings	0.1	29	0.18	0.16	3.24	0.24

- Pretreatment with aqua regia + fluoric acid

	Au g/t	Ag g/t	Pb%	Zn%	Fe%	S%
Flotation tailings	0.1	285	0.17	0.16	3.42	0.24
Cyanidation tailings	0.1	213	0.18	0.16	4.07	0.24

When comparing both results a great difference in Ag assay was observed.

3 Conclusion

- Low Ag Assay of 63 g/t in flotation tailings and 29 g/t in cyanidation tailings in the case of aqua regia pre-treatment show Ag existed in sulfide ore or on the surface of other minerals. Thus, this low grade value indicated the Ag recovery limit in this process.
- The fact that Ag assay in the case of aqua regia plus fluoric acid pretreatment is high with a level of 285 g/t in flotation tailings and 213 g/t in cyanidation tailings means that Ag mineral is included in gangues like quartz, with the results of EPMA and petreatment with aqua regia being considered together.
- Therefore, flotation tests concerning the possibility of de-silicate flotation is recommended in order to take measures towards the improvement of Ag recovery.

2) Guanacevi beneficiation plant

a) Influence of bacterial leaching on silver ore containing manganese

There is a phenomenon that the silver dissolution rate is lowered when manganese ore exists in cyanidation.

As a countermeasure to this, CMF reported that the manganese was dissolved by SO_2 before cyanidation, thereby Ag recovery was improved greatly. However, the amount of SO2 required to be added was so great (30 - 50 kg/t) that the process was not put into practical operation.

It has been reported that bacteria dissolve manganese dioxide in the presence of sulfur. Thus a combination test of bacterial leaching and cyanidation was carried out with a fundamental test on the effect of bacterial leaching as pretreatment.

1 Testing method and sample

The sample used is La Prieta ore sampled from Guanacevi beneficiation plant. The ore was ground to-200 mesh in 70%. Chemical analysis of the head ore: Au, 3 g/t; Ag, 391 g/t; Cu, 0.03%; Pb, 0.21%; Zn, 0.56%; Fe, 3.17%; S, 0.04%; Mn, 8.15% and As, 0.02%, and micrographs of the head ore are shown at the end:

The bacteria are E-6 (iron-oxidizing bacteria capable of oxidizing sulfur) and B-12 (iron-oxidizing bacteria). These bacteria were cultivated in 9 K medium for 10 days, the fractionated and further cultivated for two days while the medium was kept at 30°C, agitated and aerated. After cultivation for two days, 30 g sulfur and 650 g ore (P.D. 30%) were added to 1,500 ml with E-6 and B-12, respectively. They were then put into the leaching test for 15 days while they were kept at 30°C, agitated, and aerated.

Measurement of pH and sampling were made every 5 days. PH of the cultured solution was about 2 which increased after addition of ore to 6. Then pH was lowered to 5 by addition of sulfuric acid. After bacterial leaching for 15 days, filtration and dewatering were carried out. Subsequently, leaching for 48 hr using cyanidation and thiourea were carried out.

For the samples for non-bacterial leached, four kinds of leaching (ferric sulfate, sulfuric acid, cyanidation, and thiourea) were carried for comparison under the conditions:

Cyanidation method:	1.	pH = 10	
	2.	NaCN 1 kg/t	
Thiourea method:	1.	H_2SO_4 70 kg/t	
	2.	$CS(NH_4)_2$ 70 kg/t	
	3.	$Fe_2(SO_4)_3 \cdot 9H_2O$ 58 kg	
Ferric sulfate method	1.	$Fe_2(SO_4)_3 \cdot 9H_2O$	234 Kg/t
	2.	H_2SO_4	215 Kg/t
Sulfuric acid method		H_2SO_4	215 Kg/t

2 Test results

The change of pH with time is shown in Fig. 4.2.1. In the case of E-6-1, the pH decreased to 2 from the 2nd day, this being due to the addition of a large amount of sulfuric acid. Microscopic observations for the bacterial leaching sample on the 14th day showed a large number of bacteria attaching to the acicular sulfur crystal in the case of E-6, especially a very large number with E-b-1. On B-12 a large number of bacteria was not observed.

This was probably because the ore used was an oxide and, considering the initial increase in pH, Fe+2, of the energy source for bacteria was so poorly dissolved that the number of bacterial decreased. With B-12-1 the bacteria other than the iron-oxidizing bacteria were frequently observed. Tables 4.2.6 - 4.2.9 show the chemical analysis of filtrates and residues. Table 4.2.10 shows the leaching rates of Mn, Au and Ag, from which the following has been concluded:

- With bacteria E-6, Mn leaching was observed, which seemed to further increase with increased leaching time.
- In thiourea method the leaching rate of Mn was high irrespective of pretreatment with bacteria.
- Leaching rates for Au and Ag were generally low in all tests, but the test using the cyanidation without bacterial leaching method showed the highest values.
- A leaching rate for Ag leached for 24 hr was higher than that leached for 48 hr but the cause was not clear.

3 Conclusion

In the tests for ores containing manganese, the pretreatment by bacterial leaching did not show a notable effect. There are many subjects of study to be considered further such as recovery of Au and Ag included in the sulfide ore, selection of ore type for bacterial leaching and selection of bacterial species. The present test, therefore, would be useful as reference data in the further development of bacterial leaching technology.

3) Barones beneficiation plant

a) Flotation test of San Bernabe ore

Differential flotation is employed in actual plant operation with ores with high grades of Cu, Pb and Zn but it has not always been successful. On the other hand, after investigation the present plant was found to be antiquated with unsuitable production capacity and layout. We therefore planned the construction of a new plant where sulfide ore containing Cu, Pb and Zn could be treated in another line.

To investigate the beneficiation system for the new plant, fundamental flotation tests and differential flotation tests (NaCN method) were carried out using San Bernabe ore as the typical sulfide ore. Although the copper grade of the head ore was of a low grade of 0.7%, this example of differential flotation tests were reported here for reference.

1 Fundamental flotation test

In the fundamental flotation tests only rougher flotation was carried out and the results are shown in Table 4.1.2 and Fig. 4.2.3..

Test No.	Natural pH	NaCN g/t	ZnSO4 g/t	SO2 (g/t)	AF208 g/t	EX g/t	Frother N-125 g/t
1	6.5					100	35
2	6.5	100	300			100	35
3	6.5	50	170			80	35
4	6.5			500	140		35

The results of No. 1 fundamental flotation test showed that Cu, Pb and Ag were easily floated while Zn was not easily floated. When comparing NaCN with SO2 processes, Fe as well as Ag and Pb were less well floated than by the later process. Therefore, the cyanidation process was employed in the differential flotation.

2 Differential flotation test

Fig. 4.2.3 shows the flowsheet of this test and Table 4.2.12 gives the test results. As copper grade of the head ore was low, copper concentrate was not collected, thus the flotation results of the main metals except copper are summarized as follows:

	Assay g/t, %			Distribution %		
	Ag	Pb	Zn	Ag	Pb	Zn
Pb 3Cl.C	525	60.84	1.35	53.0	90.4	1.2
Zn 3Cl.C	29	0.32	46.60	4.3	0.7	60.8
Recovery				57.3	90.4	60.8

The above results are those from a batch test and the estimated flotation results in the plant operation for the same grade ore are shown in Table 4.2.13.

b) Investigation into the cause of low zinc recovery from Santa Marta ore

In the plant operation Santa Marta ore showed a low zinc recovery as low as 46% and the zinc grade of the tailing exceeded 1%. To study the problem, batch test were made in the Barones beneficiation plant and chemical analysis, EPMA analysis, and microscopic analysis on zinc flotation tailings were carried out.

1 Chemical analysis

Results of the chemical analysis are given in the Table below.

Ag g/t	Pb %	Zn %	Fe %	S %
64	0.13	0.58	3.59	0.46

2 EPMA analysis

Zinc flotation tailings [1]: Ag-Cu-S mineral and Pb-S mineral (Galena) were observed. Zinc did not correspond to sulfur and was supposed to be zinc oxide. Zinc flotation tailings [2]: Ag-S mineral, Cu-Fe-S mienral (Chalcopyrite) were observed as quartz middling. Iron did not correspond to sulfur and was supposed to be iron oxide.

Zinc flotation tailings [3]: Au-Cu-S mineral was observed.

3 Microscopic analysis

Pyrite was observed but zinc mineral was not.

4 Conclusion

Zinc mineral that is not easily floated in zinc flotation and which is not recovered is supposed to be composed mainly of zinc oxide.

5. EVALUATION OF MINING POTENTIAL

The ore reserve is evaluated as the first stage for the total evaluation of mining potential, wherein first the stability of ore reserve and ore deposit with room for exploration are examined for each mine, and then the mining potential is evaluated for each surveyed area. These duplicate some parts of chapter 3. After that, the production capacity of each surveyed mine is done in the second stage. Finally the mining potential of each area is evaluated.

5.1 Evaluation of Ore Reserve

In section 3.2, as for the ore reserve calculation, the calculation method of Mexican medium and smaller mines (CFM) has been compared with that of JIS methodology. The calculation results by CFM is a secure value having a margin for error because it is used as a basic criteria for providing loans and credits such as advance payments for ore production. Accordingly, when viewed from the level of JIS, the values of the probable and the possible ores have to be increased. However, such increases make sense when the mine owner has a will to develop the mine, but they are meaningless when the owner has no ambition to develop the mine or would suffer financial and economic difficulties through wanting to develop it. By taking these conditions as a premise, the ore reserve of each mine is examined as follows.

(1) Parral Area

(i) El Triunfo y La Revancha Mine (Fig. 3.3.1 a, b)

(a) The ore blocks above L5 are counted in the calculation. There is no problem with the calculation.

(b) Both the vein and the grade are relatively stable, but the real grade is only half the chemically analyzed value because of low benefication recovery.

(c) The target for future exploration is the ore intersection of drilling lower than L5.

(ii) La Prepa Mine (Fig. 3.3.2)

(a) The part above the L4.5 gallery in 100 m foreground from the southern border of the mining claim has been already stoped, and therefore the value of ore reserve in this part must be deducted.

167,670 - 36,058 = 131,612 tons

(b) Because the proven ore is so defined that basically it is confirmed by at least two sides, the above-described proven ore must be reduced by half, and the remaining half be downgraded to probable ore.

131,612/2 = 65,806 tons	:	final proven ore
65,806/2 = 32,902 tons	:	downgraded from proven to probable ore (halved according to CFM)

(c) The vein in the northern side of the probable ore has vanished due to a fault, so its ore reserve must be subtracted.

11,542 x 2 - 5,994 = 17,090 tons

This figure is the provable ore for the part down to 10 m below the gallery viewed according to JIS, but the part down to 30m should be considered to be the probable ore because the owner has ambitions to develop this lower part.

(17,090x3)/2 (according to CFM) = 25,635 tons

revised probable ore

(d) The vein in the northern side of the possible ore has also disappeared due to a fault, so its ore reserve should be excluded.

The possible ore under the galley is reckoned by shifting only the probable ore.

[(5,974x4)-5,735]/4=4,540 : revised possible ore

Collecting and compiling the above data resulted in the following table.

	Original (tons)	Reviewed (tons)
Proven	167,670	65,806
Probable	11,542	58,902 (32,902+25,635)
Possible	5,974	4,540
Total	185,186	128,883

No change in grade

(e) Both the vein width and the grade are stable.

(f) There is room for exploration in the lower part and beyond the northern fault.

(iii) La Esperanza Mine (Fig. 3.3.3)

(a) Some increase in proven ore can be expected in the upper part over the southern L2.

(b) The vein width and the grade are unstable in the strike side, but stable in the dip side.

(c) As to exploration, upward and downward spreading in the southern part and spreading to the lower northern part (the lower part of Tiro Vertical) can be expected.

(iv) Tilita Mine (Fig. 3.3.4)

(a) There is no problem with the ore reserve figures.

(b) The vein width is unstable in the strike side but is stable in the dip side.

(c) The exploration on drift mining from the bottom of Tiro Sandedro to the northeastern part is worthy of action.

(v) La Fortuna Mine (Fig. 3.3.5)

(a) An ore reserve has been estimated under the incline, but its exploration should depend on whether the owner has the will or not.

(b) The vein width seemed to be stable.

(vi) Unificaition Cordero Mine (Fig. 3.3.6)

(a) A probable ore can seemingly be expected in the south western part.

(b) Both the vein width and the grade are extremely stable.

(c) Because of many parallel veins, this is a mine of high exploration potential if counter-flood measures are well established.

(vii) Exploration Potential for Parral Area

Among the six mines surveyed, those blessed with an abundance of ore reserve and stable vein widths and grades are the La Revancha, La Presa, and Unifocacion Cordero. The veins of the La Esperanza and Tilita are unstable, though there is room for exploration. La Fortuna is not in operation. If these mines are typical for the area, it can be said that the exploration potential of the area is high, because each of the mines is provided with an enough room for exploration.

Although the area is an old mining region, future developments can be expected thanks to the remaining oxidized and sulfide ore zones resulting from no large exploitation in the past. It is also hopeful that there are generally many high grade ores.

(2) Guanacevi Area

(i) San Jose Chico Mine (Fig. 3.3.7)

(a) There is no problem with the ore reserve figures.

(b) Both the vein width and the grades are unstable.

(c) The exploration on the drift from L8 to the south is worthy of execution.

(d) The exploration on the lower part may be possible if counterflood measures are taken.

(ii) Barradon Mine (Fig. 3.3.8 a, b)

(a) Although the ore reserve of this mine seems to be overestimated, there may be no problem due to adding a safety margin to the possible ore.

(b) The grade of the remaining ore in the part now in operation is unstable.

(c) No ore reserve has been estimated for Chiripa, which is the only vein to be prospected for potential reserves.

(iii) Capuzaya Mine (Fig. 3.3.9)

(a) The probable and the possible ores have been estimated in relation to the drilling of ore at the intersection part. For the time being, the proven ore over the gallery will be the target for mining operation.

(b) Both the vein width and the grade are stable.

(c) The exploration will be applied with a shaft sinking, wherein counter-flood measures must be taken.

(iv) San Rafael (Fig. 3.3.10)

(a) There is no problem with the ore reserve figures.

(b) Both the vein width and the grade are stable.

(c) A downward development is recommendable as a next exploration.

(v) Ample Al Alto Nuevo Porvenir Mine (Fig. 3.3.11)

(a) There is no problem with the ore reserve calculation.

(b) Any manto type ore deposit has no regularity in deposition, so whether the exploration will succeed or not is fortuitous. Because the mine is new, discovery of ore deposits is expectable.

(vi) Noche Buena Mine (Fig. 3.3.12)

(a) There is no problem with the ore reserve calculation.

(b) Both the vein width and the grade are unstable.

(c) Exploration may be successful under the current working place and in the lower western part.

(vii) Exploration Potential for Guanacevi Area

Superior mines among those surveyed in the area are San Rafael and Ample Al Alto Nuevo Porvenir, being optimistic for further exploration in both aspects of ore reserve and grade. The other four mines, San Jose Chico, Barraden, Capuzaya and Noche Buena are the remaining veins of old large-scale mining and their extentions, and in some cases the mining operations are conducted on ores that were old waste products in the pits. These mines can be restored through various measures by the government undertaking the pump-up drainage cost and the drilling exploration by CRM.

(3) Barones Area

(i) San Roberto Mine (Fig. 3.3.13 a, b)

(a) The ore reserve estimation carried out reasonably by borings from the surface has been calculated in the 60 to 100 m range with some borings in the ore.

(b) Because the proven ore has been confirmed through the gallery, there is no problem with the calculation.

(c) The probable ore has been increased by twice, and the possible ore by 4 times, respectively from the values obtainable by CFM.

(d) The vein width, which is broad, and the grade are stable.

(e) The big exploration target in future is the development to the drilling ore intersection.

(ii) San Bernabe Mine (Fig. 3.3.14 a, b)

(a) There is no problem with the ore reserve figures of the San Berenabe Vein, which are actually larger than the value calculated by CFM.

(b) The ore reserve of the Pupa Vein has been estimated to include the part down to 150 m under the developed region in the lower part of the Tiro Pupa, so that this is an overestimate and the more reasonable range may be that of the probable ore. As for the breakdown, it is better to classify the lower 30 m into the probable ore, and the next lowest part into the possible ore.

9,368 : probable ore

23,419-9,368=14,051 : possible ore
(downgraded from the probable ore)

It is hard to identify the ore reserve between Pupa and Tiro Don Jesus as a proven ore, so that it is divided into the probable and the possible ores:

135,014/2=67,507 : probable ore (downgraded from the proven ore)

67,507 : possible ore (ditto)

The probable ore in the eastern lower part of Tiro Don Jesus is also similar to the above-mentioned case :

55,977/2=27,988	:	probable ore
27,989	:	possible ore (downgraded from the probable ore)

In addition, of the lower part of the gallery extending to the east from Tiro Pupa, only the extended 200 m part must be reckoned, and half of the calculated figure must be classified into probable ore and the other half into possible ore.

64,364/2=32,182	:	probable ore
32,128	:	possible ore (downgraded from the probable ore)
197,920-64,364=133,556	:	excluded from the probable ore
23,419	:	excluded from the possible ore
331,334	:	ditto
75,055	:	ditto

Compiling the above data give the following table.

		Original(ton)	Reviewed(ton)	
Proven		283,907	148,893	(283,907-135,014)
Probable		277,316	137,045	(277,316-14,051-27,989 -32,182-133,556+67,507)
Possible		429,808	141,729	(429,808-429,808+67,507 +14,051+27,989+32,182)
Total		991,031	427,757	
Grade :	Au	0.65g/t	0.54g/t	
	Ag	173g/t	147g/t	
	Pb	1.21 %	1.15 %	
	Zn	1.35 %	1.43 %	

(c) Both the vein width and the grade are very stable.

(d) There is sufficient room for exploration.

(iii) Las Cumbres Mine (Fig. 3.3.15)

(a) The probable in the lower part can be upgraded to proved ore.

(b) An probable ore and a possible ore have been counted outside a part which has not been regarded as proved ore, but they must be excluded because there was no conformity found.

Increase in proven	4,534
Probable	[(5,730x2)-3,971]=3,745
Possible	[(6,720x4)-8,553]=4,582

When compiled :

	Original(tons)	Reviewed(tons)	
Proven	7,567	12,101	(7,567+4,534)
Probable	5,730	3,745	
Possible	6,720	4,582	
Total	20,017	20,428	

There is no change in grade.

(c) Both the vein width and the grade are stable.

(d) The exploration in front of the eastern fault of Alto Vein in the gallery at the bottom part and the drift exploration in the east of Bajo Vein must be continued.

(iv) Calicanto Mine (Fig. 3.3.16 a, b)

(a) There is no problem in the ore reserve figures.

(b) There is a variety of changes in the vein width and the grade.

(c) For the time being, exploration is out of question because of an abundance of ore reserve.

(v) California Mine (Fig. 3.3.17 a, b)

(a) There is no problem in the ore reserve figures.

(b) The minable ore for open-pit mining seems to have no dispersion in the grade thanks to natural blending.

(c) No exploration is necessary for the time being because of a sufficient ore reserve for open-pit mining.

(vi) Amplicacion San Miguel Mine

(a) There is non problem with the calculation.

(b) There are some changes in the vein width, but the grade is high.

(c) The mining claim is extremely narrow so there is no room for any exploration. The only possible exploration area is the downward development, but the fact that an old shaft has been deeply extended may suggest that the deeper part had been already mined out.

(vii) Exploration Potential for Barones Area

Among all the areas surveyed this time, San Roberto, San Bernabe, Calicanto and California mines are blessed with sufficient ore reserves and have room for exploration, so they can be regarded as typical medium-scale mines. While Las Cumbres and Amplicacion San Miguel Miner are small, they hold high grade ores.

This area is an old mining district, where, differing from the Guanacevi Area, only the oxidized ore zone has been mined and the sulfide ore zone has been left without mining. This means that there are sufficient room for exploration of the sulfide ore zone, bringing about a high exploration potential. As a whole, there is a trend for low grades, and therefore the basic policy for future operation is to enhance the accessory value of ore by recovery of all components through the flotation.

5.2 Evaluation of Production Capacity of Mine

In the previous section, the ore reserve of each mine has been evaluated, and in this section the economic efficiency of each mine is investigated. In practice, by estimating the income and cost balance against the ore grade obtained through the ore reserve calculation, each mine is examined for its possibility to continue a robust and stable operation.

Most mines have not been subjected to exploration yet. If the economic efficiency is high enough, it will allow drift mining at a spot of relatively poor grade ore in a vein, bringing about an expectation of discovering new ore shoots, which means an increase in the ore reserve of the mine, resulting in a long-term maintenance-expansion of the production capacity of the mine.

Such income and cost balances are shown in Table 5.2.1. The final results of the income and cost balance is shown as the operating cash flow.

On the basis of these estimations, the production capacity and the prospects of each area is described in the following.

(1) Parral Area

As a result of calculations, there is a margin in the funds of each mine. A margin in the funds is especially important for La Esperanza and Tilita Mines where the continuity of the vein is poor, and it is very likely that these mines, can to some extent, cope with raised costs due to mining increasingly deeper parts in the future. In addition, as for La Presa Mine, which was under redevelop-ment work at the time of survey, the cash flow gained when the production has started along the right lines will be reinvested to exploration.

The cash flow level of La Revancha Mine is relatively low because the mine is now operating on oxidized ore containing only silver and the beneficiation recovery rate is low. Accordingly, it is necessary for the mine to shift to the sulfide ore in the deeper part to secure a sufficient amount of ore and to seek ores of higher value. However, burdens of expenditure for development work in the deeper parts are expected and increased mining cost. Now, a relatively simple transportation system is used but due to the structure of the mine, inevitably it will become more complicated. If the development cost for the deeper part is not feasible because of a low cash flow obtained from the grade of ore reserve, then a production increase is thought to be inexpedient because of the current low price of silver.

Despite the risk mentioned above, there is some room for exploration in this area as a whole, and the production capacity of each mine is high.

(2) Guanacevi Area

The mines here that are operating at a loss by our calculation will sooner or later be forced to shut down their operations. In addition, the mines now in operation also cannot be expected to have any production increases or a stable output for the long term because of the status quo and room for exploration is limited (San Rafael Mine). Introduction of efficient mining methods is difficult due to the shape of the ore body (Ample Al Alto Nuevo Porvenir Mine).

(3) Barones Area

As a result of our calculations, San Bernabe Mine is operated at a loss for the reason of bearing labour cost, a part of which should be shared with San Roberto. Accordingly, the income and cost balance is in the black for every mine in this area. However, there is a fortunate aspect in the beneficiation cost, when compared with that of the other two areas, it is suppressed at a low level.

The potential of ore reserve is extremely high in this area, where a lot of large and small veins, though with somewhat lower grades, lie over a wide range. The latent production capacity of crude ore is high, if a substantial profit of the mine side (the metal price minus the ore treatment charge) goes on as it is.

5.3 Evaluation of Mining Potential

(1) Parral Area

(a) In this area there are two large vein systems, one north of Parral City and another running from San Francisco del Oro to Santa Barbara. Small vein systems other than the above have been also recognized. Among them, the vein system between the San Francisco del Oro to Santa Barbara is operated by a leading enterprise, and other vein systems by medium and smaller mines.

(b) The zone north of Parral City is an old mining region, and a small number of the veins have been mined out already, but many others remain intact. Ore has been only slightly subjected to mining. Further even medium and smaller mines aim to extract not only oxidized ore zones but sulfide ore zones these days. Therefore the general potential of ore production in this area is high.

(c) The vein width and the ore grade are stable for some of the veins in this area, but are not stable for others. Since ore production depends on the stability of a vein, it is considered that operation of unstable veins will have some influence on the total ore production in this area.

(d) Medium and smaller mines will hold their current production capacities because of their profitabilities. Steady ore production will be continued because there is no move to increase the ore throughput by introducing machines and no mine will decrease its ore production due to an exhaustion of ore reserves.

(e) Reflecting the dull market prices of gold and silver and the increasing cost for entrusted beneficiation, the operation is shifting to mine ores of higher value. Since the operation is aimed at mining ores from the sulfied ore zone, setting aside the oxidized ore which the recovery rate is low. Accordingly, among the ores to be treated in the Parral beneficiation plant in future, ores from the sulfide zone will increase.

(f) Beneficiation studies are needed for ores with low beneficiation recovery rates like those from La Revancha Mine.

(2) Guanacevi Area

(a) The ore deposit of this area consists of veins crowded into a range of E-W 10 km and N-S 10 km. Some veins are in operation or under exploration by medium and larger enterprises and other are in operation by medium and smaller mines.

(b) This area has been an district of mining industry since old times, and ores have been mined from oxidized and sulfide zones in a large scale down to the deeper part. Therefore the ores that are now being mined are:

(i) Waste from the old mines which are now worthy as ores. These ores are divided to two classes. One is Terrero that is piled on surface, and another is filled in cavities in the undergorund.

(ii) Low grade ores in old mines that were not worthy for mining then but are now, so-called residual ores.

(iii) New ore deposits recently discovered.

Among the above, (i) and (ii) compose the main types in this area. Their throughput tends to fall under the influence of dull market prices of silver and the high cost for entrusted beneficiation. The remaining ore quantity is also decreasing. Discovery of new ore deposits can be expected, but the ore quantity will not be large because of the limited range of exploration.

(c) Production capacities of medium and smaller mines are sufficient, thanks to introduction of machines to some extent and well designed underground structures but it will become difficult for many mines to maintain steady ore production because their ore reserves which back up ore production rates are being depleted. Furthermore, the grade of ore produced is low, and mines operating in the red will sooner or later be forced to close.

(d) The above-mentioned decrease in ore production will be filled with entrusted beneficiation of 5,000 t/month ore supplied from Santa Cruz Mine of Penoles to the Guanacevi beneficiation plant for the coming two years.

(e) During the two-year period, new ore deposits must be discovered with a possible exploration encouragement by cooperation of the CRM. There are some inferred veins in this area, bringing credence for exploration.

(f) In this area, groundwater pressure makes any downward development difficult. To cope with this problem, it is desirable that CFM consider grants subsidies to encourage medium and smaller mines.

(3) Barones Area

(a) The ore deposit of this area is distributed in a wide range of 50 km x 15 km, extending from the south to the north of Zacatecas City, and it consists of five big vein systems - Cantela, Mala Noche, Veta Grande, Tajos de Panuco and Plomosa. Among them, part of the Veta Grande vein-system has been mined by Penoles Mining Co., Ltd., and part of the Catela vein system is now in operation as El Bote Mine of CFM. All but these two parts are in operation by medium and smaller mines.

(b) This area is an old mining district, and the part from the ground surface to the oxidized ore zone has already been mined, and only main galleries have been excavated in the sulfide ore zone. Accordingly, the ores that are now being mined by medium and smaller mines are:

(i) Waste from old mines now worthy of mining -- an ore named Terrero piled on the ground surface.

(ii) Left ores in oxidized zones from old mines and ores existing in sulfide zones.

(iii) Ores in new ore deposits recently discovered.

Among the above, medium and smaller mines are mining the (ii) class, but there are some large ore deposits in (i) and (iii) clases.

Therefore, the ore reserve potential of this area is high.

(c) Medium and smaller mines are provided with a sufficient production capacity and are hoping for full-scale operation, but they stock surplus amounts of ores at their mining sites or surpress production because of the acceptance limit of the Barones beneficiation plant. In contrast, there are some mines that are able to continue operation thanks to the low cost of entrusted beneficiation.

(d) Because of the limited capacity of Barones beneficiation plant, there are plans to build up a private beneficiation plant to treat that areas ore, a beneficiation system that would buy ores from medium and smaller mines, and heap leaching of Terrero.

(e) Because of the above-mentioned items, it will be necessary to raise production and the recovery rate of the Barones beneficiation plant.

6. MILL PRESENT CONDITION DIAGNOSIS, SUGGESTIONS AND CONCLUSIONS

6.1 Improvement Plan for the Mineral Processing Recovery

(1) Comprehension of the Optimum Conditions by Stable Operation

In order to improve the recovery of mineral processing, it is important to seize the optimum conditions such as "the proper quantity of reagents added" and "the PH value" at that time.

The optimum conditions at an on-site operation does not always conform to what is determined by a mineral processing test at an laboratory. There-fore, to attain a recovery improvement, it is essential to find the optimum operating parameters by controlling the quantity of reagents added while observing the state of flotation froth, analyzed values, etc.

(2) Stabilization of Operation by Means of Instrumentation

The instrumentation has hardly been used in these three plants. Therefore, the operation will never be stable unless important factors, such as the quantity of ore feed, quality of water supply, pulp density, grinding size, PH values, the quantity of reagents added, etc., are constantly monitored and controlled, so that the instrumentation will allow automation to be performed.

(3) Stabilization of Operation due to Improvement of Maquila and Ore-Purchaging System

The present system of Maquila and Ore-Purchasing make the stable and continuous operation impossible because the operation is often interrupted. Therefore, it will be necessary to make the operation continuous and stable by adoption of a new All Ore-Purchasing system , which is described later. In addition, adopting the All Ore-Purchasing system makes the mixed processing of sulfide ore with oxide ore possible, consequently it is practicable to select the best process of each mill for the improvement of recovery.

(4) Master of Operation Control Technique

The improvement of recovery can not be achieved only by installation of modern equipment. It is very important that the operators and the staff master the operation control technique. It is to be desired that OJT (On the Job Training) should be practiced in the new modernized beneficiation plant.

6.2 Operation Cost Reduction Plan

(1) Cost Reduction by Means of Instrumentation and Automation

Stabilization of the operation by means of instrumentation and control systems reduces losses. For example, it decreases the quantity of operator's work, saves labor, and simultaneously reduces reagents consumption.

(2) Energy Saving

For the purpose of energy saving, it is necessary to pause some machines, for example pump and flotatin cells, by changing process flow and arrangement of machines. Decreasing the number of operating machines means a reduction in maintenance expense.

(3) Cost Reduction due to the Improvement in Maquila and Ore-Purchasing System

The adoption of the all Ore-purchasing system reduces the loss time and complexity of individual treatment for each lot, allowing the operation rate to improve, and leading to further cost reduction. The office work is also simplified, and thus labor is saved.

(4) Rationalization of the Administration Department

It is necessary to improve the efficiency of certain business controls to carry forward labor savings by the installation of personal computers.

6.3 Improvement in Equipment Operation Rate

During the study of the equipment operating rate, a number of problems were identified which must be solved to improve this rate and have been outlined and clarified below:

- o Occurrence of accidental failures
- o The system of operation under the mineral processing commitment from more than one mine
- o Lack of water, unbalanced equipment, etc.

(1) The Plan for Reducing Accidental Failure Occurrence

Although details are described in maintenance considerations, first of all, it is necessary to produce a regular maintenance and repair system. In a mineral processing plant, generally, the operation rate should be almost 100 %, and the maintenance is planned so as to make that possible.

In the case of the CMF mill, no long term shutdown and maintenance plan was made. However, if a yearly maintenance plan and the proper execution system of routine management are established, accidental failures can be almost eliminated.

For this purpose, the installation of various measuring instruments, meters, alarm systems, etc. for early detection or discovery of any abnormality is effective.

(2) Maquila and Ore-Purchasing System

It seems this problem encompasses not only the equipment operation rate but also the operating efficiency of various devices in the metal recovery system have become major negative factors. To solve this, the best way is to accept all ores as custom ones.

Switching the present system to the all-custom-ore system allows the continuous operation, free from the current "state of interruption". Thus, the inefficient custom of waiting for a new opening of time for ore batch switching, should decrease losses from the original operation of shutdown, and can be expected to save time.

Also, the imbalance of operating conditions for each type of process, continuous processing of ores, some crude-ore blending of mixed processing, etc. allows the separate operation load factor of each device to be adjusted and allows each process to its maximum effectiveness. If an instrument for X-ray analysis and the determination of the instantaneous process condition within each step quickly, can be installed and utilized, it would be ideal.

To solve this problem, it is necessary to improve the recovery and operating efficiency of all devices as well as determine the equipment optimum operation rate. These synergetic effects can be expected. In addition, it allows the reasonable scheduling operations for establishing a preventive maintenance system to contribute to the reduction of failures.

(3) Others

For the imbalance of equipment problem, the problem is that there is a dispersion in the load for each process, the previous item (2), "conversion to a custom ore system", seems to be one planned solution for use of software. One of elements of this problem solving is also proper regard for hardware to first match it to the ore-supply of each device. For example, it is effective to make the feeding into the grinding system stable and variable by installing constant controlled speeds and to perform the fine adjustment of the quantity of processing ore while seeing that the balance of the whole processes is attained. It is also effective to know the load condition of each process point and equipment by installing a variety of instruments.

6.4 Improvement Plan for Maintenance

To perform the continuous operation in the mill, first of all, it is indispensable to eliminate risk in every aspect of equipment. To do so, it is essential to introduce a positive preventive maintenance system.

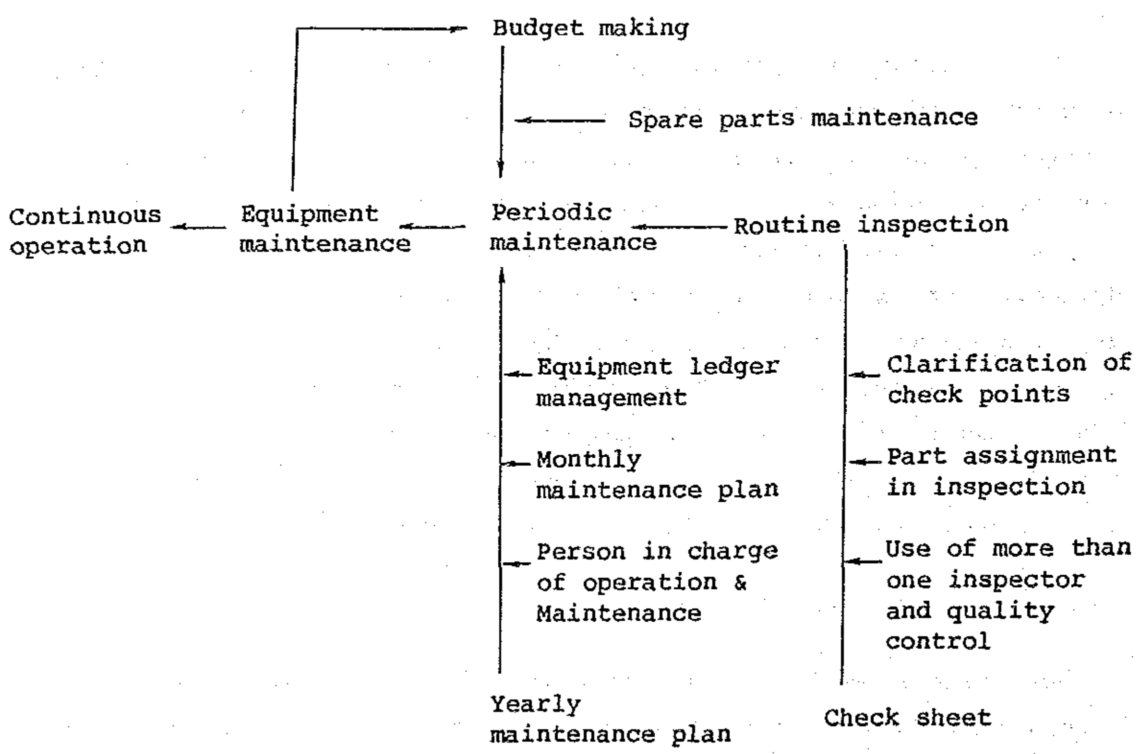
Considering the wide gap between this plan and present maintenance conditions, it would to be difficult to improve the system immediately. However, we would like to propose the following interium improvement plan for maintenance with the hope that the establishment of an ideal maintenance system in the future is be considered.

(1) Summary of the Maintenance System

At present, at each mill, the date for shutdown and maintenance is not formally set, and except during holidays, unless a failure occurs, maintenance of equipment is not done and the operation is continued. In many case, every time a failure occurs, the related equipment and the process is stopped to repair it. That brings about inconvenience and loss of the equipment operation rate.

To improve this, it will be necessary to execute a shutdown and maintenance periodically for peak performance of the operation to the full potential of the equipment.

The graphic display of measures required for the equipment maintenance is as follows:



(2) Planning of a Yearly Maintenance Work

For the main equipment in each process, a yearly maintenance plan is made. This is used to perform inspections of the expendable parts or the like at a proper interval on the basis of the repair records kept from the past. To organize the plan management, it is necessary to prepare a ledger of all pieces of equipment, so as to accumulate data such as their mfgr. specifications, repair records, serial numbers, etc. It is desirable that this ledger be prepared for all equipment being used in the plant, if possible.

Execution of a periodical inspection and maintenance plan for the main equipment to prevent 90 % of all major failures. In addition, this allows for the inventory of special parts for scheduled replacement and additional spare parts prepared in advance, resulting in improvement in every aspect of parts-procurement and resulting in a budget for maintenance cost be intentional and well-balanced for each month.

The equipment ledger will become the basis of the maintenance plan and is effective also for the estimation of the average life of expendable parts, the improvement of areas where frequent failure occurs, or the inventory management of spare parts.

(3) Enforcement of Routine Inspection

The periodical maintenance of main equipment requires technical knowledge and the experience of a person in charge of maintenance. However, it is the strict enforcement of routine inspection that supports this and makes a favorable daily operation possible.

The routine inspection must be practicable without requiring any advanced skill so that the foreman in charge of the operation management or even a worker can do it. In such a practice, it is very effective to prepare and make the most of a checksheet. For the items of the checksheet, such indication that can with certainly check the quality of the end product of the device should be checked, and such terms of expression that state concretely and simply should be used. As an ideal format, one that can be expressed by numerical values is desirable, avoiding to the utmost a format that brings about the personal differences in judgement such as "non-defective/defective" teminology. This data will effectively be used later as the basic information for device failure analysis, the elapsed-time change of a condition, or the improvement of a device or process. Until a variety of measuring instruments are installed, it should be made a rule to record events even if "defective/non-defective" terminology is used for each process and device on the checksheet on the daily report log.

The routine inspection should not be performed by only one specified person in charge. It is important that the observation assignment be made for each shift of the operation, and more than one person perform it with a common judgment reference. All workers need to make an effort for the early discovery of abnormalities by executing a double or triple check. The certain execution of this observation work is not only effective in the maintenance of favorable operation, but also will produce pride and respect for the increased level of each inspector's knowledge on a device and his skill and the enhancement of his concern for the equipment.

(4) Summary

Establishment of a maintenance management system and raised consciousness of workers, not the simple maintenance of the repair system, provides the expectation of an improved effect such as the material study of expendable parts, the improvement in organization, the use of common expendable parts for each device, as well as the enhancement in the entire stability of operation. In general, equipment with a high rate of failure and the reasons for failure are limited. As the records of repaired devices and replaced parts become clearer, areas of concern will become obvious. Repeated study of equipment failure and ideas to improve procedures result in further fulfillment of the total maintenance system and cost reduction, leading to further improvement.

For reference, examples of the maintenance yearly plan table, equipment ledger, daily operation report (checksheet), etc. are appended (see Table 6.4.1 to 6.4.4).

6.5 Improvement in Maquila and Ore-Purchasing System

To solve problems in the present condition, the following improvement plan is suggested:

(1) All Ore-Purchasing System

In this system, ore is tested for quantity and grade at the time of acceptance (crushing process), and the price for the ore calculated under a standard price sheet is paid to each mine. The conditions for the price should be very specific and simplified.

(2) Processing System

Whether the ore in each mine is processed in a mixed state or singly (without being mixed) should be selected freely according to the circumstances at the time. In either case, it is not necessary to individually distinguish ore or its component products (concentrate) for each mine (the continuous operation is possible), and great recovery and cost reduction can be expected.

(3) Fundamental Beneficiation Results (Annual Production Plan)

On the assumption that ore in each mine is processed in a mixed state, or continuously and as a whole, the annual production plan is made, while on the basis of the operational results in the past and the test results of mineral processing in the lab, a monthly average result of mineral processing is established. This result is desirable to be put together as a whole in a unit of mill. However, it is also possible to set up different results according to the number of ore types.

(4) Price for Metal

For the metal paid by the refinery for each refining, the overall recovery rate is calculated by the refining recovery factor and on the ore-sale conditions for refining multiplied by the beneficiation recovery rate, which is decided according to the actual results of the production plan.

Each metal contained in ore is bought based on this overall recovery rate. For the official quotation of metal, the international market price at the time of buying is used.

(5) Lower Limit Grade for Crude Ore

The lower limit grade for crude ore is set up for each metal to make the metal with ingredients lower than this grade unsalable.

(6) Beneficiation Cost

All the expenses accruing at the mill such as mineral processing operating cost, overhead cost, and depreciation expenses are included in the estimate as the mineral processing cost and deducted from the total metal price. In this case, the same amount of money per ton for ore in each mine is equally deducted.

(7) Concentrate Selling Expense, Refining T/C and R/C

Since T/C and R/C according to the concentrate marketing expense and the refining condition vary in proportion to the grades of lead, copper, zinc, etc. contained in crude ore, these costs should be deducted from the price for each metal from a proportional calculation of them based on the crude ore grades in the production plan.

(8) Refining Penalty

Since the refining penalty per ton (ore) is small, the fixed amount of money in terms of US$0.1 is used based on the actual result. After it is added equally to the mineral processing cost, this is deducted from the price for the metal.

(9) Income and Cost of Mill

When ore is bought in this custom ore condition, if the same operating result as in the production plan is achieved, the income and costs of the mill becomes nearly zero. Actually, however, the difference between the actual operating result and the production plan accrues as the margin or loss from the difference, so the balance should vary.

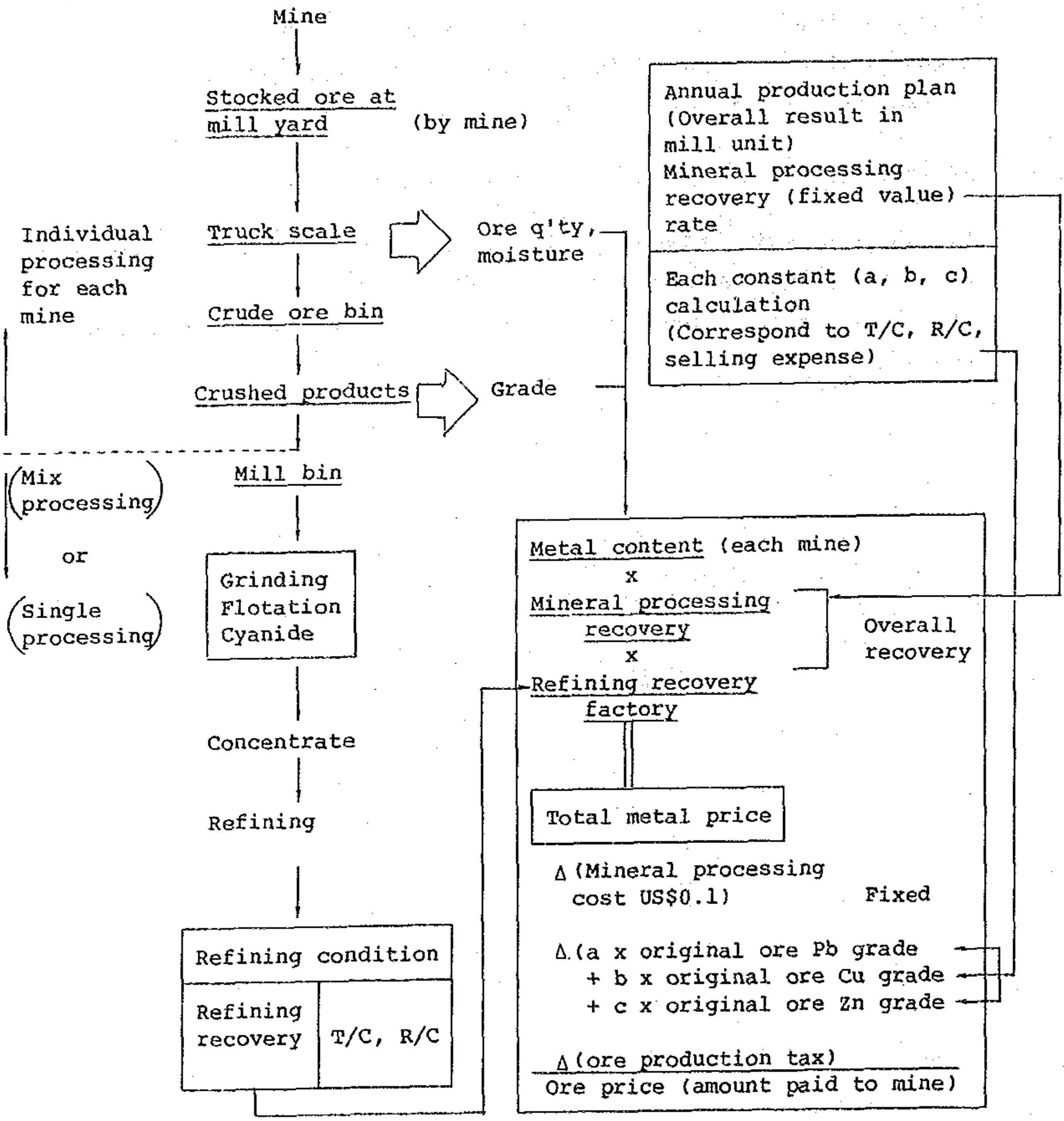
(10) Restudy of Condition

It is necessary that the annual production plan and an estimate of the mineral processing costs be revised every year based on the actual result during the previous year, and that on the basis of those figures, the condition of the mineral processing recovery rate or the mineral processing cost be readjusted as necessary.

(11) *Individual Condition for Difficult-in-Processing Ore*

For the ore that is extremely low in the mineral processing recovery and difficult to process, as an exception, after discussion with the individual owner of the mine, a single custom ore condition should be set up.

Ore-buying procedure and calculation method
of ore price in improvement plan



(Δ :means minus)

Example: Ore price calculation
(Refer to Chapter 8.5, Extension Plan in Barones Mill, "Calculation of Price for Custom Ore")

6.6 Rationalization of Administrative Department

When improvement of management in each mill is carried out, one of the important factors is business rationalization.

It is an indispensable that condition be based on the operation. In this case, however, it is necessary to restudy the working environment that make up the business contents to provide management, the operations manager, or employees with rapid and timely information.

The result of our examination on the 3 mills was that all of the mills routinely make irresponsible operating decisions without making up a budget. Although some computers have been installed, the practical use of them is still inadequant. In view of this condition, points of improvement should be drastic budget & result orientated controls and the effective use of computers.

1. Budget and Result Orientated Controls

(1) Budget Preparation

The annual or half-year budget (in units of monthly amounts of money) is drawn up for each mill. Points to be noted in the budget making process are described later based on both documentation prepared and procedures set up on how to prepare those documents.

a. Raw material-purchasing budget
Various raw material are purchased from many mines, but as grade varies and quantity purchased from each mine changes, the budget including the time frame for purchasing is made.

b. Processing plan
Considering types of processing, mix or custom, should be determined according to the raw material-purchasing budget, or the considerations for major variation in factors of operation such as the equipment maintenance due to a shutdown, should be incorporated when planning the budget.

The cost control unit is set up for each administrative organization to compute the processing costs corresponding to its processing plan.

Based on the above items, the budget for income and cost is made.

c. Budget for administrative and auxiliary departments

The cost budget is made up for each department such as the administration, analysis, ore-acceptance,etc.

d. Budget for overall income and costs

Based on the income calculated from item b, this budget is assembled, to which the costs of items b and c are allocated.

e. Personnel plan

f. Fund plan

(2) Operation

At present, C.F.M., which is controlled by a centralized control system from the head office, the updated feedback control to each mill is impossible. Therefore, it should be required that the documentation on budget and actual results be prepared at the accounting department at each mill, they should be compared and analyzed in each mill, and if the results are lower than the budget, measures devised are prepared on a monthy basis. In this case, it is also desirable that related documents be sent to the head office to receive their approval and instructions.

(3) Measures to Execute Budget and Result Oriented Controls

At present, the number of persons in charge of administration in each mill is not sufficient in either quantity or quality.

To implement this, the installation of computers for making a variety of ledgers and their effective use are suggested.

2. Installation of Computers and their Effective Use

With the installation of computers and making effective use of them, the following are described later from the aspect of their installation effect: Determination for the replacement of the current work with the computer, selection of the items to be computerized in new work (the budget, results of control ledger), operation of them, calculation of installation expense, etc.

(1) Replacement of Current Work with the Computer

a. Statement for concentrate sales
b. Statement for custom crude ore
c. Receipt and payment statements for ore and concentrate
d. Receipt and payment statements for stock
e. Statement of salary
f. Fixed assets ledger
g. Statement of depreciation expense

(2) Items to be computerized in the new work

a. Budget comparison table by element
(Refer to the document separately appended)
b. Income statement

(3) Operation

In the same way as pointed out in the flow chart for business rationalization separately appended, the "key-in" is made based on data from the side of on-site accounting. On the basic of the primary ledger outputed, the data required for the comparison table between the budget and results by each element, product receipt and payment ledger, and income statement is reentered. Since it is expensive to prepare a variety of ledgers in total with only the initial data input, existing software is to be used.

7. ECONOMIC EVALUATION OF CURRENT STATE

The Mexican government has set forth the rapid elimination of deficits in its state-operated enterprises for balancing income and expenditure as one of the most crucial policies.

However, it is clear that the existence of CFM's beneficiation plants should not only be evaluated in terms of profitability. Because such plants shoulder very important responsibilities for encouraging medium and small mines and for generating other economic activities and promoting employment in those relevant regions.

In this economic evaluation, for each beneficiation plant, we have shown contents of net sales and sales costs, outline and general economic indices of sale's profit, administrative expenses, selling expenses and ordinary profit, and lastly to obtain break-even points and marginal safety factors by calculating the ratio of variable costs to the total amount of costs.

For both Guanacevi and Borones beneficiation plants, which are operating with deficits, we have some descriptions concerning the extent of income increase or expense reduction which both plants must attain to balance the income and expenditure.

At CFM's beneficiation plants, unified report forms are used for financial statements and monthly reports are submitted to the head office on the same forms as a rule. For profit and loss, only sales P/L is submitted and no production P/L is prepared. The treated ore (raw material) volume is obtained in the P/L calculation only from the difference between stock volumes at the beginning and end of the term. Accordingly, the connection between the operation (production) and P/L calculation is very obscure and difficult to seize. In fact, even if sales are booked by product, sales volume by product cannot be obtained from economic materials. Since sales costs have not been classified by product, it is not possible to analyze the profitability in comparison between maquila system and the ore-purchasing operation or the advantage compared between sulfide ore (for floatation) and oxide ore (for cyanidation).

CFM has not performed the revaluation of each plant's assets. With the recent severe inflation in Mexico (1986: 105.7%, 1987: 159.1% and 1988: 51.7%) taken into consideration, even management indices such as the turnover ratio of total liabilities and net worth; the ratio of recurring profit to total liabilities and net worth, which are normally obtained from the balance sheet and used for business analyses of companies, seem to be somewhat vague. In this connection, these management indices were not considered to be very necessary considering the true purposes of this study. Therefore, we have decided to make this economic evaluation chiefly on the basis of the profit and loss statement. In addition, we have come to make no comparison of the profit and loss statement by fiscal year, and performed analysis chiefly on the basis of the newest materials for the first half (January to June) of 1989.

7.1 Parral Beneficiation Plant

Except for the fact that no revaluation of assets has been performed, this plant is operated very soundly and no important problems exist.

(1) Sales

In 1988, the plant attained sales of 7,303 million pesos, in which those of lead concentrates (5,879 million pesos: 80.51%) and Ag precipi-tates (1,195 million pesos: 16.37%) accounted for about 97% of the total. The remainder is sales of zinc concentrates, high grade non-treated ore, and the maquila fees. (See Table 7.1.2)

In the first half of 1989, the total sales were 4,652 million pesos, in which those of lead concentrates (3,463 million pesos: 74.45%) and Ag precipitates (1,044 million pesos: 22.45) accounted, as in the preceding year, for almost 97% of the total. (See Table 7.1.6.)

The concentrates and Ag precipitates are products obtained by treating the ore which has been purchased from mine owners. Since the treated ore volume was 85,670 tons in 1988 and 38,465 tons in the first half of 1989, sales per ton of treated ore were 85,241 pesos and 120,932 pesos respectively, showing very high levels (about 2.3 times the figures of Barones Beneficiation Plant). This shows that the benefi-ciation recovery rate is high (high grade of ore raises the recovery).

(2) Sales Costs

a) Raw Material Cost (Ore Purchasing Expenses) (See Tables 7.1.3 and 7.1.7)

This cost was 4,915 million pesos (57,367 pesos/ton) in 1988 and 3,329 million pesos (86,555 pesos/ton) in the first half of 1989. The cost accounted for 73% and 77% of the total sales costs, and for 67% and 72% of the total sales, respectively. The fact that the raw material cost per ton of treated ore is almost double the same cost of Barones Beneficiation Plant, shows that the grade of purchased ore is higher.

Ore-purchasing conditions are as follows:

- o The settlement of ore prices is performed following the confirmation of actual recovery after beneficiation. (See the progress report.)
- o The beneficiation fee to be deducted from ore prices is set at US 13 dollars/ton (slightly more than 30,000 pesos/ton based on the exchange rate at the time of this survey).

b) Operating Costs (See Tables 7.1.3, 7.1.4, 7.1.7 and 7.1.8.)

The costs consist of direct and indirect costs and depreciation expense.

The direct costs are classified into personnel expense, material costs, the cost of electric power, and others.

The operating costs in 1988 were 1,806 million pesos (21,080 pesos/ton of treated ore), which consisted of direct costs of 1,595 million pesos (88.3%), indirect costs of 189 million pesos (10.5%), and depreciation expenses of 22 million pesos (1.2%). The costs in the first half of 1989 were 988 million pesos (25,683 pesos/ton of treated ore), which consisted of direct costs of 904 million pesos (91.5%), indirect costs of 68 million pesos (6.9%), and depreciation expense of 16 million pesos (1.6%).

In 1988 and the first half of 1989, shares of personnel expenses, material costs, and the cost of electric power were 30% (28%), 44% (43%) and 25% (28%) respectively without considerable yearly change (showing figures for the first half of 1989 in parentheses).

At all CFM's beneficiation plants, the following unified depreciation rates are applied and the depreciation is satisfactorily carried out.

Vehicles	20.00% (5 years)
Machinery and equipment	10.00% (10 years)
Furniture and instruments	10.00% (")
Buildings and structures	6.67% (15 years)
Test and research facilities	6.67% (")

As mentioned at the beginning of this item, however, no revaluation of assets has been performed despite the experience of very severe inflation, so that the amount of depreciation has decreased exceedingly. This fact seems to have really caused the equipment at each beneficiation plant to become very superannuated without proper maintenance and improvement carried out and that the operational rate and beneficiation recovery rates have declined. If a more critical cost controls can be put into practice, it would be possible to perform correct depreciation and completion of the maintenance and improvement of equipment, as far as Parral Beneficiation Plant is concerned.

(3) Sales Profit (See Tables 7.1.1 and 7.1.5)

The operating profit was 582 million pesos in 1988 and 334 million pesos in the first half of 1989. The profit per ton of treated ore was 6,794 pesos and 8,693 pesos in both periods respectively.

The ratio of sales profit to sales was 7.8% and 7.2% in both periods respectively, almost the same. (see Table 8.1.9.)

(4) Administrative Expenses and Selling Expenses (See Tables 7.1.1 and 7.1.5.)

The expenses in 1988 and the first half of 1989 were respectively 214 million pesos and 127 million pesos for administrative expenses, and 160 million pesos and 17 million pesos for selling expenses. The ratio of selling expenses to sales was 5.1% and 3.1% in both periods respectively. Selling expenses per employee were 4,738 thousand pesos/ person/year and 3,649 thousand pesos/person/year (amount in a term x 2). (See Table 7.1.9.)

(5) Operating Profit and Recurring Profit (See Tables 7.1.1 and 7.1.5)

Achievements in 1988 and the first half of 1989 were respectively 208 million pesos and 190 million pesos for operating profit, and 256 million pesos and 201 million pesos for recurring profit. The ratio of recurring profit to sales was 3.5% in 1988 and 4.32% in the first half of 1989.

In the first half of 1989, the recurring profit was 2,546 thousand pesos/employee and 5,228 pesos/ton of treated ore. (See Table 7.1.9.)

(6) Break-Even Point

In order to find the break-even point, we classified the total costs in the first half of 1989 into variable and fixed costs on the basis of the following:

(i) All expenses for ore purchasing are deemed as variable cost.

(ii) The ratio of the totaled overtime pay and holiday-service pay to personnel expenses is calculated first. Direct and indirect costs and the personnel expenses in administrative expenses which are divided proportionally to the ratio (26.1%) are deemed as variable cost.

(iii) Travelling expense, vehicle maintenance expense, and gasoline and lubricating oil expenses among indirect costs are deemed as variable cost.

(iv) Travelling and vehicle maintenance expenses among administrative expenses are deemed as variable cost.

(v) Selling expenses are all deemed as variable cost.

As a result of the above classification, the total costs of 4,461 million pesos are divided into the fixed costs of 364 million pesos (8.17%) and variable costs of 4,097 million pesos (91.83%). Based on these results, the following figures have been calculated:

Rate of variable costs	88.08%
Marginal profit	555 million pesos
Marginal profit rate	11.92%
Break-even rate of sales	3,139 million pesos
Break-even rate	67.48%

7) Conclusion

The break-even rate means that even the decrease in current sales at the rate of 32.52% does not cause deficit, and the state of business operation is still very stable under the present conditions. However, room is left for making an effort further to improve income and expenditure in such manners as the reduction of employees, cost of electric power and material costs. Accordingly, if more reasonable management makes it possible to take steps such as a stable beneficiation fee for a certain period, the plant will contribute to the encouragement of the regional mining industry.

7.2 Guanacevi Beneficiation Plant

This plant performs maquila beneficiation alone and has been operating with a deficit except for 1984 and 1987. With mining potential of surrounding medium and small mines taken into consideration, there is anticipation of a shortage of necessary ore volume. For the continuance of its own operation, to say nothing of the considerable improvement in income and expenditure that can be achieved, the prospecting in the surrounding area is necessary and indispensable.

(1) Sales (See Tables 7.2.2 and 7.2.6.)

Sales were 1,564 million pesos in 1988 and 1,231 million pesos in the first half of 1989. They may be all considered as maquila fees (14,000 pesos/ton in 1988 and 30,000 pesos/ton in 1989) although the sales include those of machines and parts in very small amount. Since the treated ore volume was 111,347 tons in 1988 and 45,689 tons in the first half of 1989, sales per ton of treated ore were 14,000 pesos and 26,941 pesos respectively. (See Table 7.2.9.) (The reason why sales were less on per-ton basis in 1989, than the maquila fee was that a part of the treated ore was received before the raise of the fee and that the amount 22,000 pesos/ton was applied as a transitional step.) The treated ore volume had decreased at the annual rate of about 18%.

When the maquila fee was changed to the current amount on January 9, 1989, the party which bears the conveying expense at the plant (from the stockyard to crushers) was switched from mine owner to the plant. Products are bulk concentrates only and are all returned to a relevant mine owner.

(2) Sales Costs (See Tables 7.2.3, 7.2,4, 7.2.7, 7.2.8 and 7.2.9.)

a) Raw Material Cost (Ore Purchasing Expenses)
Since the entire ore is beneficated in maquila system, no raw material cost occurs.

b) Operating Costs

As at the Parral Beneficiation Plant, the costs consist of direct and indirect costs and depreciation expense. The direct costs are classified into personnel expenses, material costs, and the cost of electric power.

The operating costs in 1988 were 1,961 million pesos, which consisted of direct costs of 1,364 million pesos (69.6%), indirect costs of 565 million pesos (28.8%), and depreciation expenses of 20 million pesos (1.6%). Those in the first half of 1989 were 1,280 million pesos, which were composed of direct costs of 905 million pesos (71.1%), indirect costs of 354 million pesos (27.3%), and depreciation expense of 20 million pesos (1.6%), each share being almost the same as that in 1988.

In 1988 and the first half of 1989, shares of personnel expenses, material costs, and the cost of electric power in direct costs were 27% (21%), 50% (56%) and 23% (23%) respectively (showing figures for the first half of 1989 in parentheses).
In the latter period, operating costs per ton of treated ore were 28,000 pesos, increasing at the expensive rate of 10%, in the absolute amount, than those of Parral Beneficiation Plant. However, considering that the Guanacevi plant performs only the flotation treatment and does not operate a cyanide process, whose treating costs are more expensive, the above operating cost can be deemed as very high. In particular, the share of material costs is exceedingly high and also shows a considerably greater increase over the preceding year.

Since the plant performs maquila beneficiation only, it cannot carry out the mixed treatment of ore and must control and beneficiate ore by lot (mine). This has come to cause high costs and the decline of its operation rate.

In comparison with the nominal capacity of 600 ton/day or 108,000 ton/term, the treated ore volume of 45,689 tons in the first half of 1989 is far smaller and the operation rate of 42.3% is very low. The number of employees (96 persons) is also considered to be excessive.

Matters concerning the depreciation expense are as mentioned in the section of Parral Beneficiation Plant, and its share in the operation costs shows almost the same figure as that of the above plant. In the current state, no room is left for performing depreciation on the basis of revaluated assets.

(3) Sales Profit and Loss (See Tables 7.2.1 and 7.2.5.)

The plant already has a deficit at this accounting stage. The amount of loss was 401 million pesos in 1988 and 49 million pesos in the first half of 1989. The considerable decrease in the loss amount compared with that of the preceding year is due to the improvement in maquila fee (raised from 14,000 pesos/ton to 30,000 pesos/ton) which began in January, 1989. The fact that it could not go into surplus operation despite a doubling of sales due to the raise of the fee, shows how costs increased during that period. Also during that period, operation costs per ton rose from 17,607 pesos to 28,008 pesos and the total costs including general administrative expenses per ton rose from 19,458 peso to 30,602 peso.

(4) Administrative Expenses and Selling Expenses (See Tables 7.2.1, 7.2.5 and 7.2.9.)

No selling expenses occur because the plant performs the maquila beneficiation only and returns all products to mine owners.

Administrative expenses were 201 million peso in 1988 and 118 million pesos in the first half of 1989. The ratio of administrative expenses to sales did not change at 9.6% in both periods. Administrative expenses per employee were 2,098 thousand pesos/person/year and 2,465 thousand pesos/person/year.

(5) Operating and Recurring Profit and Loss (See Tables 7.2.1, 7.2.5 and 7.2.9.)

In 1988, operating and recurring losses were 603 million pesos and 366 million pesos respectively. The reason why the recurring loss fell below the operating loss was that the plant obtained non-recurring income of 237 million pesos as consignment analysis and investigation fees.

In the first half of 1989, operating and recurring losses were 167 million pesos and 174 million pesos. The ratio of recurring profit to sales was minus 14.16% in this period. In addition, the recurring loss was 1,816 thousand pesos/employee and 3,815 pesos/ton (treated ore).

(6) Break-Even Point (See Tables 7.2.10 and 7.2.11.)

Using the same method as that in the case of Parral Beneficiation Plant, we classified the total costs in the first half of 1989 into variable and fixed costs on the basis of the following:

(i) The ratio of the totaled overtime pay and holiday-service pay to personnel expenses is calculated first. The portion of personnel expenses in direct and indirect costs and in general administrative expenses, which is divided proportionally to the ratio (29.58%), is deemed as variable costs.

(ii) Travelling expense, vehicle maintenance expense, and gasoline and lubricating oil expenses along with indirect costs are deemed as variable costs.

(iii) Travelling and vehicle maintenance expenses among administrative expenses are deemed as variable costs.

As a result of the above classification, the total costs of 1,398 million pesos are divided into fixed costs of 508 million pesos (36.31%) and the variable costs of 891 million pesos (63.69%).
Based on these results, the following figures have been calculated:

Rate of variable costs	72.35%
Marginal profit	340 million peso
Marginal profit rate	27.65%
Break-even rate of sales	1,836 million pesos
Break-even rate	149.16%

(7) Conclusion

In the current level of the cost, income and expenditure will not balance unless the current sales of 1,231 million pesos are increased to 1,836 million pesos or at the rate of about 50%.

In order to obtain break-even rate of sales (1,836 million pesos), the maquila fee must be raised to 40,200 pesos/ton (a 67% increase) if the current treated ore volume (45,689 tons/term) is not changed, or alternatively the treated ore volume needs to be increased to 61,200 tons/term (a 34% increase) if the fee is kept at current levels. In the light of the mining potential for this area is limited and the treat-able ore volume will probably decrease in the future, each of the above ideas is overly optimistic. Accordingly, except for cost reductions by streamlining operations, no measures for improving income and expenditure were conceived.

In order to attain balance of income and expenditure at current levels of income, the operation needs to be drastically streamlined by, for example, reducing the total amount (718 million pesos) of material costs (sales costs plus administrative costs) at the rate of 14% (196 million pesos). In this case, recurring profit of about 21 million pesos would be obtained.

7.3 Barones Beneficiation Plant

This plant has been obliged to continue operation with considerable deficit every year, and has the most difficult problems among the three beneficiation plants which we visited. For eliminating the deficit, the plant must increase income by raising the maquila fee and at the same time, reduce operating costs. However, in this area alone, a revision of maquila fee was not applied in January, 1989.

Since surrounding small mine-owners are politically powerful, the revision here has come into political problems, which make economic viewpoints more difficult to institute.

(1) Sales (See Tables 7.3.2, 7.3.6 and 7.3.9.)

In 1988, the plant attained sales of 3,728 million pesos, which consisted of 499 million pesos (13,38%) for maquila fee, 1,477 million pesos (39.63%) for lead concentrates, and 1,647 million pesos (44.17%) for Ag presipitates. These three items covered 97% or more of the total sales. The remainder is covered by zinc concentrates (44 million pesos: 1.19%), copper concentrates (21 million pesos: 0.57%), and machines and parts (40 million pesos: 1.06%).

In the first half of 1989, the total sales were 1,761 million pesos, which were covered by the maquila fee (449 million pesos: 25.48%), lead concentrates (253 million pesos: 14.38%), and Ag precipitates (1,059 million pesos: 60.14%). No sales of zinc and copper concentrates, machines, and parts were recorded, on the other hand, sales of Ag prepitates and maquila fee increased exceedingly.

For the maquila beneficiation, only the flotation (nominal capacity. 250 ton/day) of sulfide ore is performed to obtain the maquila fee of 16,500 pesos/ton. In the first half of 1989, the fee was 15,106 pesos/ton on average. The difference of 9,906 pesos/ton between the average fee and actual beneficiation cost (operating cost) of 25,012 pesos/ton constitutes a loss in the consignment beneficiation.

The concentrates and Ag precipitates are products obtained by treating the ore which has been purchased from mine owners. Sales of such products were 53,266 pesos/ton (purchased ore), less than half the sales of 120,932 pesos/ton at Parral Beneficiation Plant. (When the raw material cost per ton is deducted from the sales per ton of treated ores, only the amount of 8,663 pesos/ton remains, and the difference between this amount and the operating cost of 25,012 pesos/ton constitutes the loss of 16,349 pesos/ton due to ore purchasing.)

(2) Sales Costs (See Tables 7.3.3, 7.3,4, 7.3.7 and 7.3.8.)

a) Raw Material Cost (Ore Purchasing Expenses)
The ore purchased is only oxide ore for cyaniding treatment. Samples extracted at the time of receiving ore and those obtained at the stockyard are mixed and analyzed to calculate recovery. On the basis of this recovery, the advance payment for the ore price is made. (The amount to be paid in advance is limited to 60% of the figure calculated by the expression "ore price x recovery".)

In the actual beneficiation process, samples are extracted from crushed ore and undergo analysis and test again to decide the final recovery. The ore price is settled on the basis of the recovery, and the beneficiation fee to be deducted from the ore price is 17,500 pesos/ton.

The recovery decided in this process is the figure calculated on the basis of beneficiation tests and is not based on actual operation results. This differs greatly from the case of Parral Beneficiation Plant. The actual recovery is considerably less than the figure obtained from the beneficiation tests and the loss based on the difference of recovery is borne by the plant.

The beneficiation fee of 17,500 pesos/ton (beneficiation cost, 17,000 pesos/ton + ore-handling charge, 500 pesos/ton), which is deducted from ore prices, is considerably less than the actual operating cost for the treated ore of 25,012 pesos/ton.

The raw material cost was 2,251 million pesos (28,209 pesos/ton) in 1988 and 1,099 million pesos (44,603 pesos/ton) in the first half of 1989. The cost accounted for 51.12% and 44.69% of the total sales costs, and for 60.39% and 62.40% of the total sales respectively. Since the plant is run at such a large deficit, the ratio of sales exceeds that of sales costs.

b) Operating Costs

Like other beneficiations plants, the costs consist of direct and indirect costs and depreciation expense. The direct costs are classified into personnel expenses, material costs, and the cost of electric power.

The operating costs in 1988 were 2,182 million pesos (17,188 pesos/ton), which consisted of direct costs of 1,795 million pesos 82.29%), indirect costs of 373 million pesos (17.10%), and depreciation expense of 13 million pesos (0.61%). The costs in the first half of 1989 were 1,359 million pesos (25,012 pesos/ton), which were composed of direct costs of 1,119 million pesos (82.30%), indirect costs of 228 million pesos (16.80%), and depreciation expense of 12 million pesos (0.90%).

In 1988 and the first half of 1989, shares of personnel expenses, material costs, and the cost of electric power in direct costs were 27,95% (26.66%), 46.84% (48.50%) and 25.21% (24.84%) respectively (showing figures for the first half of 1989 in parentheses).

The depreciation expense is exceedingly less than those of the other two plants.

(3) Sales Profit and Loss (See Table 7.3.1, 7.3.5 and 7.3.9.)

The plant already has a deficit at this accounting stage. The amount of loss was 676 million pesos in 1988 and 698 million pesos in the first half of 1989. The operating loss per ton of treated ore was 5,326 pesos in 1988 and as much as 12,841 pesos in the first half of 1989. In this period also, the loss per employee exceeded 5,700 thousand pesos and the ratio of sales profit to sales was 39.63%.

The large amount of deficit has been caused by the fact that both the beneficiation fee to be deducted from ore prices in the ore purchasing system and maquila fee received from mine owners have been limited to a very low amount. The operating costs per employee (11,140 thousand pesos), those per ton of treated ore (25,012 pesos), and tonnage of treated ore per employee (445 tons) are almost the same as those of Parral Beneficiation Plant, and figures in terms of costs are actually lower.

(4) Administrative Expense and Selling Expenses (See Tables 7.3.1, 7.3.5 and 7.3.9.)

In 1988 and the first half of 1989, administrative expenses were 178 million pesos and 106 million pesos, and selling expenses were 306 million pesos and 71 million pesos, respectively. The ratio of administrative and selling expenses to sales was 12.98% and 10.07% respectively, and those expenses per employee were 3,966 thousand pesos/ person/ year and 2,907 thousand pesos/person/year. In comparison with Parral Beneficiation Plant, these amounts are lower, but he ratio is higher. This is because of lower sales at this plant.

(5) Operating and Recurring Profit and Loss (See Tables 7.3.1, 7.3.5 and 7.3.9.)

In 1988 and the first half of 1989, the operating losses were 1,160 million pesos and 875 million pesos respectively, while the recurring loss was 1,109 million pesos and 858 million peso, respectively. In the latter period, the ratio of recurring profit to sales, recurring loss per employee and the loss per ton (treated ore) were minus 48.75%, 7,037 thousand pesos and 15,799 pesos.

(6) Break-Even Point (See Tables 7.3.10 and 7.3.11.)

In order to find the break-even point, we classified the total costs in the first half of 1989 into variable and fixed costs on the basis of the following:

(i) All expenses for purchasing ore to be treated are deemed as variable costs.

(ii) The ratio of the totaled overtime pay and holiday - service pay to personnel expenses is calculated first. The portion of personnel expenses in direct and indirect costs and in administrative expenses, which is divided proportionally to the ratio (34.85%), is deemed as variable costs.

(iii) Traveling expense, vehicle maintenance expense, and gasoline and lubricating oil expenses are among indirect costs and as such are deemed variable costs.

(iv) Travelling expense, vehicle maintenance expense, and gasoline and lubricating oil expenses among general administrative expenses are deemed as variable costs.

(v) Selling expenses are all deemed as variable costs.

As a result of the above classifications, the total costs of 2,636 million pesos are divided into the fixed costs of 465 million pesos (17.63%) and the variable costs of 2,171 million pesos (82.37%).

Based on these results, the following figures have been calculated:

Rate of variable costs	123.30%
Marginal profit	minus 410 million pesos
Marginal profit rate	minus 23.30%

Since the variable costs exceed sales, the break-even point cannot be calculated.

a) Trial Calculation Based on Assumption

Under the current conditions, in order to balance income and expenditure with each other at the sales profit and loss stage, operating costs need to be reduced by 51%. Also, for balancing ordinary income and expenditure with each other, the total costs excluding raw material cost (operating costs + general administrative and distribution cost) must be reduced by 56%.

On the other hand, in order to attain a balance between income and expenditure with costs kept at present conditions, the maquila and beneficiation fee need to be raised to 32,500 pesos/ton (a 86% increase).

Each of these ideas would be almost impossible to implement. Therefore, on the assumption that the same maquila and beneficiation fee of 30,000 pesos/ton as those available at other CFM's beneficiation plants is accepted by the miners, we have prepared a profit and loss statement with revisions as follows:

1) Among sales, the income due to maquila fee is to be calculated as "treated ore volume x 30,000 peso/ton"
2) Among production costs, consignment beneficiation fee to be deduced from purchased ore prices is to be calculated as "purchased ore volume x 30,000 pesos/ton".

In the profit and loss statement based on the above assumption, the deficit of 108 million pesos still occurs at the ordinary income and expenditure stage, though some sales profit is obtained.

According to our trial calculation, however, the 5 to 6% reduction of operating costs will enable the income and expenditure to be balanced. The cost reduction to this extent is deemed possible if the streamlining steps are taken as mentioned in the section for modernization of beneficiation plants.

7) Conclusion

The operating costs per ton of treated ore (25,012 pesos) and those per employee (11,140 thousand pesos/term) of this plant are lower than both figures of Parral and Guanacevi beneficiation plants, and many points of further improvement remain. However, the deficit at this plant is not due to high costs. Its real cause lies in the fact that the maquila fee and purchased ore beneficiation fee are limited to levels which are considerably different from the actual beneficiation costs (operating costs). Since the maquila fee is limited, the low grade ore which is difficult to treat is sent to this plant in great quantity. The plant cannot raise its recovery rate in the beneficiation process because of superannuated equipment for one example. As a result, the proposal for raising the beneficiation fee is not accepted by mine owners. These conditions seem to have formed a vicious circle.

No measured to improve the state of income and expenditure might be found unless the same large-scale streamlining steps as those proposed for the Guarancevi Beneficiation Plant are taken decidedly and the beneficiation fee is raised in some way. However, in order to obtain the mine owners' consent for a raise of beneficiation fee, it is indispensable to perform a great renovation such as eliminating useless operations and also improving the recovery rate by constructing a model beneficiation plant equipped with modern equipment. El Bote Beneficiation Plant (the privateuse plant of El Bote Mine under direct management of CFM), which is located near this plant, performs maquila beneficiation also, and grains profit by receiving a maquila fee of nearly 30,000 pesos/ton. If Barones Beneficiation Plant cannot receive the fee of this amount, it would be one good idea for the plant to leave maquila beneficiation entirely to the El Bote plant, and to concentrate its efforts on the ore-purchasing system using the recommended modern flotation equipment.

8. MODERNIZATION PLAN OF BENEFICIATION PLANTS

8.1 Outline

The following four plans for modernization of beneficiation plants were developed:

a) Modernization of the existing facilities of Parral Beneficiation Plant

b) Modernization of the existing facilities of Guanacevi Beneficiation Plant

c) Modernization of the existing facilities of Barones Beneficiation Plant

d) Plan for the establishment of a new beneficiation plant in Barones

8.1.1 Beneficiation Capacity and Grade

For Parral and Guanacevi Beneficiation Plants, only modernization of existing facilities was planned, leaving the beneficiation capacity at the present level of 6,400 t/month and 7,800 t/month, respectively. As for Barones Beneficiation Plant, establishment of a new plant of a capacity of 3,900 t/month, as well as modernization of existing facilities was planned to raise the total capacity from the present level of 9,100 t/month to 13,000 t/month. The grade of the ore processed in Parral and Guanacevi Beneficiation Plants will be kept the same as the present grade, while the grade of the Ag ore processed in the newly built beneficiation plant in Barones is set about 15 g/t higher.

<u>Beneficiation Capacity and Grade</u>

	Beneficiation capacity t/month	Grade				
		Au g/t	Ag g/t	Pb %	Cu %	Zn %
Parral	6,411	0.74	325	0.6	-	0.2
Guanacevi	7,751	1.45	235	-	-	-
Barones (total)	12,956	0.57	170	0.2	0.1	0.5
Existing Facilities	9,056	0.47	175	-	-	-
New Plant	3,900	0.80	160	0.8	0.4	1.6
Barones (current) (actual record in 1989)	9,056	0.46	155	0.3	0.1	0.5

8.1.2 Outline of the Modernization Plan for Existing Facilities of Parral Beneficiation Plant

Table 8.1.1 shows the outline of the modernization plans for the existing facilities of the three beneficiation plants.

The modernization plan for Parral Beneficiation Plant includes improvement of the dust collecting system to collect dust from the grinding plant, instrumentation to help stabilize operation, renewal of worn-out ball mills, and rationalization of the administration section to save labor. The total facility investment will be 1,493,000,000 pesos (US$563,000).

Carrying out modernization will result in a saving of about 5,100 pesos per ton of crude ore owing to improvements in the recovery rate for each kind of metal by 2 to 3%, and about 700 pesos per ton of crude ore owing to a reduction in sodium cyanide consumption.

The total depreciation and the interest will be about 2,300 pesos per ton of crude ore. Consequently, the balance will be about 3,500 pesos per ton of crude ore, the investment efficiency being 18.3% in ARR and 5.5 years in PB.

8.1.3 Outline of the Modernization Plan for existing Facilities of Guanacevi Beneficiation Plant

The modernization plan for Guanacevi Beneficiation Plant involves the improvement of the grinding facilities to stabilize operation and save energy, rationalization and integration of the flotation system to save energy, development of the reagent facilities to stabilize operation and reduce the amount of reagents to be used, installation of a filter press to reduce the cost of concentrate dehydration and drying, and rationalization of the administration section to save labor. The total facility investment will be about 810,000,000 pesos (US$306,000).

The execution of modernization will result in a saving of about 3,500 pesos per ton of crude ore owing to improvements in the recovery rates for Au and Ag by about 2%, and about 2,700 pesos per ton of crude ore owing to energy saving.

The total depreciation and interest will be about 1,000 pesos per ton of crude ore. Consequently, the balance will be about 5,200 pesos per ton of crude ore, the investment efficiency being 59.2% in ARR and 1.7 years in PB.

8.1.4 Outline of the Modernization Plan of Existing Facilities of Barones Beneficiation Plant

The modernization plan of existing facilities of Barones Beneficiation Plant involves system improvement employing the flotation-cyanidation straight processing method, in which a mixture of oxidized ore and sulfudized ore can be handled, instrumentation to stabilize operation and save labor, and rationalization of the administration section to save labor. The total facility investment will be about 612,000,000 pesos (US$231,000).

The execution of modernization will result in saving of about 3,000 pesos per ton of crude ore owing to improvements in the recovery rates for Au and Ag by 2% and 4% respectively, and about 1,200 pesos per ton of crude ore owing to a cut in the number of workers in the existing plant by 21.

The total depreciation and interest will be about 700 pesos per ton of crude ore. Consequently, the balance will be about 3,500 pesos per ton of crude ore, the investment efficiency being 63.7% in ARR and 1.6 years in BP.

8.1.5 Purpose and Necessity of the Plan for Development of a New Beneficiation Plant in Barones

The purpose and necessity of development of a modern beneficiation plant adjacent to the existing Barones Beneficiation Plant is shown as follows:

a) Increase in the beneficiation capacity

The beneficiation capacity will be increased by 3,900 t/month, because the small and intermediate scale private mines in Zacatecas State expect to have a beneficiation capacity greater than that of the present Barones Beneficiation Plant.

b) Reduction of the cost of the existing plant

Since Barones Beneficiation Plant is now operating at a heavy deficit, it is necessary to reduce the operation cost by transfer of workers from the Plant and to reduce the general administration costs and fixed costs required for analysis and laboratories.

c) New plant with modern facilities

Since the existing facilities were quite old and the investment efficienty of development or overall facility renewal for the existing buildings would be low, it was determined that construction of a new plant with a set of modern facilities for the whole process of crushing, grinding, flotation, and concentrate dehydration would be beneficial.

d) Technical training and education

The OJT (On-the-Job Training) method was thought to be the best way to let personnel master the technical knowhow of operating modern facilities and modern operation management techniques. Consequently, the new plant is planned to be constructed as a model beneficiation plant to be used for training and education of personnel.

e) Achievement of a high recovery rate

When a modern automated plant with full instrumentation is operated by highly educated personnel and is administered by staff who have mastered advanced operation management techniques in which QC methods are adopted, and an all custom ore system and modern facility protection and maintenance system are introduced, operation conditions can almost always be optimized, resulting in a substantial increase in the beneficiation recovery rate.

f) Production of various kinds of concentrates

In addition to Au and Ag, high grade Pb, Cu and Zn are intended to be recovered at a high recovery rate. Recovery of iron sulfide (FeS) concentrates containing Au or Ag will also be considered in the future.

8.1.6 Outline of the plan for development of a new beneficiation plant in Barones

A new plant (for crushing, grinding, flotation and dehydration) adopting Pb-Cu-Zn selective fotation will be constructed within the site of the Barones Beneficiation Plant. The beneficiation capacity is 150 t/day, or

3,900 t/month assuming 20 days of operation per month. The grade of crude or is set at 0.8 g/t for Au, 160 g/t for Ag, 0.8% g/t for Pb, 0.4% g/t for Cu and 1.6% g/t for Zn.

Table 8.1.2 shows the expected beneficiation results.

The expected recovery rates are 33% for Au, 76% for Ag, 73% for Pb, 86% for Cu and 68% for Zn. These are all higher than the previous values for the Barones Beneficiation Plant (average values for January through June, 1989); i.e. 21% for Au, 43.3% for Ag, 57.5% for Pb, 73.1% for Cu and 42.9% for Zn. The above expected rates are lower, however, for Pb and Zn in comparison with the recovery rates expected from batch tests for San Bernabe Mine; i.e. 68% for Ag, 91.9% for Pb and 89.6% for Zn.

8.2 Modernization Plan for Existing Facilities of Parral Beneficiation Plant

8.2.1 Facility Improvement Plan

(1) Development of the crushing dust collecting system

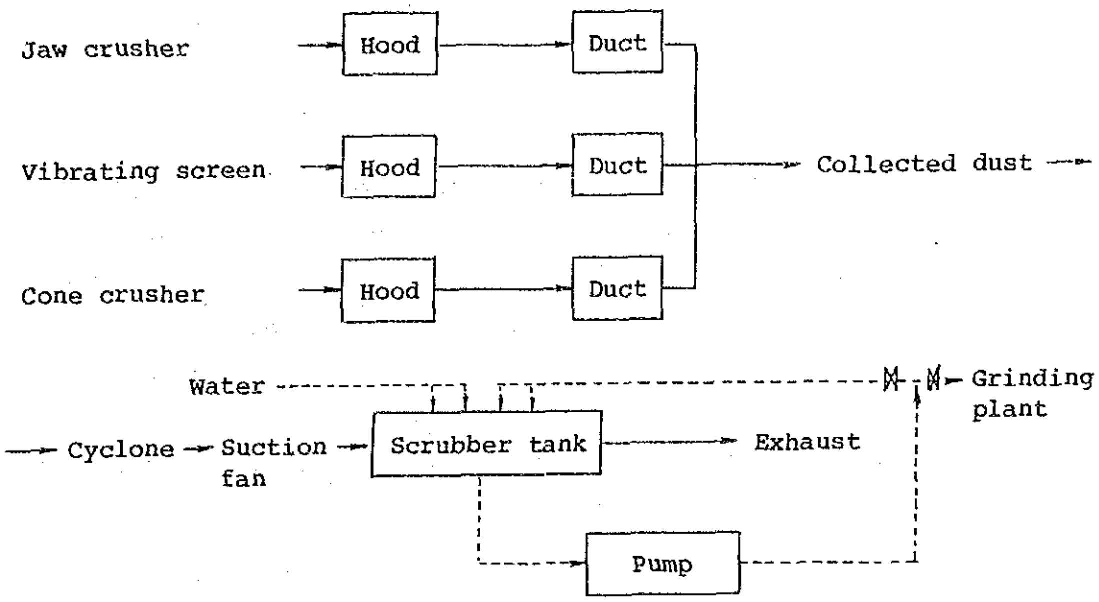
a) Purpose

Since the crushing plant produces quite a large amount of dust, the working environment for the operators is harsh. Dust also causes serious damage to equipment. For example, problems with electrical contacts are frequently caused by dust entering electric equipment. Consequently, a dust collecting system will be developed.

b) Content of construction work

The operating efficiency of the existing dust collecting system is low, because dust is collected from all over the crushing plant through a duct, the open end of which is located inside the plant. In the new dust collecting system, dust producing machines and systems are provided with a hood, and dust is collected directly through ducts to improve operating efficiency. Moreover, since only a cyclone is used to collect dust in the existing system and a considerable amount of dust is discharged to the outside of the crushing plant building which contaminates the environment, a scrubber tank will be provided in the new system for the wet dust collection.

Flow



Only facilities shown in a box [ ] are to be newly constructed. Others facilities already exist.

c) Rough estimate of the construction cost

Hood and duct installation

Scrubber tank manufacturing and installation

Pump (2.2 Kw) purchase and installation

Total cost = 26,500,000 pesos

d) Effects

1 Improvement of the working environment

2 Prevention of problems in the electrical and mechanical equipment

3 Improvement of the operation rate of the facilities

4 Reduction of maintenance costs

(2) Instrumentation

a) Crushing conveyer scale

1 Purpose: Continuous weighing of the ore to be crushed

2 Installation position: No. 1 belt conveyer for crushing

3 Specifications: Load-cell-type conveyer weighing machine
Maximum weighing capacity of 100 t/h
Outdoor installation type controller
Wide range integrator

4 Estimate of the cost: Total cost of purchasing and installing the instruments 50,350,000 pesos

5 Effects:

o Since the amount of crushed ore is continuously displayed, the target for crushing, the amount of maximum instantaneous crushing, etc. can be set.

o Since natural fluctuations in the amount of crude ore bin extraction can be coped with, operating problems can be prevented.

o Consequently, the operation rate of the crushing facilities will be improved, and maintenance costs will be reduced.

b) Constant mill feeder

1 Purpose: The amount of or fed to the ball mills is continuously measured, and the speed of the fine grain bin extraction conveyer is automatically controlled, so that ore id fed to the ball mills at a fixed rate.

2 Installation Positions: Two feeder sets will be installed: one on the No. 1 ball mill feeding conveyer and the other on the No. 2 ball mill feeding conveyer.

3 Specifications:

Load-cell-type conveyer weighing machine

Maximum weighing capacity 50 t/h

Conveyer speed controller

Wide range indicator

Converter

VS motor (2.2 Kw)

Control panel, Operation panel

4 Estimate of the cost:

Total cost of purchasing and installing the instruments

212,000,000 pesos (106,000,000 pesos/set)

5 Effects:

- o The rate of ore grinding will be stavilized.
- o If the maximum operation is achieved, the amount of ore processed per day can be increased.
- o P.D of the grinding system will be stabilized, operating problems will be reduced, and the operation rate will be improved. Maintenance costs will also be reduced.
- o The ground particle size will be stabilized, and the processig rate of the flotation system will be stabilized.
- o Since operation can be readily managed, and the optimum conditions can be set, beneficiation results will be sustantially improved.
- o continuous stable operation will enable labor saving, e.g. a reduction in the number of workers monitoring fine grain bin extraction and operation for the grinding system and flotation system.

c) Water flowmeter

1 Purpose:

Continuous measurement of the flow rate of water used for the grinding system.

2 Installation position:

Four positions in total; i.e. at the inlet and outlet of No. 1 BM and the inlet and outlet of No. 2 BM.

3 Specifications:

Four vinyl chloride flowmeters of float type

SIZE 3B

MAX 1 l/min.

4 Estimate of the cost:

7,950,000 pesos for four flowmeters including the installation cost.

5 Effects:

- o P.D of the grinding system will be stabilized.
- o The beneficiation results will be improved.
- o Consumption of water will be reduced.

d) Automatic cyanidation pH control system

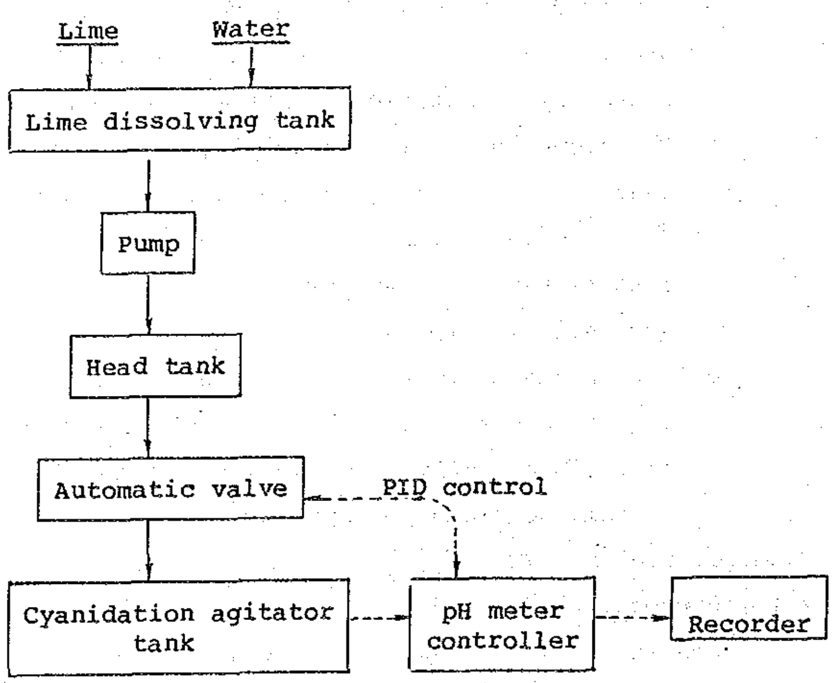
1 Purpose:

Continuous measurement of cyanidation pH and automatic control of the amount of milk of lime to be added.

2 Installation position:

In the cyanidation agitator (dissolution agitator tank)

3 System flow:



4 Specifications:

pH meter (AC 100 V four-wire type)

Controller (AC 100 V IN, OUT DC4-20 mA)

Recorder (AC 100 V IN, DC4-20 mA)

Lime control valve

Lime dissolution tank

Pump (3.7 KW)

Hed tank

5 Estimate of the cost:

58,300,000 pesos, including the installation cost.

6 Effects:

- o Condition pH will be stavilized.
- o Lime consumption will be reduced.
- o Reduction in the number of workers required for pH control, and labor saving in lime dissolution.

e) Automatic tank level detection system for the primary pumps of the grinding system

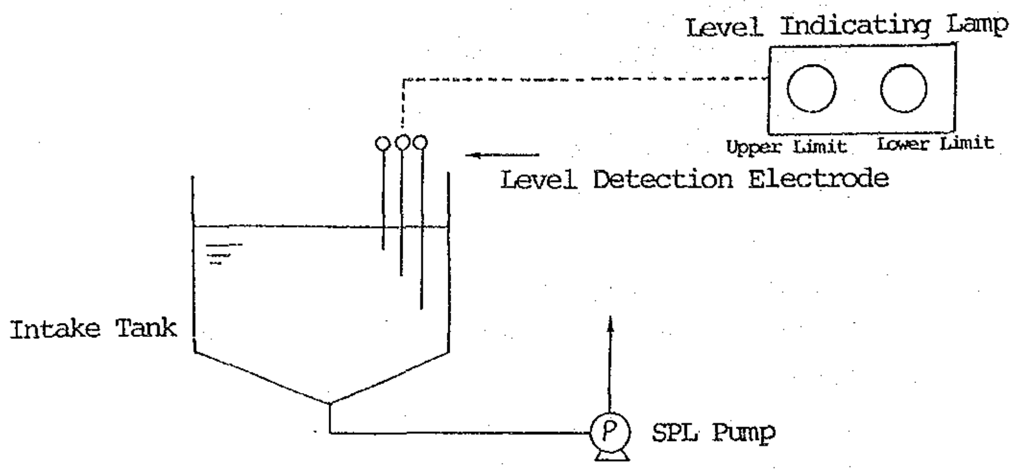
1 Purpose:

Upper-and lower-level detection in the intake tanks for the pumps

2 Installation positions:

At the intake tanks for the exhaust pumps (SRL 5" x 4") of No. 1 and No. 2 ball mills

3 Detection flow:



4 Specifications:

Electrode

Level report board

5 Estimate of the cost

21,200,000 pesos for two sets

6 Effects:

- o Abnormal fluctuations in the ore volume will be detected the early stage.
- o Abnormal operation of a pump will be detected in the early stage.
- o Ore leakage will be reduced, resulting in labor saving.
- o Due to early detection of parоblems, the operation rate of the equipment will be improved, and the maintenance cost will be reduced.

f) Problem alarm system for mechanical and electrical equipment

1 Purpose:

Meter relays installed in the motors of major systems will automatically break the circuit in abnormal conditions, and a lamp on an alarm display panel and a buzzer will come on simultaneously.

2 Installation position:

The alarm display panel will be installed in the grinding and flotation building.

3 Specifications:

Meter relays 20 units

Display panel

Power supply set and others

4 Estimate of the cost:

Total cost including wiring, 55,650,000 pesos

5 Effects:

- o Reduction in the frequency of failure of a motor or equipment
- o Reduction in the maintenance cost
- o Improvement of the operation rate of equipment
- o Labor saving

g) Sodium cyanide dissolution and addition system

1 Purpose:

Dissolution of sodium cyanide, storage of the solution, and addition of the solution at a fixed rate using quantitative pumps

2 Installation position:

In the cyanidation plant

3 Specifications:

Agitator tank (1.2 kW)	1 unit
Storage tank	1 unit
Quantitative pump	2 units
Installation work	

4 Rough estimate of the cost:

25,970,000 pesos including installation cost

5 Effects:

- o The rate of addition of sodium cyanide will be stabilized and the optimum conditions will be achieved.
- o The recovery rates of Au and Ag will be improved.
- o The chances of excessive addition of sodium cyanide and its loss at the time of dissolution will be reduced, resulting in a reduction of sodium cyanide consumption
- o Reduction in the number of processes for dissolution and addition of sodium cyanide

(3) Renewal and development of facilities

a) Renewal and development of a ball mill

1 Purpose:

No. 1 ball mill (MARCY 7.5' x 7.5') and No. 2 ball mill (MARCY 7' x 7') are quite worn-out, having been operated for 9 and 15 years, respectively. Since No. 3 ball mill (HARD-(INGLE, conical mill) is too small it is not being operated. Therefore, No. 3 fine grain bottle is also out of operation. In order to use the full capacity of the grinding system, No. 3 ball mill will be removed, and a new 7' x 7' ball mill will be installed.

2 Specification and estimate of the cost

Purchase and installation of a 7' x 7' ball mill (150 kW)
939,355,000 pesos

(4) Total construction cost

Construction item	1,000 pesos
1) Development of the crushing dust collecting system	26,500
2) Instrumentation	(431,420)
a) Crushing conveyer scale	50,350
b) Constant mill feeder	212,000
c) Water flowmeter	7,950
d) Automatic cyanidation pH control system	58,300
e) Automatic tank level detection system for the primary pump of the grinding system	21,200
f) Problem alarm system for mechanical and electrical equipment	55,650
g) Sodium cyanide dissolution and addition system	25,970
3) Renewal and development of equipment	
a) Renewal and development of a ball mill	929,355
Total	1,387,275,000 pesos

(5) Estimate of balance improvement

a) Improvement of the recovery rates

Records of Parral Beneficiation Plant for January to June, 1989

Beneficiation capacity: 6,411 t/month

	Au	Ag	Pb	Zn
Crude ore grade:	0.74 g/t	325 g/t	0.6 %	0.2 %
Beneficiation recovery rate (%):	64	65	50	45
Smelting extraction rate (%):	92	94.05	85	82
Total recovery rate (%)	58.88	61.13	42.50	36.90

	US$ (6 months)	US$/t	Pesos/t	Sales increase per % of recovery rate (1,000 pesos/% • month)
Sales of Au	191,151	4.97	13,169	1,319
Sales of Ag	1,270,264	33.02	87,511	8,631
Sales of Pb	12,018	0.31	828	106
Sales of Zn	22,635	0.59	1,559	222

When the above mentioned modernization work is carried out, operation of the plant will be stabilized. It is estimated that the beneficiation recovery rate will be increased by 5%.

	Current recovery rate (%)		Increase rate (%)	Increase of monthly production (1,000 pesos/month)
Au	64.0	x	0.05 = 3.2	1,319 x 3.2 = 4,221
Ag	65.0	x	0.05 = 3,25	631 x 3.25 = 28,051
Pb	50.0	x	0.05 = 2.5	106 x 2.5 = 265
Zn	45.0	x	0.05 = 2.25	222 x 2.25 = 500
	Total			33,037

b) Reduction in the cost

1 Expenses: 2,185,000 pesos/month

The expenses for consumable materials such as reagents will be reduced owing to introduction of instrumentation.

o Consumption of sodium cyanide per ton of ore will be reduced by 10%.

Present consumption: 0.7 kg/ton of ore

Unit cost of sodium cyanide: 3,377 pesos/kg

Average monthly tons of crude ore treated: 6,411 t/month (January to June, 1989)

Cost reduction per month

0.7 kg/t x 0.1 x 3,377 pesos/kg x 6,411 t/month

= 1,515,000 pesos/month

o Others

The expenses for consumable materials used in the flotation and cyanidation systems will be reduced by 2%.

Current expenses for consumable materials:

Flotation system	1,709 pesos/ton of ore
Cyanidation system	3,515 pesos/ton of ore
Total	5,224 pesos/ton of ore

Cost reduction per month

5,224 peso/t x 6,411 t/month x 0.02

= 670,000 pesos/month

2 Maintenance cost: 162,000 pesos/month

The maintenance cost will be reduced owing to development of the crushed dust collecting system, introduction of instrumentation and, renewal and development of a ball mill.

Current maintenance cost: 1,262 pesos/ton of ore

Cost reduction rate: 2%

Cost reduction per month

1,262 pesos/t x 0.02 x 6,411 t/month

= 162,000 pesos/month

3 Total cost reduction per month: 2,347,000 pesos/month

When a new ball mill is installed in place of No. 3 ball mill, additional power of 150 KW will be required. In normal operation, however, either No. 1 ball mill (165 KW) or No. 2 ball mill (162 KW) will be kept on stand by, and power consumption will not be increased. Consequently, the total cost reduction will be

1 + 2 = 2,347,000 pesos/month

(6) Investment efficiency

a) Facility investment: 1,387,257,000 pesos

b) Depreciation fund (10-year depreciation):

10,923,000 pesos/month

1,387,275 x 0.95 10 (years) 12 (months)

= 10,923,000 pesos/month

c) Interest (5% per year): 2.890,000 pesos/month

d) Production increase: 33,037,000 pesos/month

e) Reduction of the cost: 2,347,000 pesos/month

f) Balance improvement: (33,073 + 2,347) - (10,923 + 2,890)

= 35,384 - 13,813

= 21,571,000 pesos/month

g) Investment efficiency:

o ARR (Accounting Rate of Return)

$$\frac{21.571 \times 12}{1,387,275} = 18.7\%$$

o PB (Payback Period)

$$\frac{1,387,275}{258,852} = 5.4 \text{ years}$$

8.2.2 Rationalization Plan for the Administration Section

(1) Estimate of Computer Introduction Cost

The total cost of introducing computers is estimated to be 106,000,000 pesos, or 53,000,000 pesos for hardware and 53,000,000 pesos for software, as shown in the attached table of computer introduction costs. The price of existing software is estimated on the basis of similar software available in Japan, and software preparing cost is estimated as that by Mexican engineers.

(2) Effects of Introduction of Computers

When computers are introduced for accounting, the operation efficiency can be improved, which results in reduction in the number of workers required. In addition, workers may become conscious of the cost and respond immediately to unexpected material consumption and expenditure, which results in reduction of the operation cost.

It is expected that five computer operators will be needed. Supporting that two superiors are also needed, the total number of workers will be 7. Since 9 to 10 persons are now employed in office work, the number of workers will possibly be reduced by 2. The cost reduction will be

703,000 pesos/man-month (average for the three beneficiation plants, including labor cost) x 2 men = 1,406,000 pesos/month

The operation cost can also be reduced by introduction of computers for accounting, which will enable instantaneous observation of the operation conditions and immediate response to abnormal cost increases. For example, when the amount of reagents consumed the previous day is found to be remarkably high, measures can be immediately taken without waiting for the monthly accounts to identify the cause, i.e. an increase in the amount of ore processed, failure of a reagent pump, or ore which is quite different from usual. Material consumption and expenditure can be reduced in this way.

Since a reduction of the operation cost is mainly cauesd by 1 to 1.5% reduction in material expense, which is to be included in the direct cost, (778,000,000 pesos for the Parral Plant, 1,022,000,000 pesos for the Guanacevi Plant or 1,085,000,000 pesos for Barones; values for January to June, 1989 were converted into the yearly cost), the reduction will be about 883,000 pesos/month. Together with a reduction of the labor cost, the total amount of cost reduction will be 2,289,000 pesos/month.

(3) Investment Efficiency

Amount of Investment: 106,000,000 pesos

Depreciation Fund (ten-year depreciation):

$$106{,}000{,}000 \times 0.95 \div 10 \text{ (years)} \div 12 \text{ (months)}$$
$$= 839{,}000 \text{ pesos/month}$$

Interest (5% per year)

$$106{,}000{,}000 \times 1/2 \times 0.05 \div 12 \text{ (months)}$$
$$= 221{,}000 \text{ pesos/month}$$

Balance Improvement:

2,289,000 pesos/month

Investment Efficiency

ARR:

$$\frac{(2{,}289 - 839 - 221) \times 12}{106{,}000} = \frac{1{,}229 \times 12}{106{,}000}$$

$$= \frac{14{,}748}{106{,}000} = 13.9\%$$

PB: $\frac{106{,}000}{14{,}748} = 7.2$ years

8.3 Modernization Plan for Existing Facilities of the Guanacevi Beneficiation Plant

Facility Improvement Plan

8.3.1 Improvement of the Grinding System

(1) Present Status

The current flow sheet of the grinding system is shown in Fig. 8.3.1.

Ball Mill	No. 1	7' x 7.5'	DENVER	150 KW	(Primary mill)
Ball Mill	No. 2	7' x 5'	FIMSA	150 KW	(Primary mill)
Ball Mill	No. 3	6' x 5'	ALLIS-CHALMERS	85 KW	(Secondary mill)
Ball Mill	No. 4	7' x 7.5'	DENVER	150 KW	(Secondary mill)
Ball Mill	No. 5	7' x 5'	MARCY	110 KW	(Primary mill)

Processed Ore	Average per Month	Monthly Operation Rate
1,989	7,751 t/month	260 days/month
		298 t/day

When No. 1 BM (7' x 7.5' DENVER) and No. 4 BM (7' x 7.5' DENVER) are in operation, processing 298 t/day or 149 t/day.mill is possible. The reason is shown as follows:

<Processing Capacity of Ball Mill>

The following values are assumed for use in the calculation:

F80 = 18,800

P80 = 74

Wi = 12

$$W = \frac{10 \times 12}{74} - \frac{10 \times 12}{18,800} = 13.07 \text{ KWH/S.T}$$

Assuming that two ball mills are used for processing at the rate of about 300 t/day, which is thought to be reasonable according to actual records,

13.07 1.102 x 1.341 x 330/2 x 1/24 = 132.8

Taking various factors into consideration,

EF_1, EF2, EF6, FE7, EF8: not used

EF_3 = 1.042

EF_4 Pr = 18800/74 = 254

Fo = 4000 13/12 = 4163.3

$$EF_4 = \frac{254 + (12-7) \quad (18,800 - 4163.3)/4163.3}{254} = 1.07$$

$$EF_5 = \frac{74 + 10.3}{1.145 x 74} = 0.99$$

Power requirement

132.8 x 1.042 x 1.07 x 0.97 = 147 HP

The horsepower of the pinion shaft of the 7' x 7' BM (2" ball is used) is 145 HP which is almost equal to the value obtained above.
(Reference; Mineral Processing Plant Design, Mular, BHAPPU)

(2) Flow after Improvement

The flow sheet after improvement is shown in Fig. 8.3.2.

(3) Contents of Construction Work

1	Variable speed Belt conveyor	Four units	1 Construciton of a constant mill feeder
2	"		
3	"		
4	"		
5	Constant speed conveyor	Two units	2 Development of a mill bin extraction conveyor
6	"		
7	Belt scale	Two units	(→ 1)
8	"		
9	Unit cell (#24)	Two units	3 Construction of unit cell facility
10	" (")		

(4) Rough Estimate of the Construction Cost: 300,944,000 pesos

1	Construction of a constant mill feeder	212,000,000 pesos
2	Development of a mill bin extraction conveyor	148,824,000 pesos
3	Construction of a unit-cell flotation facility	74,120,000 pesos
	Total	300,944,000 pesos

(5) Effects

1) Construction of a constant mill feeder

- Stabilization of operation of the grinding system
- Reduction in the occurrence of operating problems
- Improvement in the operation rate of the facilities
- Reduction of maintenance cost
- Improvement in recovery rate
- Labor saving

2) Development of the mill bin extraction conveyor

Purpose: Use of No.2 BM (FISMA 7' x 5') as a stand-by mill

- Improvement in the operation rate of the facilities
- Reuction of maintenance cost

3) Construction of a unit-cell flotation facility

(6) Balance Improvement:

28,366,000 pesos/month

- Improvement in recovery rate:

17,945,000 pesos/month

Processing ore 7751 t/monthly

	Au	Ag
Original ore grade		
	1.45 g/T	253 g/T
Beneficiation recovery rate	78%	77%
Smelting recovery rate	92%	94.05%
Overall recovery rate	71.76%	72.42%

Sales	US$ (for 7 months)	Pesos/ ton of ore	Pesos/t.% of the recovery rate
Au	656,314	32,055	411 pesos/t.%
Ag	1,714,423	83,735	1,087 pesos/t.%
Total	2,370,737	115,790	

	Improvement in the recovery rate (present rate x 2%)	Improvement in sales 000 pesos/month
Au	78 -> 79.56% (+1.56%)	411 x 1.56 x 7751 = 4,970
Ag	77 -> 78.54% (+1.54%)	1,087 x 154 x 7751 = 12,975
Total		17,945,000 pesos/month

• Energy saving: 10,166,000 persos/month

Decrease		Increase
No. 2 BM	150 KW	Unit cell 11 KW x 2 = 22 KW
No. 3 BM	85	
No. 4 BM	110	
Total	345	

Difference 345 - 22 = 323 KW

323 KW x 0.52 x 24 (hours) x 26 (dasy/month) x 97.0 pesos

(10,166,000 peso/month

• Reduction of the maintenance cost : 255,000 pesos/month

Record of grinding system maintenance cot

January to June, 1989) 1,277,000 pesos/mohth

Reduction rate 20%

Improvement target 1,277,000 pesos/month x 0.2

255,000 pesos/month

8.3.2 Rationalization of the Flotation System

(1) Purpose

Machines which are not required to be operated can be kept idle by modification of the floatation system and a change in the positions of the flotator.

(2) Content of the Construction Work

The current flow and the ratinalized flow are shown in Fig. 8.3.3 and Fig. 8.3.4.

1) The positions of the six primary roughing cells (DR#100) will be raised, so that tailings can flow into the secondary roughing cells (DR#100, six cells) by the natural head pressure, and that a pump (GALIGHER 4") can be kept idle.

2) The secondary conditioner (6' x 5'), which is unnecessary, will be kept idle.

3) The pipe arrangement will be changed to send the froth (float) from the secondary roughing to the cleaning cells (SUB-A #50, 6 cells) froth from the primary roughing, so that the cleaning cells for froth of the secondary roughing (SUB-A #50, 4 cells) can be kept idle.

(3) Rough Estimation of Construction Cost:

11,119,000 pesos

(4) Effects

1) Energy saving

KW values of the machines to be kept idle:

Pump (GALIGHER 4") :	5.5 KW
Conditioner (6' x 5') :	5.5 KW
Four flotation cells (SUB-A#50):	2.2 KW (11.0 KW x 2)
Total	3.3 KW

• Balance Improvement:

33 KW x 0.52% x 24 KW x 26 dasys/month x 97.0 pesos/KWH

= 1.039,000 pesos/month

2) Reduction of the Maintenance Cost

Record of the flotation system maintenance cost (January to June, 1989)

479,000 pesos/month (62 pesos/ton of crude ore)

Rate of cost reduction: 10%

• Balance Improvement:

479,000 pesos/month x 0.1 = 48,000 pesos

8.3.3 Improvement of Reagent Facilities

(1) Purpose

Dissolution of reagent for flotation, storage of the solution, and addtiion of the solution at a fixed rate using diaphram pumps.

(2) Installation Position and Flow

Installation Position: in the flotation plant

Flow: Dissolution tank -> storage tank -> quantitative pump -> (addition)

(3) Rough Estimate of the Construction Cost: 43,392,000 pesos

1	Dissolution tank	4 units	Total construction cost 83,392,000 pesos
2	Storage tank	4 units	
3	Diaphram	9 units	
4	Installation		

(4) Effects: 9,335,000 pesos/month

1 Reduction in reagent consumption (5%)

- Record of reagent consumption (January to April, 1989): 933 pesos/ton of crude ore
- Cost Reduction:

  933 pesos/t x 7,751 t/month x 0.05 = 362,000 pesos/month

2 Improvement in Recovery Rate (1%)

Au: 78% x 0.01 = 0.78% (increased)

Ag: 77% x 0.01 = 0.77% (increased)

Au: 411 pesos/t.% x 0.78% x 7,751 t/month
= 2,485,000 pesos/month

Ag: 1,078 pesos/t.% x 0.77 x 7,751 t/month
= 6,488,000 pesos/month

Total 8,973,000 pesos/month

8.3.4 Equipment for a Filter Press for Concentrate Dehydration

(1) Purpose:

The disk filter and the dryer now being used will be taken out, and a filter press will be newly installed and used for concentrate dehydration.

(2) Flow:

Bulk concentrates -> Thickener -> Filter press -> dehydration cakes

(3) Rough Estimate of Construciton Cost:

308,339,000 pesos
Filter press and its installation

(4) Effects: 6,983,000 pesos/month

1) Reduction in the Drying Cost:
Record of Drying Cost (1988): 870 pesos/ton of crude ore
870 pesos/ton of crude ore x 7,751 t/month
= 6,743,000 pesos/month (1)

2) Labor Saving
Record of the cost of loading concentrates for drying (1988):
331 pesos/ton of crude ore
331 pesos/on of crude ore x 7,751 t/month
= 2,566,000 pesos/month
Balance improvement (reduction by 30%)
2,566 x 0.3 = 770 poesos/month (2)

Total ((1) + (2)) 7,513,000 pesos/month
(969 pesos/ton of crude ore)

3) Cost of Filter Press Operation (Increase): 530,000 pesos/month
Expenses for consumable materials, e.g. canvas filter
50 pesos/ton of crude ore x 7,751 t/month
= 388,000 pesos/month

Power expenses: 4.5 KW x 0.52 x 24 Hr x 26 days/month x 97 pesos/KWH
= 142,000 pesos/month
(18 pesos/ton of crude ore)

Total 388 + 142 = 530,000 pesos/month

Overall effect: (1) + (2) - (3) = 6,983,000 pesos/month

(5) Economic Evaluation

1) Improvement of the Grinding System

1 Construction Cost: 300,944,000 pesos

2 Depreciation Fund (fixed amount, 10 years)

300,944 x 0.95 ÷ 10 ÷ 12 = 2,382,000 pesos/month

3 Interest: (5% per year)

300,944 x 1/2 x 0.05 ÷ 12 = 627,000 pesos/month

4 Balance Improvement

28,366,000 pesos/month

5 Investment Efficiency:

. ARR (Accounting Rate of Return)

$$\frac{(28,366 - 627 - 7,382) \times 12}{300,944} = 101.1\%$$

. PB (Payback Period)

$$\frac{300,944}{304,284} = 0.99 \text{ year (approximately one year)}$$

2) Rationalization of the Flotation System

1 Construction Cost: 11,119,000 pesos

2 Depreciation Fund: (fixed amount, 10 years)

11,119 x 0.95 ÷ 10 ÷ 12 = 88,000 pesos/month

3 Interest (5% per year)

11,119 x 1/2 x 0.05 ÷ 12 = 23,000 pesos/month

4 Balance Improvement

1,087,000 pesos/month

5 Investment Efficiency:

$$\text{ARR: } \frac{(1,087 - 23 - 88) \times 12}{11,119} = 105.3\%$$

$$\text{BP: } \frac{11,119}{11,712} = 0.95 \text{ (approximately one year)}$$

3) Improvement of Reagent Facilities

1 Construction Cost: 83,392,000 pesos

2 Depreciation: (fixed amount, ten years)

83,392 x 0.95 ÷ 10 ÷ 12 = 660,000 pesos/month

3 Interest: (5% per year)

83,392 x 1/2 x 0.05 ÷ 12 = 174,000 pesos/month

4 Balance Improvement:

9,335,000 pesos/month

5 Investment Efficiency:

ARR: $$\frac{(9,335-174-660) \times 12}{83,392} = 122.3\%$$

BP: $$\frac{83,392}{102,012} = 0.82 \text{ year (approximately ten months)}$$

4) Installation of a Filter Press for Concentrate Dehydration

1 Construction Cost: 308,339,000 pesos

2 Depreciation: (fixed amount, ten years)

308,339 x 0.95 ÷ 10 ÷ 12 = 2,441,000 pesos/month

3 Interest: (5% per year)

308,339 x 1/2 x 0.05 ÷ 12 = 642,000 pesos/month

4 Balance Improvement

6,983,000 pesos/month

5 Investment Efficiency:

ARR: $$\frac{(6983-642-2441) \times 12}{308,339} = 15.2\%$$

BP: $$\frac{308,339}{46,800} = 6.6 \text{ years}$$

5) Overall Evaluation:

1 Contruction Cost: 703,794,000 pesos

2 Depreciation: (fixed amount, 10 years)

703,794 x 0.95 x1/10 x 1/12 = 5,572,000 pesos/month

3 Interest: (5% per year)

703,794 x 1/2 x 0.05 x 1/12 = 1,466,000 pesos/month

4 Balance Improvement:

45,771,000 pesos/month

5 Investment Efficiency:

ARR: $$\frac{(45,771-1,466-5,572) \times 12}{703,794} = 66.0\%$$

BP: $$\frac{703,794}{464,794} = 1.5 \text{ years (one yer and a half)}$$

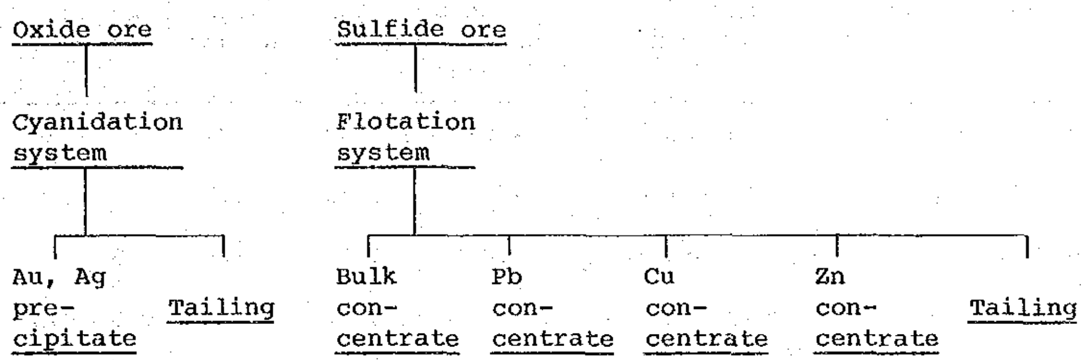
8.4 Modernization Plan for Existing Facilities of Barones Beneficiation Plant

Contents

(1) Improvement of the Processing System

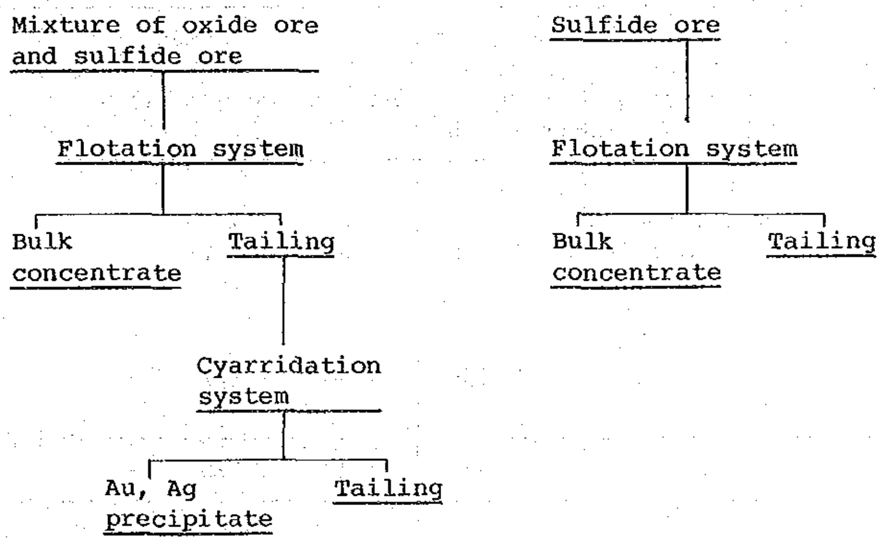
1) Processing System

a) Present State

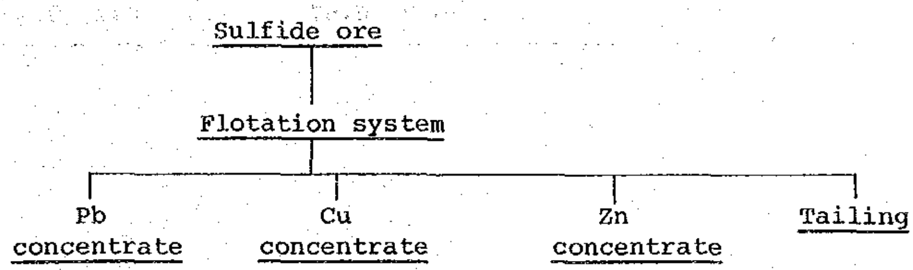


b) Modernization Plan

Existing Beneficiation Plant



New Beneficiation System



2) Amount of Processed Ore and Crude Ore Grade

a) Present state (Records for January to June, 1989)

Kind of ore	Kind of processing	Amount of processed ore (t/month)	Grade				
			Au g/t	Ag g/t	Pb%	Cu%	Zn%
Oxide ore	Cyanidation	2,814	0.60	171	-	-	-
Sulfide ore	Bulk flotation	2,591	0.38	177	-	-	-
Sulfide ore	Pb-Zn flotation	1,475	0.51	165	0.9	-	1.5
Sulfide ore	Pb-Cu-Zn flotation	2,176	0.31	100	0.5	0.5	1.0
Total		9,056	0.46	155	0.3	0.1	0.5

b) Modernization Plan

	Kind of ore	Kind of processing	Amount of processed ore (t/month)	Grade				
				Au g/t	Ag g/t	Pb%	Cu%	Zn%
Existing Beneficiation plant	Mixture of oxide ore and sulfide ore	Bulk flotation cyanidation	3,600	0.60	171	-	-	-
	Sulfide ore	Bulk flotation	5,456	0.38	177	-	-	-
		Subtotal	9,056	0.47	175	-	-	-
New beneficiation plant	Sulfide ore	Pb-Cu-Zn flotation	3,900	0.80	160	0.8	0.4	1.6
		Total	12,956	0.57	170	0.2	0.1	0.5