CHAPTER 4.

MINE DEVELOPMENT

CHAPTER 4. MINE DEVELOPMENT

This chapter will describe basic items concerning development of the mine, from clay mining and supply to the bentonite plant itself.

The bentonite mine will be developed in the southwestern part of Los Cimientos. Mine facilities will include mining pits, waste disposal area, stock yard, repair shop, office building, and others.

A basic plan will be drawn up and costs be estimated for construction periods for mine facilities, mining operation, transportation, stocking, etc. according to the staged production plan for 23 years.

The production plan is characterized by operation on a staged production scale based on the bentonite demand in Guatemala for 1978 to 1981. That is, the project will be started with a production capacity that can nearly meet the present market demand, and production will subsequently be increased in two stages as new applications for bentonite are developed.

The mine facilities will be built in two years. The mine itself will be operated 300 days a year. Clay will be mined from pits during the 200-day dry season (eight months from October through May of next year) and by stripping in the 100-day wet season (four months from June to September).

Mined clay will temporarily be stocked in the mine's stock yard to ensure stable supply to the bentonite processing plant for the entire 300 days of operation.

Maintenance to be performed on mine machines and electric equipment at the repair shop will be limited to simple, minor repairs.

1 General Situation of Los Cimientos

Los Cimientos is located in the administrative area of San José la Arada, Chiquimula.

1) Location

Los Cimientos lies at 89°38' W Long. and 14°42' N Lat. and is situated at a straight line distance of 16 km southwest of the center of Chiquimula.

National Highway No. 10 runs from Chiquimula up to Esmeralda plantation; from this point a provincial road extends to San José la Arada. This covers a road distance of about 12 km. A local road branches to the west from a 9 km point on the provincial road to Ipala. Los Cimientos is another 1 km off this local road.

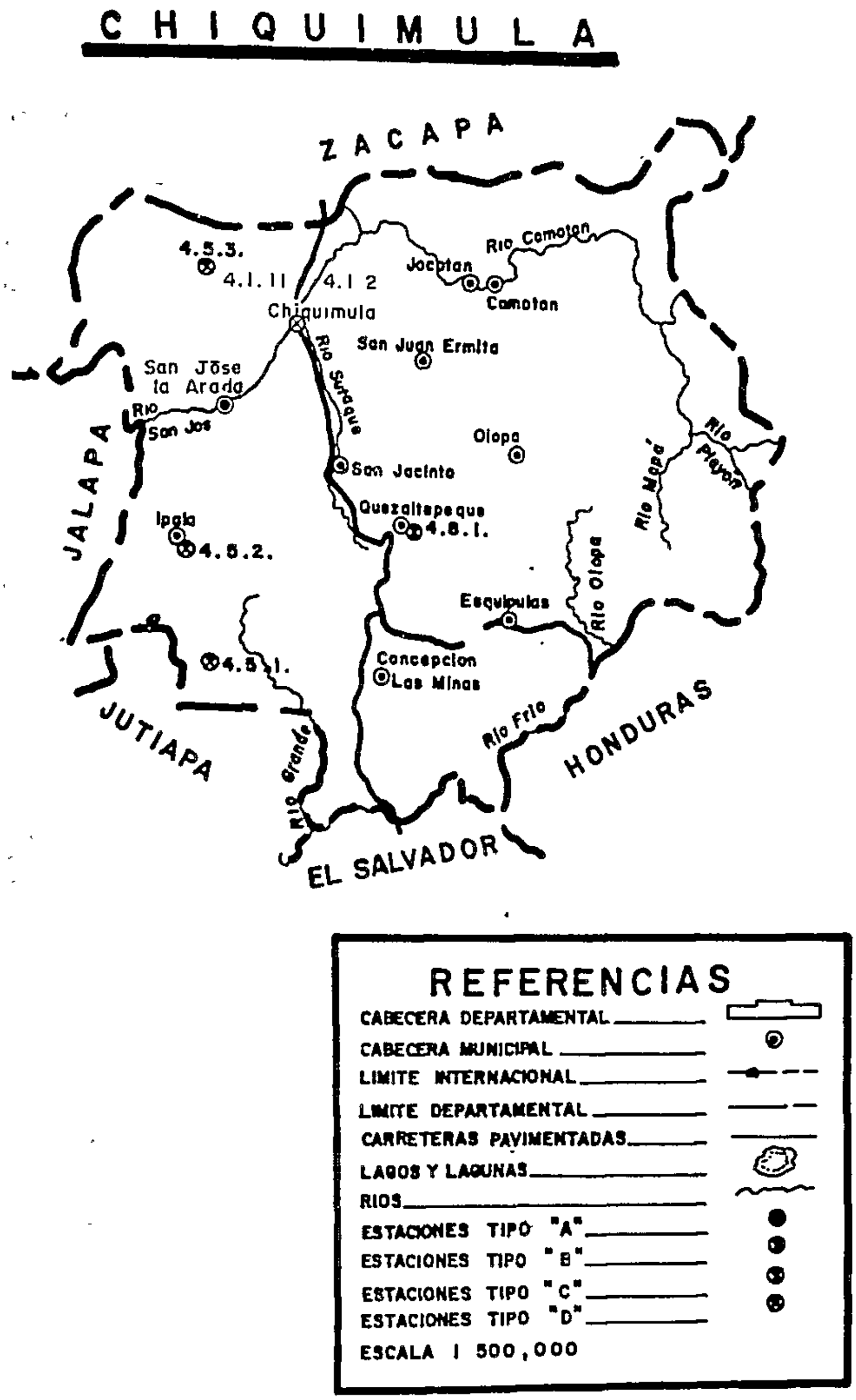
Another local road which branches off to the east from the provincial road will lead to El Rincón where the nearest railway station for Los Cimientos exists.

Houses, plantations, pastures, bentonite outcrops, etc. are all found at an altitude ranging from 860 m to 910 m above sea level.

2) Transportation

Bus services are available from Chiquimula to Ipala via San Jose la Arada and the junction for the local road to Los Cimientos. The bus makes five trips a day. Los Cimientos is accessible from Chiquimula in 40 minutes by jeep.

Fig. 4-1 Location Map of Chiquimula and Ipala Observatory



Source: Ministerio de Comunicaciones y Obras Publicas Guatemala, C.A.

3) Precipitation (Table 4-1)

According to data from Ipala Observatory, the nearest meteorological station, the rainy season for Los Cimientos lasts four months from June to September.

From records during the past 36 years, the mean annual precipitation was 794 mm. The monthly peak in the rainy season was 177 mm recorded in September. The daily peak was 14 mm in June.

Records for the single year of 1979 show that the annual rainfall was 831 mm, with the monthly peak 208 mm in June and daily peak 12 mm is July.

Both sets of records confirm that the total precipitation for the four months of the rainy season accounts for 80% of annual rainfall.

4) Temperature and humidity (Table 4-2)

According to temperature records for 1979, the hottest months of the years are April and May, the period immediately before the rainy season sets in. The average monthly temperature is 25°C to 26°C, with the highest 33°C in April. December and January, midway of the dry season are the coolest months of the year with the monthly average of 22°C to 23°C and lows of 14.6°C in January.

Humidity is high both in the latter part of the rainy season and at the end of the rainy season, with the highest monthly average 82% in September. This drops from the middle to the latter part of the dry season. The lowest monthly average is 64% for January.

The survey for this project was conducted in October, during which conditions were pleasant, especially in the shade and after the sunset.

Table 4-1 Precipitation (Ipala)

MES	ESTACION: 4. 5. 2. P. NOMBRE: Ipala F. I. C. A. MUNICIPIO: Ipala LATITUD: 14°37'05", LONGITUD: 89°37'08" AÑOS DE REGISTRO: 36 ALTITUD: 827 mts.	
	PRECIPITACION	
	TOTAL	DIAS
Enero	0. 5	1
Febrero	2. 6	1
Marzo	5. 3	1
Abril	14. 3	1
Mayo	45. 9	5
Junio	173. 1	14
Julio	145. 5	10
Agosto	129. 7	9
Septiembre	177. 4	12
Octubre	86. 7	6
Noviembre	10. 1	1
Diciembre	3. 4	1
ANUAL	794. 3	59

ESTACION: 4. 5. 2 NOMBRE: Ipala, Fequa DEPARTAMENTO: CHIQUIMULA
LATITUD: 14°37'05" LONG.: 89°37'08" ELEVACION: 827 Mts.
AÑO 1979

MES	TEMPERATURAS					PRECIPITACION		HUMEDAD RELATIVA %
		Promedios de		Absolutas		TT.		
	Media	Máxima	Mínima	Máxima	Mínima	Total	Díac	Media
Enero						0. 0	0	
Febrero						1. 3	1	
Marzo						2. 5	1	
Abril						50. 8	3	
Mayo						86. 9	5	
Junio						208. 3	9	
Julio						108. 2	12	
Agosto						129. 8	11	
Septiembre						207. 0	10	
Octubre						36. 6	8	
Noviembre						0. 0	0	
Diciembre						0. 0	0	
ANUAL						831. 4	60	

Source: Ministerio de Comunicaciones y Obras Publicas Guatemala, C.A.

Table 4-2 Temperature and Humidity

ESTACION: 4.5.4 NOMBRE: Ipala, PHC DEPARTAMENTO: CHIQUIMULA

LATITUD: 14°37'27" LONG.: 89°36'50" ELEVACION: 827 Mts.

AÑO: 1979

MES	TEMPERATURAS			ABSOLUTAS		PRESION ATMOSFERICA			HUMEDAD RELATIVA		
	Máx.	Mín.	Med.	Máx.	Mín.	Máx.	Mín.	Med.	Máx.	Mín.	Med.
Enero	29.1	14.6	22.9	34.5	10.3				98	32	64
Febrero	29.2	16.2	22.8	32.8	13.5				96	31	66
Marzo											
Abril	33.0	18.9	25.9	36.8	16.0				96	31	65
Mayo	31.0	18.8	25.3	34.2	15.0				95	41	71
Junio	29.2	19.6	24.1	31.5	17.5				97	49	78
Julio	30.1	19.2	24.6	32.0	17.5				89	49	77
Agosto	29.4	19.1	24.2	31.8	18.0				98	48	79
Sept.	28.0	19.0	23.2	30.5	16.0				98	47	82
Octubre	29.0	18 9	23.9	30.5	16.0				98	44	81
Nov.	28.6	16.6	23.4	35.0	13.5				98	40	74
Dic.	27.8	15.6	22.3	31.5	11.5				98	37	75
ANUAL											

Source: Ministerio de Comunicaciones y Obras Publicas Guatemala, C.A.

5) Population

The village of Los Cimientos is comprised of about 100 households with a population of about 500.

Villagers move into their own independent homes after marriage, and live as a nuclear family.

6) Education

According to records of Chiquimula Branch, Education Bureau, the number of primary school pupils in grades 1-6 in Los Cimientos is 93. The number of teachers is three (according to information obtained by inquiry).

The total number of primary school pupils for San José la Arada is 1,065 and that of teachers 34.

Education is actively promoted, reflecting government measures to eliminate illiteracy throughout the country. It is said the illiteracy rate among the youth is very low even in remote and secluded places in the mountains.

7) Living Conditions

Houses in San José la Arada have electric lighting by means of power supply in single-phase current from Chiquimula. However, oil lamps are still used for lighting in Los Cimientos.

Most villagers in Los Cimientos are engaged in agriculture. They alternately grow corn and beans on hills near the village. The land, said to be fertile, yields two crops yearly, and other than what is needed for self-sufficiency is shipped to the market.

Pigs, cattle and chickens are raised, but the pasture in the village is small so milk production is said to drop in the dry season due to lack of grass.

Corn and beans are staple foods, and cheese from milk is a source of animal protein.

A small valley stream serves as the water supply.

8) Labor Force and Wages

Labor for the mine can be supplied from Los Cimientos and the vicinity of San José la Arada. Wages for farmhands are very low. In the case of laborers engaged in cutting sugar cane, earnings are only 2.5 to 3.0 Q a day.

When a gypsum mine was operated several years ago, the weekly wage is said to have been about 10 Q.

9) Road Conditions

National Highway No. 10 is 29.2 m-wide paved road. The provincial road is a 5 m unpaved road.

Side ditches for drain are too small in capacity to handle runoff during torrential rains so that road surfaces suffer damage caused by overflows.

The provincial road crosses rivers at four points in the section between the national highway and San José la Arada. There are no bridges at two of these points. When the rivers rise due to heavy rains, the road is closed to traffic.

The local road from the provincial road to Los Cimientos is 4 m in width and is satisfactory for vehiclar traffic.

Village roads are 3 to 4 m wide and trucks of about 10 t class can use these roads at reduced speeds.

10) Railway and El Rincón Station

The nearest railway station for Los Cimientos is El Rincón. A railway runs from San José port to Puerto Barrios port on the Atlantic. This railway forks at Zacapa and passes through Chiquimula as the only available railway that crosses the border into San Salvador. However, this railway is not worthy of study as a means of transportation because of its small operating capacity.

11) Groundwater

If water exists in Los Cimientos, it is expected in the basalts overlying the impermeable, argillized rhyolites, but the basalts are argillized and impermeable because they form a cap rock at the bentonite forming time. Also the fissures of basalts are filled with clay or chalcedony and surface water does not permeate to the underground.

Even though groundwater exists in rainy season, it becomes dry in dry season because the water-catching area near Los Cimientos is very narrow.

As to the El Rincón Formation which is sedimentary and deep-seated, data that it is permeable and accompanied by water are not obtained.

2 Technical Procedure for Mine Development

Technical procedure for preparations and construction work to be undertaken before mining operation is as follows:

1) A waste disposal area will be provided to collect removed overburden in one place.

2) A pre-stripping of 100,000 m^3 (250,000 t) will be performed as preparations for mining more than 880 mL of clay bentonite as well as to control the stripping ratio during mining to about 0.5 : 1.

3) Irregularity of bentonite outcrops will be graded to improve drainage of the level that will become the pit surface.

4) The road from the mining pit to the provincial road and its drain ditches will be constructed.

5) Roads around the pit and approaches to the stock yard will be constructed.

6) A drain water sump and a settling pond for the mining pit will be provided.

7) The stock yard will be constructed.

8) Office buildings will be built.

Immediately before transition from the first stage operation period to the second, additional facilities including a repair shop, warehouse, generator house, offices and stock yard will be constructed to meet the increase in the scale of mining operation.

Mine machinery and transportation equipment such as tractor shovels and trucks will be added to the machinery and equipment for the first stage operation period.

Work on the pit and its vicinity for the mining preparations is important as the arrangement of the mining face to ensure smooth transition from construction to operation. It is thus desirable that this work be performed under direct management.

3 Organization and Personnel Plan for Mine Operation

The projected organization required for operation of the mine is shown in Fig. 4-2.

Responsibilities required for mining and transportation are to conduct detailed surveys of bentonite deposits to draw up specific mining plans, and to operate machinery and equipment such as trucks and drainage pumps. Their supplementary functions include minor repairs and clerical work such as accounting and administration.

Man-day productivity will be 7.5 T for the first stage of operation, 9.2 T for the second and 13.5 T for the third.

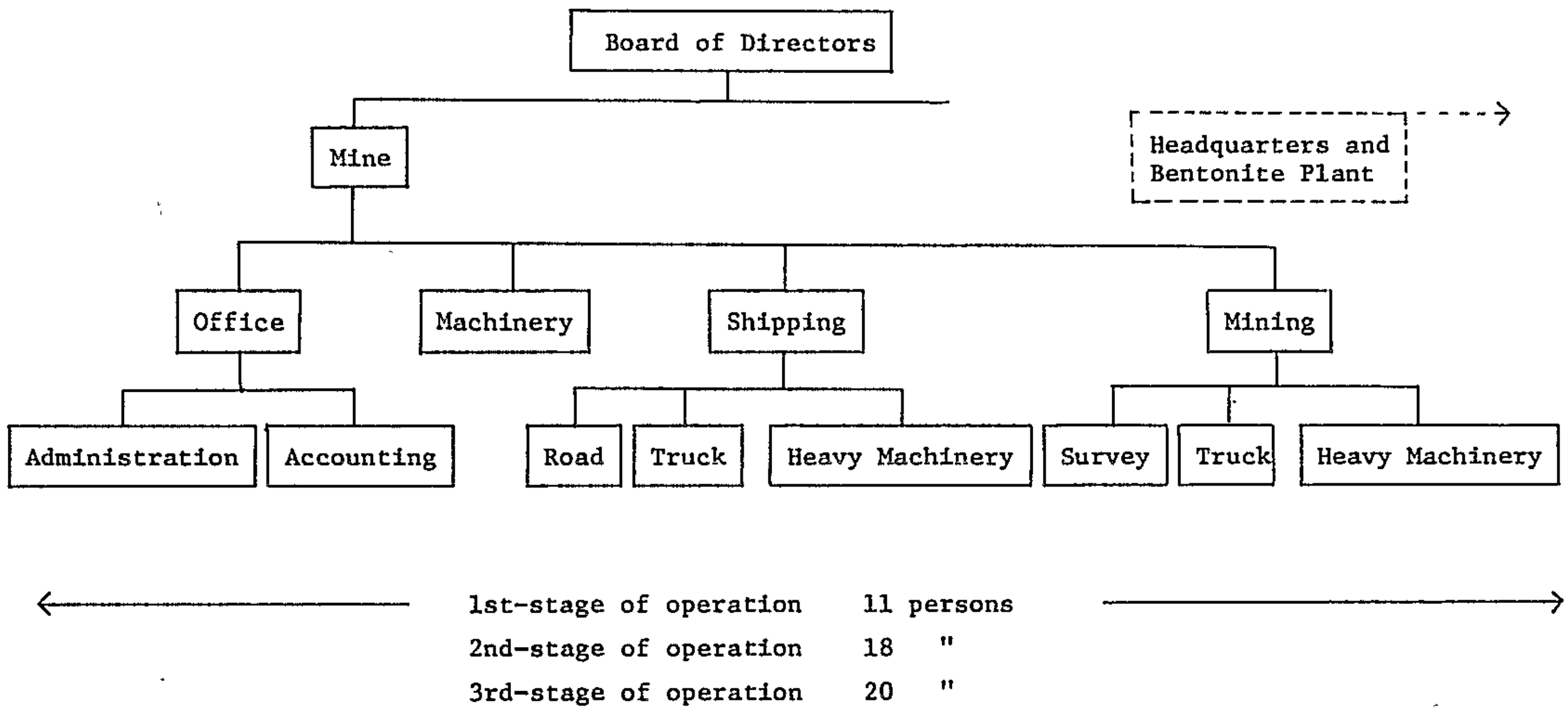
4 Clay Mining

The clay mining plan will be formulated based on production in three stages.

During the construction period with initial investments, 32% of the total overburden will be removed. This will bring the ratio of overburden to bentonite ore (hereinafter called stripping ratio) to 0.48 : 1.

Based on this ratio, mining operation will be conducted in the following manner:

Fig. 4-2 Organizational Chart of Plant with Number of Personnel



1) Removal of overburden (hereinafter called stripping)
Overburden for one year's clay supply requirement will be removed during the four months of the rainy season.

2) One year's clay supply requirement will be mined during the eight months of the dry season.

Since the relations between 1) and 2) will balance when
Stripping ratio: 0.48 : 1
Ratio of working days in dry season to those in rainy season: 1 : 0.5

both mine machinery and stripping equipment can commonly be used throughout the two seasons.

Stripping volume for the four months annually averages:

$$\begin{pmatrix}\text{Volume of clay}\\ \text{to be mined}\\ \text{during 8 months}\end{pmatrix} \times \begin{pmatrix}\text{Stripping}\\ \text{ratio}\end{pmatrix} \times \begin{pmatrix}\text{Specific}\\ \text{gravity of}\\ \text{overburden}\end{pmatrix}$$

Consequently, the average annual volume for the first stage of operation is $8{,}300\ m^3 \times 0.48 \times 2.5 = 9{,}960$ T. The corresponding figure for the second stage of operation is 19,800 T and that for the third stage 32,400 T.

Clay to be mined over the eight months is

$$\frac{\text{Clay supply to plant per day} \times 300\ \text{days}}{200\ \text{days}}$$

Hence, for the first stage of operation,

$$\frac{55\ \text{T} \times 300\ \text{days}}{200\ \text{days}} = 83\ \text{T/day}$$

Likewise, clay for the second stage is calculated to be 165 T/day and that for the third 270 T/day.

Clay will be stocked in the stock yard and dried, reducing about 1 to 3% of moisture content.

Of the daily clay production, 67% will be transported to the processing plant by truck. Consequently, about 33% will be left to accumulate in the stock yard every day. This stockpile will be used as crude clay to be supplied to the plant during the four months of the rainy season.

4-1 Clay Production

The plan calls for mining 900,000 T over a period of 23 years by increasing gradually output of clay in three stages.

1) First stage of operation

Clay supply to plant:	55 T/D x 25 D/M x 12 M
Monthly	1,375 T (27-30% in moisture content)
Annual	16,500 T (ditto)
Clay production:	83 T/D x 25 D/M x 8 M
Monthly	2,073 T (30% in moisture content)
Annual	16,600 T (ditto)

2) Second stage of operation

Clay supply to plant:	110 T/D x 25 D/M x 12 M
Monthly	2,750 T (27-30% in moisture content)
Annual	33,000 T (ditto)
Clay production:	165 T/D x 25 D/M x 8 M
Monthly	4,125 T (30% in moisture content)
Annual	33,000 T (ditto)

3) Third stage

Clay supply to plant:	180 T/D x 25 D/M x 12 M
Monthly	4,500 T (27-30% in moisture content)
Annual	54,000 T (ditto)
Clay production:	270 T/D x 25 D/M x 8 M
Monthly	6,750 T (30% in moisture content)
Annual	54,000 T (ditto)

4-2 Stripping

To mine the total projected quantity of 900,000 T (430,000 m^3) of clay, 790,000 T (320,000 m^3) of overburden must be removed.

Since 100,000 m^3 of this stripping is removed in the initial construction period under the plan, required stripping per cubic meter of clay to be mined can be calculated to 0.48 m^3 (in terms of weight ratio, 790,000 T - 250,000 T : 900,000 T = 0.6 : 1).

4-3 Total Clay Production and Stripping

Based on a stripping ratio of 0.48 : 1, the average annual total excavation is as follows:

First stage of operation:

Clay	16,600 T
Overburden	9,960 T
Total	26,560 T

Second stage of operation:

Clay	33,000	T
Overburden	19,800	T
Total	52,800	T

Third stage of operation:

Clay	54,000	T
Overburden	32,400	T
Total	86,400	T

4-4 Mining Method

1) Mining method

The typical mining method is 5 m-high bench cut with shovel loader. Also the clay will be loaded by the same shovel loader on to truck for transportion to the stock yard.

Work in the mining pit will be conducted only in the dry season. When the pit levels drop below 880 mL, arrangements will be required to facilitate drainage during the four months of the rainy season.

Drainage will be performed by pumping up water from a sump to be provided in the pit.

The pit below 880 mL will need an approach from the road. Adjustment of its level as required according to changes in pit level will be made along with stripping work during the four-month period.

After 23 years, 900,000 T will have been mined, and the resulting final pit will extend about 300 m from north to south and about 100 m from east to west, with a maximum depth of 25 m from the level of the road.

This clay of 900,000 T represents the entire prospective reserves in the mining area of 300 m x 100 m x 25 m.

2) Stripping

Stripping 100,000 m^3 pre-mining of operation will remove the greater majority of overburden close to bentonite above 880 mL.

During the four months of the rainy season, stripping will be carried out in the area planned for mining during the subsequent eight months.

Compressive strength of the overburden (basalt) covering bentonite deposits is estimated at 200 to 500 kg/cm^2. Although fresh rocks probably exceeding 1,000 kg/cm^2 are found in places, RQD* is less than 20%. Thus the site presents favorable conditions with good ripperbility.

For these reasons, a ripper will be used to break rocks for stripping.

Rocks broken by ripper will be gathered by bulldozer or shovel loader and then loaded on to truck by shovel loader for transportation to the waste disposal area.

All equipment including bulldozer, shovel loader and truck will also be used during the following eight months of the dry season for mining clay bentonite.

Since stripping is performed during the four months of the rainy season, this work can cause rain water to flow into the pit more readily.

Note: * Rock Quality Designation

This in turn will increase the daily pump-up load for pit drainage throughout the four-month period, one of the major problems facing the execution plan.

Although the face during stripping work is liable to become irregular, bench cut will be the basic form; likewise for the actual clay mining.

3) Pit drainage and measures against inflow of water

Pit drainage will be performed by pumping up water collected in a sump to be provided in the bottom of the pit (the sump should be about 2 m in depth with an appropriate length and width).

The pump up plan will be made based on precipitation data recorded at Ipala.

The greatest daily rainfall was 19 mm recorded in September. Based on this recorded peak, the pump-up plan will be made on assumption that water will flow into the pit with a daily precipitation of about 20 mm.

If the pit space is considered to be an area subject to precipitation, this area will grow to 300 m x 100 m = 3 x 10^4 m^2 toward the end of the projected mining operation. This area corresponds to approximately 600 m^3 per day.

If the pit is submerged, the affected pit face will fall. Therefore, the plan calls for daily pumping up operation throughout the four months of the rainy season, even though work in the pit is suspended during this period.

The pump capacity shall have the capacity to drain 600 m^3 of water in six hours.

Ditch will be constructed and maintained in the vicinity of the pit to reduce pumping up work during the rainy season.

4-5 Loading and Transportation

Common loading and transportation machines will alternately be used for four months of stripping and eight months of clay mining. Shovel loaders will be used for loading and dump trucks for transportation.

Shovel loaders and dump trucks other than those for mining will be used for loading at the stock yard and transportation to the processing plant.

4-6 Mine Machinery

Heavy duty machinery for mining, loading and transportation will be provided, as well as incidental mining equipment such as pump, generator and compressor.

Table 4-3 shows a list of mine machinery to be used. Major specifications of each piece of equipment are as follows:

1) Bulldozer

The bulldozer shall be equipped with treads for swampy soil because it is likely to be used for bulldozing irregularities in the pit.

It shall be capable of mounting attachments including a ripper for stripping and a back-hoe for constructing ditch.

Tabel 4-3 Mine Machinery and Facilities

Description		Quantity and Specifications	
		Q'ty	Specifications
Machinery	Bulldozer	1 units(s)	25∿30 t-class with ripper and back-hoe attachments
	Shovel Loader	1 "	1.8 m^3 bucket capacity class for swamp
	Shovel Loader	1 "	1.0 m^3 bucket capacity class for swamp
	Truck	3∿7 "	10 t-dump
	Pump	2 "	1.0 m^3/min · 20 m-head
	Generator	3 "	10 kVA 2 units 3.5 kVA 1 unit
	Compressor	1 "	7 kg/cm^2, 5 m^3/min-class
	Jeep	1 "	6-seater class
	Water Wagon	1 "	1∿2 m^3
	Bus for Commuters	1 "	Passenger capacity of 20∿30
	Communication Equipment	1 "	(For exclusive use in communications with plant)
Facilities	Repair Shop	1 set(s)	130∿140 m^2 · 3 t-hoist, and pit
	Warehouse	1 "	15∿20 m^2
	Generator House	2 "	Only roof to be provided
	Stock Yard	1 "	950∿1,000 m^2 Only roof to be provided
	Office	1 "	60 m^2

Its weight shall be more than 25 t for ripping work to break basalt.

2) Shovel loader

The shovel loader shall be equipped with treads for swamp soil because of its application for clay mining.

For use in combination with a 10 t dump truck, the type of shovel loader should be determined so that its bucket capacity, weight and height when the bucket is raised will meet the truck's specifications.

3) Dump truck

Model should be selected in consideration of its use in combination with the shovel loader.

4) Back-hoe

The back-hoe to be attached to the bulldozer will be used mainly for construction and maintenance of ditch. Its bucket capacity should be decided based on the bucket width that will suit the dimensions of planned ditch.

5) Pump

The total pump capacity shall be capable of pumping an estimate daily peak of 600 m^3 in the rainy season in less than six hours. To meet the increased pit area in the years toward the end of the projected mining operation, two to three pump units will be required to operate simultaneously.

6) Generator and compressor

The generator shall have a sufficient generating capacity as a power supply to drainage pumps. For the compressor, small capacity models shall be selected for multi-purpose applications.

4-7 Mine Operation Cost (Tables 4-4, 4-5 and 4-6)

The mining cost consists of labor cost, equipment and material cost and overhead expenses. The total mining cost estimated based on the basic plan is $4.37/t for the first stage of operation, $4.16/t for the second and $3.62/t for the third.

The mining cost per product ton will be reduced with each succeeding stage. This is mainly because the labor cost, a fixed cost item, is reduced due to the economy of scale.

For costs by type of work, transportation cost is the highest in each of the three production stages, accounting for 44, 46 and 47% respectively.

Stripping and clay mining costs will gradually drop due to the economy of scale as production is increased.

Wages, the base of labor cost, will be estimated for employees under long-term contracts and short-term contracts separately.

The lowest wage level will be based on the minimum wage system in Guatemala.

Table 4-4 Mine Operation Cost

First Stage of Operation (1st to 6th year)

Production: 12,600 t/year

Cost by type of work $/t

	Strip-ping	Mining	Clay supply	Inci-dental	Total	
					Total	%
Fixed cost						
Labor	0.35	0.71	0.49	0.49	2.04	
Maintenance and others	0.08	0.15	0.36	0.04	0.63	
Sub-total	0.43	0.86	0.85	0.53	2.67	61
Variable cost						
Labor	0	0	0.21	0	0.21	
Maintenance and others	0.06	0.11	0.25	0.02	0.44	
Fuel, oil and grease	0.14	0.25	0.60	0.06	1.05	
Sub-total	0.20	0.36	1.06	0.08	1.70	39
Total						
Labor	0.35	0.71	0.70	0.49	2.25	52
Maintenance and others	0.14	0.26	0.61	0.06	0.07	24
Fuel, oil and grease	0.14	0.25	0.60	0.06	1.05	24
Total	0.63	1.22	1.91	0.61	4.37	
%	14	28	44	14		100

Table 4-5 Mine Operation Cost

Second Stage of Operation (7th to 12th year)

Production: 24,900 t/year

	Cost by type of work $/t					
	Strip-ping	Mining	Clay supply	Inci-dental	Total	
					Total	%
Fixed cost						
Labor	0.25	0.50	0.53	0.35	1.63	
Maintenance and others	0.10	0.15	0.37	0.08	0.70	
Sub-total	0.35	0.65	0.09	0.43	2.33	56
Variable cost						
Labor	0.02	0.03	0.16	0	0.21	
Maintenance and others	0.08	0.11	0.25	0.05	0.49	
Fuel, oil and grease	0.16	0.25	0.60	0.12	1.13	
Sub-total	0.26	0.39	1.01	0.17	1.83	44
Total						
Labor	0.27	0.53	0.69	0.35	1.84	44
Maintenance and others	0.18	0.26	0.62	0.13	1.19	29
Fuel, oil and grease	0.16	0.25	0.60	0.12	1.13	27
Total	0.61	1.04	1.91	0.60	4.16	
%	15	25	46	14		100

Table 4-6 Mine Operation Cost

Third Stage of Operation (13th to 23rd year)

Production: 41,700 t/year

	Cost by type of work $/t					
	Strip-ping	Mining	Clay supply	Inci-dental	Total	
					Total	%
Fixed cost						
Labor	0.15	0.30	0.43	0.21	1.09	
Maintenance and others	0.10	0.14	0.36	0.12	0.72	
Sub-total	0.25	0.44	0.79	0.33	1.81	50
Variable cost						
Labor	0.01	0.02	0.09	0	0.12	
Maintenance and others	0.08	0.10	0.25	0.08	0.51	
Fuel, oil and grease	0.16	0.24	0.58	0.20	1.18	
Sub-total	0.25	0.36	0.92	0.28	1.81	50
Total						
Labor	0.16	0.32	0.52	0.21	1.21	33
Maintenance and others	0.18	0.24	0.61	0.20	1.23	34
Fuel, oil and grease	0.16	0.24	0.58	0.20	1.18	33
Total	0.50	0.80	1.71	0.61	3.62	
%	14	22	47	17		100

5 Mine Facilities (Table 4-7)

The mining project consists of stripping clay mining, and transportation of clay supply to the processing plant.

To ensure smooth execution of these major operations, a stock yard, repair shop, generator house, waste disposal area and settling pond are required as well as incidental facilities including an office, warehouse, and water tank.

In addition, equipment for communications with the bentonite plant, water-tank car, and means of transportation including a commuter bus and jeeps are needed.

These facilities and equipment should be built or delivered in time for the relevant operating year according to the production plan.

Table 4-7 Major Mine Facilities

Description	Quantity and Capacity	
	Q'ty	Capacity
Stock yard	1 set	5,000T-10,000T-18,000T
Repair shop	1 set	Minor repairs
Generator house	2 sets	-
Waste disposal area	1 set	537,000 m^3
Settling pond	2-6 sets	40 m^3
Warehouse	1 set	-
Water tank	1 set	1-2 t
Office	1 set	-
Access road	Approx. 1.2 km	10 t-truck

5-1 Mine Facilities

1) Stock yard

The stock yard must have a capacity for continuing clay supply to the plant even during the four months of the rainy season when clay bentonite mining is suspended.

The stocking capacity required is 5,500 T (about 3,930 m^3 in volume when in stockpiled condition) for the first stage of operation, 11,000 T (about 7,860 m^3) for the second and 18,000 T (about 12,860 m^3) for the third.

The stock yard needs a roof which should have a sufficient clearance above the gound to allow a shovel loader to freely enter and leave the yard with its bucket held below the horizontal position.

2) Repair shop

Although this repair shop is primarily intended to effect minor repairs on machines, a 2-t class hoist will be installed in the shop building since there is need to handle large machines.

A pit will also be provided to facilitate inspection of the underside of vehicles.

The shop will be built immediately before the second stage of operation is commenced.

3) Generator house

This house will accommodate a generator for operation of drainage pumps for the pit.

The generator is a portable type so that it can readily be relocated as pumps are moved. Accordingly, the generator house should be a type that can be easily disassembled and reassembled.

4) Waste disposal area

The total stripping volume required for mining 900,000 T of clay bentonite is approximately 316,000 m^3. This volume will increase to 537,000 m^3 when overburden is broken with a ripper and transported to the waste disposal area by truck.

A space to accumulate this waste volume will be located in the valley on the northwest side of the pit and waste will be piled at a repose angle.

5) Settling pond

Pumped up drain water contains a large amount of sand which will deposit in the ditch and cause poor drainage.

Bacause defective drains are liable to damage roads around the pit, the pumped up water will be discharged into the ditch after large particles of earth and sand are allow to diposit in the settling pond.

The size of the settling pond should be about 40 m^3 (for example, 2 m wide x 10 m long x 2 m deep).

6) Incidental facilities

In the first stage of operation, houses in Los Cimientos will be rented for use as the office and warehouse. However, from in the second stage, independent buildings will be used for these purposes.

A resting room will be needed as welfare facilities of the mine. Facilities to be provided in either field office or repair shop will be used for resting.

A water tank with a capacity of about 1 m^3 will be installed for drinking water and other service water.

In the first stage of operation, jeeps will be used as means of transportation for commuters. As production is increased, a small bus will be operated for transportation of mine workers.

The office will be provided with wireless telephone for communication with the plant.

5-2 Construction Cost

The total investment over the entire project period is $2,674,000.* Of this amount, $2,553,000 (95%) is the cost of machinery and equipment. The remaining $121,000 (5%) will be used as the construction cost.

Of the facility equipment cost, $2,197,000 (86%) will be used for purchase of mine machinery including bulldozer, shovel loader, truck, pump, generator, and compressor, $172,000 (7%) for incidental equipment such as commuter bus, and jeep, $64,000 (3%) for office, repair shop and other buildings, and $120,000 (4%) for land.

The cost of pre-stripping accounts for $70,000 (58%) of the total construction cost.

Note: * Reserve funds not included.

6 Clay Transportation

One year's requirement of clay supply will be mined during the eight months of the dry season and will be transported through the stock yard to the plant for 12 months without interruption.

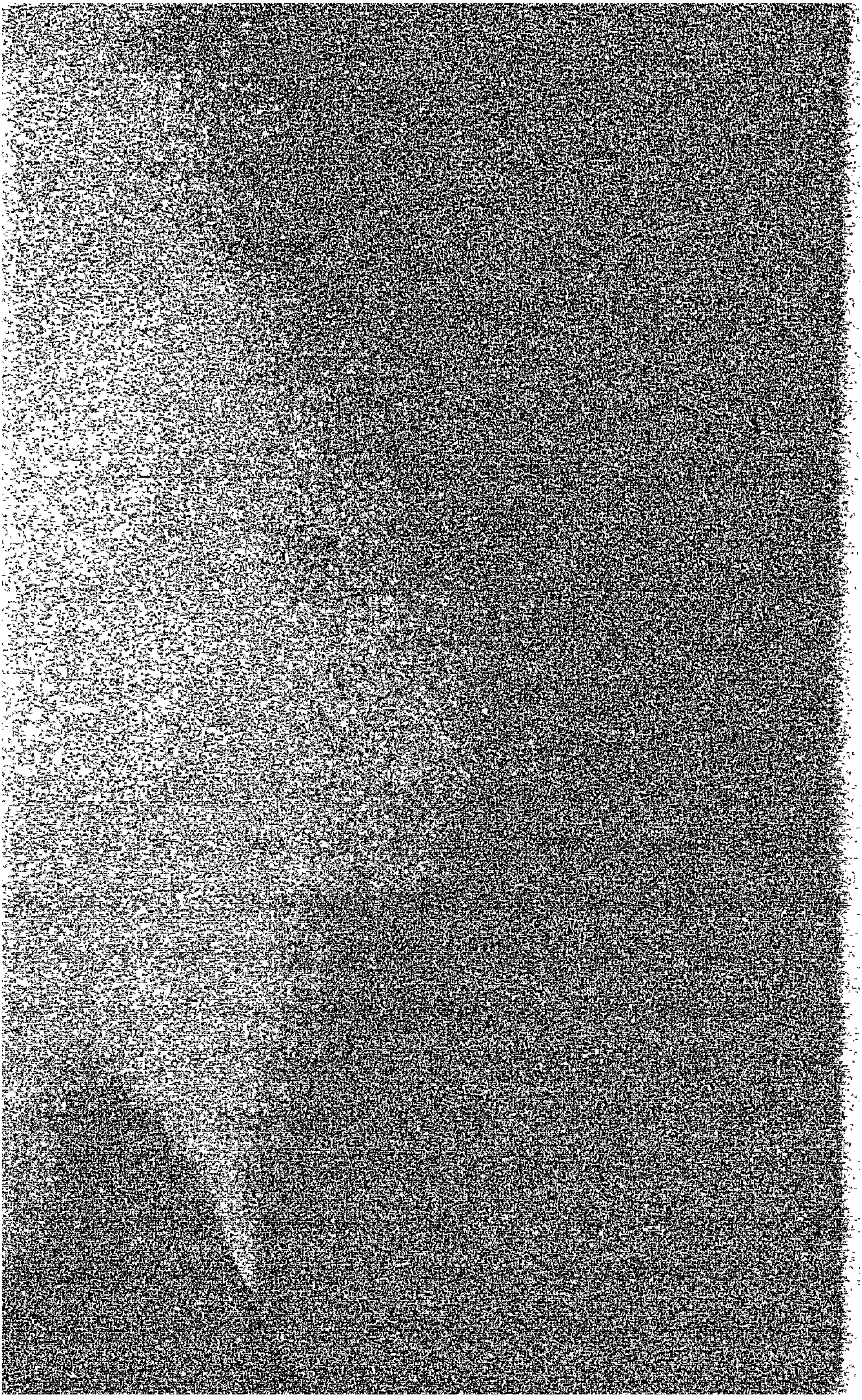
Stockpile in the stock yard will peak in May at the end of the dry season.

This peak amount will be equivalent to four months' production. Stock will nearly be deplated by September when the rainy season is over.

Clay will be loaded on to trucks by shovel loader and transported to the plant by 10-t class dump truck.

CHAPTER 5.

BENTONITE PLANT



CHAPTER 5 BENTONITE PLANT

This chapter will describe the location of the bentonite plant and basic requirements of the plant including its facilities and capacity. The plant will be constructed in Chiquimula.

Its facilities will include a production plant comprising a stock yard for crude clay to be supplied from the mine, stock bin, crusher, milling machine, dryer, bentonite hopper and other equipment. In addition, incidental facilities will be installed such as pump up equipment for underground water, office and analysis laboratory.

The capacity for the target production in the first stage of operation will be considered one plant. With this one plant as the base, a basic plan for shipping and transportation methods will be drawn up and required costs estimated.

Construction period of the plant will be set as two years. The plant will be operated for 300 days per year, and the number of plant and operating hours of the plant will be increased in stages.

For the first stage of operation, one plant unit will be operated for 11 hours per day on two shifts.

For the second stage of operation, two plant units will be operated for 11 hours per day on two shifts.

1 General Situation of Chiquimula

The city of Chiquimula is located in Chiquimula Department.

1) Location

Chiquimula is located at 89°33' west longitude and 14°48' north latitude, a straight-line distance of about 105 km to the east of Guatemala City.

Its road distance from Guatemala City via National Highway Nos. 9 and 10 is 185 km.

2) Traffic

Bus services are conveniently available between Guatemala City and Chiquimula via National Highway Nos. 9 and 10.

The railway that passes through Chiquimula is a trunk line but its transportation capacity is too small to be a convenient means of transportation.

Chiquimula is accessible from Guatemala is about three hours by jeep.

3) Precipitation

According to observatin data recorded for 36 years by Chiquimula observatory, the rainy season lasts four months from June to September.

From the records for 36 years, the mean annual precipitation is 646 mm. The monthly peak in the rainy season is 149 mm in June. The daily peak is 10 mm in June and September.

The total rainfall in the four-month rainy season accounts for 79% of the annual precipitation.

Table 5-1 Precipitation (Chiquimula)

M E S	ESTACION: 4.1.2. NOMBRE: Chiquimula F.I.C.A. MUNICIPIO: Chiquimula LATITUD: 14°47'50" LONGITUD: 89°32'08" ALTITUD: 380 mts. AÑOS DE REGISTRO: 36 P R E C I P I T A C I O N	
	T O T A L	D I A S
Enero	0.4	
Febrero	0.9	1
Marzo	1.5	1
Abril	10.1	1
Mayo	49.8	3
Junio	149.6	10
Julio	107.8	7
Agosto	112.4	8
Septiembre	140.4	10
Octubre	63.5	5
Noviembre	8.0	1
Diciembre	1.7	1
A N U A L	646.1	45°

ESTACION: 4.1.2 NOMBRE: CHIQUIMULA FEGUA DEPARTAMENTO: CHIQUIMULA

LATITUD: 14°47'50" LONG.: 89°32'08" ELEVACION: 380 Mts.

A Ñ O 1979

MES	T E M P E R A T U R A S					PRECIPITACION mm.		HUMEDAD RELATIVA %
		Promedios de		Absolutas				
	Media	Máxima	Mínima	Máxima	Mínima	Total	Días	Media
Enero						0.0	0	
Febrero						0.0	0	
Marzo						11.4	2	
Abril						34.3	3	
Mayo						201.9	7	
Junio						180.3	8	
Julio						138.4	13	
Agosto						227.3	10	
Septiembre						231.1	13	
Octubre						59.7	6	
Noviembre						0.0	0	
Diciembre						12.7	1	
ANUAL						1094.1	63	

Source: Ministerio de Comunicaciones y Obras Publicas Guatemala, C.A.

4) Temperature and humidity

From results of observation for 24 years, higher temperatures prevail over a period from immediately before to the beginning of the rainy season. Monthly average in the rainy season is 34°C to 35°C. The highest temperature was 35.2°C recorded in May. The coldest month in the year is December, the mid-point in the dry season. Monthly average for the dry season is 29.1°C. The lowest temperature was 17°C recorded in January.

Humidity is high in the latter part of the rainy season, September to October, with 74% in monthly average. Humidity drops in the latter part of the dry season, April to May, with the lowest monthly average being 59% in April.

5) Population

The population of Chiquimula is said to be 60,000.

6) Education

Education is very active and there are 325 establishments from kindergartens to junior high schools.

The number of pupils in grades one through six in the city area is said to be 3,518, and that of teachers 115.

It is recorded that the number of pupils and students will amount to 8,221 if high school students and students of a normal school who enroll from junior high schools, as well as students of vocational schools such as accounting and secretarial training are included.

There is also a vocational training center in Chiquimula where skilled workers are being trained. It will be possible to recruit skilled workers from this center for this project.

Table 5-2 Temperature, Humidity (Chiquimula)

ESTACION: 4. 1. 1. NOMBRE: Chiquimula MUNICIPIO: Chiquimula

LATITUD: 14°47'55" LONGITUD: 89°32'48" ALTITUD: 423.82 metros.

AÑOS DE REGISTRO: 24

MES	TEMPERATURAS °C					PRECIPITACION		HUMEDAD RELATIVA %
		PROMEDIOS DE		ABSOLUTAS				
	Media	Máxima	Mínima	Máxima	Mínima	total mm.	Dias	
Enero	24.3	29.8	17.0	35.0	10.5	0.5	1	67
Febrero	25.4	30.2	17.8	35.3	12.0	0.1	1	67
Marzo	26.6	34.0	19.8	39.7	16.1	1.5	1	62
Abril	28.5	34.7	21.3	39.9	16.5	5.2	1	59
Mayo	28.7	35.2	21.6	38.4	18.2	39.1	3	62
Junio	27.3	32.9	21.4	38.8	18.5	122.6	8	69
Julio	26.6	32.2	20.7	36.0	18.0	94.0	6	68
Agosto	27.0	33.1	20.7	36.0	18.3	95.5	7	68
Septiembre	25.4	31.8	20.5	35.9	17.7	122.5	9	74
Octubre	26.5	31.5	20.0	35.7	17.5	52.8	4	74
Noviembre	24.6	29.7	18.2	35.9	12.0	4.4	1	72
Diciembre	24.2	29.1	27.6	35.1	10.5	0.8	1	70
ANUAL	26.3	32.0	19.7	39.9	10.5	539.2	39	68

Source: Ministerio de Comunicaciones y Obras Publicas Guatemala, C.A.

7) Life

The populace enjoys reasonably good living standards with adequate food, clothing and shelter on earnings mainly from agriculture and related activities in Chiquimula and vicinity.

8) Labor force and wages

Chiquimula can supply the labor force necessary for the bentonite plant.

Wages will be determined according to the existing minimum wage system enforced by law or generally accepted wage bases.

9) Road conditions

National Highway No. 10, which runs through the eastern part of Chiquimula, and major roads in the city are all paved.

10) Railways

Chiquimula station is situated at 380 m above sea level, 238 km away from San Salvador and 29 km away from Zacapa.

A combination train is operated about once a week but it is said the schedule is not reliable.

The rail is 30 kg/m, the rail gauge 914 mm, tie spacing 60 to 80 cm, and dimensions of ties 15 cm x 20 cm x 2.0 to 2.2 m. Railway maintenance is poor with worn rails, irregular rail gauge and cant, and insufficient securing of rails to ties.

Because its topography is quite hilly, Guatemala places top priority on development of roads, assigning railways a much more limited role.

Consequently, in the study of transportation problems for this project, the use of railways is not considered.

11) Power supply

As of 1981, Chiquimula is supplied with 3.4 kV, 2,000 kW power. In two years, this supply will be increased to 6.9 kV, 5,000 kW power.

INDE has been implementing a major project for increasing power transmission capacity. Under this plan, the loop line connecting Guatemala, Progreso, Zacapa, Chiquimula, Jalapa and then Guatemala will be completed. The section up to Zacapa is scheduled for completion by around June 1982. By two years later, the transmission line from Zacapa will be extended to Chiquimula.

As of 1981, power consumption in Chiquimula is 1,200 kW. Demand for power is expected to grow at an annual rate of 15%.

Upon completion of the transmission line between Zacapa and Chiquimula two years later, transmission capacity will be increased to 20,000 kW. Power transmission service can be started when expansion work has been completed at Aguacapa and Chixoy power stations.

In relation to INDE's power supply plan, the bentonite plant will require 530 kWH per unit plant. This requirement can be met with the existing power supply capacity.

12) Groundwater

Chiquimula City is situated in the near-center of a basin elonging in NNE-SSW and on the alluvial fan on the left bank of the San José river.

The basin is about 15 km in long diameter and about 5 km in short diameter, and the San José river flows to NNE in the center of the basin.

The basin is constituted of continuations and overlappings of many broad alluvial fans, and a large quantity of sand and gravel is supplied at present from the wall around the basin in rainy season.

The proposed site for a bentonite processing plant is situated on the northeastern end of the urban area of Chiquimula City and near the branching point of a tributary of the San José river.

The proposed site, which is situated between rivers of about 700 m north and about 1 km south both with over 17 km length and is composed of permeable bed of sand and gravel, is geographically and geologically favorable for collecting groundwater.

2 Location of Bentonite Plant

The bentonite plant will be built in the northeastern part of Chiquimula.

2-1 Requirements for Plant Location

Requirements for plant location are as follows:

1) Proximity to markets in distance and time
2) Convenient road conditions for transportation
3) Proximity to ports of shipment and borders for exports
4) Availability of required power supply
5) Free access to sources of fuel, oil and lubricants
6) Easy availability of labor

7) Availability of water supply

8) Easy acquisition of required land

9) Away from densely populated areas

2-2 Candidate Sites for Plant Location

Candidate sites sati fying all these conditions for plant location are found in both Chiquimula and Zacapa.

Chiquimula and Zacapa are 20 km apart from each other. Both cities are linked by National Highway No.10 and also close to No.9.

Guatemala is 153 km from the junction of Nos.9 and while Santo Tomás, the port of shipment on the east coast, is 164 km away. Thus, the road junction is situated nearly midway between both points.

The distance from Guatemala to San José, the port of shipment on the west coast, is about 80 km. This port is 233 km away from the junction of National Highway Nos.9 and 10.

Both cities are also close to the borders with Honduras or El Salvador. National Highway No.10 crosses the border with Honduras and No.9 the border with El Salvador. Consequently, both markets are only a short distance away if bentonite is to be exported overland.

After comparison between Chiquimula and Zacapa, it has been concluded that Chiquimula will offer more advantages as the proposed site of the bentonite plant. The major reason for this decision is that Chiquimula is situated in the same administrative area (Chiquimula Department) as Los Cimientos, where the bentonite is mined.

3 Bentonite Plant

The bentonite plant will be expanded in a staged production plan. The capacity for required production in the first stage of operation will be assumed to be one plant unit facilities. Based on this unit, the basic production will be formulated and required construction cost for this plan will be estimated.

3-1 Bentonite Plant Facilities

Typical facilities of plant, in production flow, are crude stock bin - feeder - belt conveyor - crusher - belt conveyer - mixer-extender - dryer - belt conveyer - mill - cyclone - bentonite hopper.

Additionally, a stock yard for about five days supply will be needed on the crude receiving side, and a packing machine and product warehouse for about five days production on the bentonite hopper side.

3-2 Production Capacity of Plant

The bentonite plant will be operated for 300 days per year, and production capacity per unit will be set as 5 T/hour in crude supply and 3.85 t/hour in bentonite.

In the first stage of operation, one unit will be operated in two shifts for 11 hours to produce 42 t/day and 12,000 t/year.

In the second stage, two units will be operated in two shifts for 11 hours to produce 83 t/day and 24,900 t/year.

In the third stage, three units will be operated in two shifts for 11 hours to produce 139 t/day and 41,700 t/year.

3-3 Incidental Facilities of the Plant

Incidental facilities of the plant will include underground water pumping equipment, office and analysis laboratory. In addition, pumps, trucks for shipment, jeeps and communication equipment will be needed as machinery.

1) Pumping up equipment for underground water

A 100 m-deep well will be drilled to obtain underground water and the required volume of water will be pumped up with a capacity of about 0.5 to 1.0 m^3 per minute. This water will be used in cooling compressors at the plant, as service water for the mine, and for many other purposes.

The area around the proposed site of the plant is formed by alluvial layers of gravel and sand. Thus, geographically and geologically, this area is suited for obtaining underground water.

2) Office and analysis

The office will be provided with functions to control plant operation, as well as headquarters functions to make a general supervision of clay mining, bentonite production and marketing. In addition, an assay laboratory will be installed to check product quality.

3) Pump and water tank

Pumped up water will be stocked in a water tank of about 1 m^3 capacity. The pump will automatically be operated as the water level in the tank changes.

A safety device will be installed on the pump to automatically stop its operation when the water level in the well drops.

4) Delivery truck

To estimate required amount of investment, the trucking plan will be made on the assumption that products will be transported over a distance of about 200 km from the plant.

Bentonite will be packed either in a 1-ton flexible container or in 25 kg bags. The loading capacity of the truck will be assumed to be 15 t.

The truck can make one trip per day for transportation, considering its loading capacity of 15 t, loading and unloading time, and time required for travelling 200 km.

5) Communication equipment

The wireless telephone will be used exclusively for communications with the mine.

3-4 Construction Cost

The investment for the entire project period will amount to $11,612,000.*

Of this total, purchases of equipment and facilities account for $10,810,000 (93%). The rest, $802,000 (7%), is construction cost.

The equipment and facilities down broken into : $7,794,000 (72%) for production plant; $2,900,000 (27%) for pumping up equipment, delivery truck, jeep, communications equipment; $44,000 (<1%) for office and laboratory buildings; and $72,000 (<1%) for acquisition of land.

Note: * No reserve funds included.

Of the construction cost, \$747,000 (93%) will be used in building the bentonite plant.

Table 5-3 Bentonite Plant Machinery and Facilities

Description		Quantity and Specifications	
		Q'ty	Specification
Machinery	Plant	1-3 unit(s)	Receiving, crushing, milling, drying, etc.
	Delivery Truck	3-10 "	15 t-class conventional truck
	Jeep	1 "	6-seater
	Pump	1 "	1 m^3/min.
	Communication Equipment	1 '	(For communications with mine)
Facilities	Office	1 set	Concurrently serving as head offices
	Laboratory	1 "	To be provided in office

Table 5-4 Major Items of Facilities for Bentonite Plant

Description	Quatity and Capacity	
	Q'ty	Capacity
Plant	1-3 unit(s)	Crude supply per unit 5 t/hr.
Pump	1 set	1 m^3/min.
Office	1 "	-
Laboratory	1 "	-

CHAPTER 6.

BENTONITE PRODUCTION

CHAPTER 6 BENTONITE PRODUCTION

This chapter will describe production process and basic points of production.

Under the staged production plan, the number of plant units will be increased and plant operation hours adjusted for bentonite production.

1 Production Plan

In the first stage of operation, the plant will produce 42 t/day, 1,050 t/month, and 12,600 t/year. In the second stage of operation, the plant will produce 83 t/day, 2,075 t/month, and 24,900 t/year. In the third stage of operation, the plant will produce 139 t/day, 3,475 t/month, and 41,700 t/year.

2 Production Process

Crude clay supplied from the mine is fed through hopper, feeder and conveyer to roll crusher, where crude clay is crushed into sizes suitable for drying.

Crushed crude clay is mixed with the activation reactor and then sent to the rotary dryer.

Dryed crude clay is pulverized by roller mill and fraction in required particle size is collected by cyclone.

The product is fed through bucket elevator and screw conveyor to hopper (Fig 6-1).

The particles are small enough to penetrate a 200-mesh screen (74 μ).

The moisture content is 30% for crude clay in the pit and 27% to 30% for crude clay when supplied to the plant.

It will be assumed that the moisture content will be reduced to about 7%* for the final product.

The temperature of heated air of the dryer will be 600°C to 700°C at its inlet and 100°C to 200°C at its outlet.

The plant operation will be completely automated.

3 Properties and Applications

Clay bentonite in Los Cimientos can be processed into bentonite for a wide range of applications at the bentonite plant by activation reactor.

Its swelling property, cation exchange capacity, coking property, thixotropy, etc. can be exploited for its application to bond for molding sand, muddy water for drilling and civil foundation work and carrier for agricultural chemicals and fertilizers.

Applications to fillers for paints, ink and cosmetics can also be developed because of its whiteness and high viscosity.

Its low consistency and high viscosity in the form of muddy water will make it suitable for use as oil-well drilling muds.

Note: * The moisture content of the product is estimated to be about 7% to 12%. The lowest value of 7% was assumed for this study.

Which of these properties is to be exploited or for which particular applications bentonite is to be produced will call for an overall judgement based on a specific mining and production plan as well as a business and marketing plan. The execution plan on mining and production will require results to be obtained from a considerably detailed survey of bentonite deposits in Los Cimientos and an additional analysis of bentonite properties.

4 Quality Control

Two methods of quality control are available: One method is to check directly products and the other to control the quality of crude clay to be supplied to the plant.

The direct quality control method consists of obtaining samples from products processed by the cyclone and analyzing a few items of the required properties for the intended application.

Complete quality control for the bentonite production project will require accurate supply to the plant of crude clay that has particular properties demanded under the production plan.

Thus much severe control of crude clay supply will be needed depending on relations between the production plan and available properties of bentonite in natural condition.

The reason for this particular requirement will be explained by citing an example below.

Analytical data on swelling property, CEC*, apparent viscosity, plasticity viscosity and yield value confirm that both samples P4-1 and P15-1 are bentonite ores of the highest grade and are suited for use as oil-well drilling muds. However, samples mined in the area adjacent to where P4-1 and P15-1 occur have no equivalent properties.

Note: * Cation Exchange Capacity

Consequently, if bentonite for oil-well muds is to be produced, it will be required that crude clay with properties equivalent to either P4-1 or P15-1 be supplied to the bentonite plant.

In other words, the production plant will be required to make a production plan to supply the product meeting a sales plan and then to instruct the mine to supply crude clay of the specified quality.

In such case, required crude clay control can be made possible by systematically mining clay by grade (properties) in the pit.

5 Transportation of Products

Products will be transported both in bulk in a 1 t-flexible container and in 25 kg bags.

To estimate production cost, transportation distance will be assumed to be 200 km.

At a distance of 200 km from the bentonite plant, Guatemala City and the export port of Santo Tomás are situated.

For transportation, a conventional 15 t truck will be used.

6 Organization and Personnel Plan for Bentonite Plant

The organization required for operation of the bentonite plant will be assumed as shown in Fig. 6-2.

Functions required for production and shipment will include automated plant operation, packing, transportation, and quality

Fig. 6-1 Typical Flow Sheet for Bentonite Processing Plant

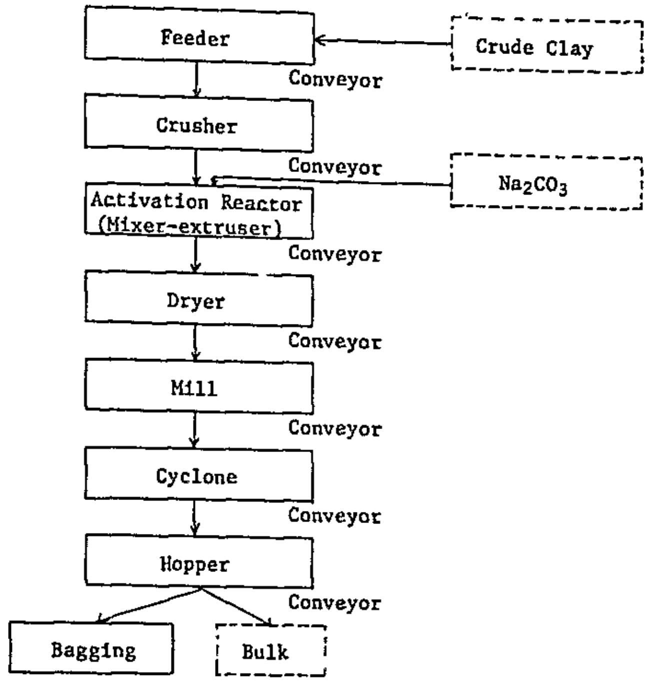
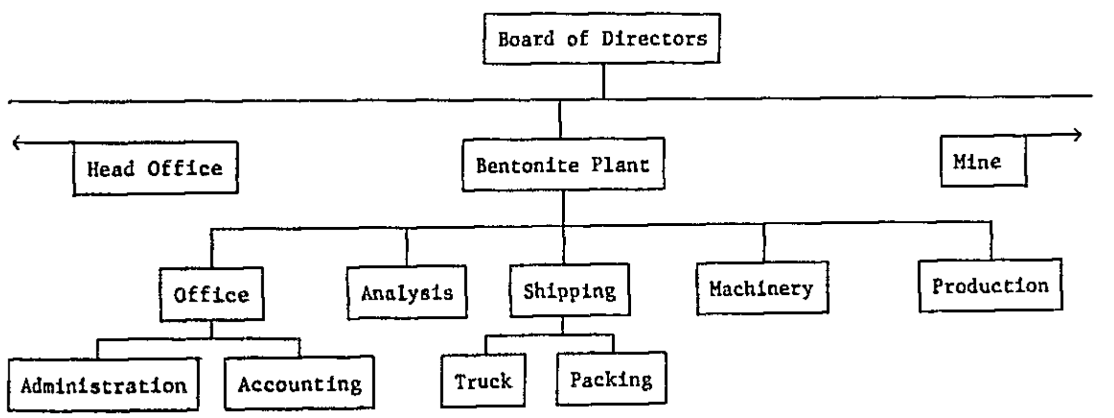


Fig. 6-2 Organizational Chart of Plant with Number of Personnel



1st-stage of operation 17 persons

2nd-stage of operation 24 "

3rd-stage of operation 35 "

control. Accounting, administration and other clerical work will also be needed as incidental functions.

Personnel required to perform these functions will be planned as shown in Fig. 6-2.

Productivity per head (excluding packing and transportation) will be 4.2 t/day for the first stage of operation, 12 t/day for the second stage, and 15 t/day for the third.

7 Operation Cost of Bentonite Plant

The operation cost of the bentonite plant comprises labor cost, equipment and facilities cost, and overhead expenses. The total operation cost will be $53.22/t for the first stage of operation, $52.54/t for the second and $50.92/t for the third.

The operation cost per product ton will be reduced as stages advance mainly because the fixed cost of labor decreases due to the economy of scale.

By type of work, the production cost will account for the greater majority of the total operation cost. Its share will grow from 93% to 95% and then to 96% as stages advance. This is because the utility consumption cost increases with the expansion of operation.

Wages, the base of labor cost, will be estimated by dividing wages of employees under long-term contracts and those under short-term contract.

The lowest base of wages will be obtained based on the minimum wage system in Guatemala.

Table 6-1 Operation Cost of Bentonite Plant

First Stage of Operation (1st to 6th year)

Production: 12,600 t/year

Cost by type of work $/t

	Production	Shipping	Analysis	Incidental	Total	%
Fixed Cost						
Labor	0.62	1.34	0.41	1.09	3.46	
Maintenance & Spare Parts	0.68	0	0	0	0.68	
Utility Consumption	10.34	0	0	0	10.34	
Others	0.29	0	0	0	0.29	
Sub-total	11.93	1.34	0.41	1.09	14.77	28
Variable Cost						
Labor	0	0.10	0	0.10	0.20	
Maintenance & Spare Parts	1.59	0.17	0	0	1.76	
Utility Consumption	24.09	0.40	0	0	24.49	
Others	12.00	0	0	0	12.00	
Sub-total	37.68	0.67	0	0.1	38.45	72
Total						
Labor	0.62	1.44	0.41	1.19	3.66	7
Maintenance & Spare Parts	2.27	0.17	0	0	2.44	5
Utility Consumption	34.43	0.40	0	0	34.83	65
Others	12.29	0	0	0	12.29	23
Total	49.61	2.01	0.41	1.19	53.22	
%	93	4	1	2		100

Table 6-2 Operation Cost of Bentonite Plant

Second Stage of Operation (7th to 12th year)

Production: 24,900 t/year

	Cost by type of work $/t					
	Production	Shipping	Analysis	Incidental	Total	
					Total	%
Total						
Labor	0.52	1.13	0.21	0.55	2.41	
Maintenance & Spare Parts	0.68	0	0	0	0.68	
Utility Consumption	10.45	0	0	0	10.45	
Others	0.29	0	0	0	0.29	
Sub-total	11.94	1.13	0.21	0.55	13.83	26
Variable Cost						
Labor	0	0.10	0	0.05	0.15	
Maintenance & Spare Parts	1.60	0.17	0	0	1.77	
Utility Consumption	24.39	0.40	0	0	24.79	
Others	12.00	0	0	0	12.00	
Sub-total	37.99	0.67	0	0.05	38.71	74
Total						
Labor	0.52	1.23	0.21	0.60	2.56	5
Maintenance & Spare Parts	2.28	0.17	0	0	2.45	5
Utility Consumption	34.84	0.40	0	0	35.24	67
Others	12.29	0	0	0	12.29	23
Total	49.93	1.80	0.21	0.60	52.54	
%	95	3	1	1		100

Table 6-3 Operation Cost of Bentonite Plant

Second Stage of Operation (13th to 23rd year)

Production: 41,700 t/year

	Cost by type of work $/t					
	Produc-tion	Ship-ping	Analy-sis	Inci-dental	Total	
					Total	%
Fixed Cost						
Labor	0.31	1.09	0.12	0.32	1.84	
Maintenance & Spare Parts	0.62	0	0	0	0.62	
Utility Consumption	10.22	0	0	0	10.22	
Others	0.29	0	0	0	0.29	
Sub-total	11.44	1.09	0.12	0.32	12.97	25
Variable Cost						
Labor	0	0.09	0	0.03	0.12	
Maintenance & Spare Parts	1.43	0.17	0	0	1.60	
Utility Consumption	23.83	0.40	0	0	24.23	
Others	12.00	0	0	0	12.00	
Sub-total	37.26	0.66	0	0.03	37.95	75
Total						
Labor	0.31	1.18	0.12	0.35	1.96	4
Maintenance & Spare Parts	2.05	0.17	0	0	2.22	4
Utility Consumption	34.05	0.40	0	0	34.45	68
Others	12.29	0	0	0	12.29	24
Total	48.7	1.75	0.12	0.35	50.92	
%	96	3	1			100