of the drill cores. The Perau ore horizon shows an almost monoclinic structure, and no disturbance of a geologic structure can be observed.

1–2 Ore Deposits

1–2–1 Perau Deposit and New Ore Deposit

(1) Perau Deposit

The Perau deposit, a lead ore deposit, is emplaced harmoniously in limestone and/or dolomite to carbonate schist (AIIs) of the Açungui I formation in a strata-bound form.

The underground and drilling explorations have so far confirmed the extent of mineralization to about 800 m at one level and about 120 m along the dip. The main ore body lies between G_1 and G_2 levels, with a scale of about 350 m (strike side) x 120 m (dip side). It has several ore shoots, repeating swell and pinch, and its lower limit is about the G_2 level about 120 m below the surface (Fig. II–1–4, II–1–6).

The characteristic of the ore mineral assemblage of the Perau deposit is that the main components of galena and pyrite, and subordinate chalcopyrite and sphalerite can be observed with the naked eye. Pyrrhotite, marcasite and tetrahedrite can be seen under the microscope.

Galena and pyrite are arranged harmoniously with the bedding of the country rock, showing a stratiform. Galena sometimes fills the cracks in the wall rock and pyrite as a mobile fluid, forming "hanekomi" (meaning plunging into) which consists of coarse-grained galena cutting the structure of the ore bed and wall rock.

(2) New Ore Deposit

The new ore deposit, discovered by the collaborative survey of Japan and Brazil, is a strate-bound deposit (dipping 25° to 30°) of barite-sulfide (galena, sphalerite and iron sulfide ore) emplaced in limestone and/ore dolomite to carbonate schist (AIIs) of the Açungui I formation. It is located in the western side of the Perau deposit.

The new ore deposit is considered to be distributed almost in the same horizon as that of the Perau deposit. However, the new deposit is characteristically accompanied by a large quantity of barite and contains a greater quantity of sphalerite. Therefore, it is likely that the minerals were crystallized and deposited from an ore solution of a different nature.

Although the new deposit can on the whole be stratigraphically regarded to be the same horizon as the Perau deposit, it is thought that mineralization of the barite-sulfide zone is followed by that of the Perau deposit and that the zone lies in a small upper horizon, because, in the hole AG–01, the mineralized zone of the Perau-type deposit (which is not accompanied with barite and sphalerite) was encountered immediately below the barite-sulfide zone, and because a barite-galena zone is found at the G_2 level of the Perau mine several meters above the horizon of the Perau deposit.

The geological cross sections produced from the drill data are shown in Fig. II–1–5. The details of mineralization of each hole are as follows.

Hole AG–01; The section between 255.95 m and 263.45 m was a barite-sulfide zone, the grade of BaO ranges from 15 to 27 %, others minerals contain about 4 % lead, about 3 % zinc, about 100 g/t silver and 100 to 500 ppm copper.

In the mineralized zone (263.45 – 269.90 m) under the barite-sulfide zone, in which barite is absent, lead grade is from 2.3 to 3.0 %, while copper is very low in content, and silver grade is from 60 to 100 g/t, showing a similar pattern to the Perau deposit.

Hole AG–02; The barite-sulfide zone is found in two sections at 242.85 m to 247.85 m and 251.40 m to 253.60 m. In the upper mineralized zone, lead grade is 5 %, whilst zinc grade is less than 1 %. Silver grade is about 90 g/t, and copper grade is 45 to 480 ppm, showing a considerable variation. Copper is higher in grade in the carbonate rock in the upper section, partly showing 1.2 % Cu.

Lead and zinc grades are almost the same in the mineralized zone between 251.40 m and 253.60 m, indicating that zinc is higher in grade than in the upper mineralized zone.

Hole AG–03; The mineralized zone becomes poor, showing an appearance of a marginal part of the ore deposit. Both Zn and BaO grades are low and the mineralized zone shows a similar pattern of the Perau deposit.

Hole AG–04; The mineralized zone becomes poorer, and it was encountered in three sections which are 196.95 to 197.15 m, 199.80 to 199.90 m and 200.65 to 200.75 m. The first one is a barite-sulfide zone and the rest contain only galena.

Hole AG–05; A barite-sulfide zone was encountered between 354.65 m and 358.35 m. The sections rich in ore minerals are found between 354.65 m and 355.65 m and 357.85 m to 358.35 m, but the mineralized zone is thin compared with those of AG–01 and AG–02, showing close to the margin of the deposit.

Hole AG–06; A barite-sulfide zone was encountered between 327.55 m and 329.40 m. More pyrrhotite is observed in comparison to other holes. This mineralized zone is notably poor both in grade and thickness when compared with those in the Holes AG–01 and AG–02, suggesting a marginal part.

1–2–2 Potential of Ore Deposit

(1) Potential and Ore Reserve of Perau Deposit

The scale of the Perau deposit in operation is approximately 350 m in strike length and approximately 120 m in dip length. Local swelling and pinching are repeatedly observed in the deposit, which is consequently separated into several bonanzas. The lower limit relating the bottoms of the bonanzas is almost parallel to the ground surface (Fig. II–1–6).

The ore reserves of the Perau mine in 1983 reported to DNPM are as follows.

Proved ore	283,056 tons
Probably ore reserve	315,462 "
Possible ore reserve	91,020 "

Systematic sampling, analysis and sketch underground must be carried out continuously in order to obtain the basic data for the ore reserve calculation. However, such work has not been done in the Perau mine.

Although the calculation of ore reserve is made once a year by a geologist of the Panelas mine, the reliability of the calculation for ore reserve would be low because of difficulty in precise calculation of ore reserve due to insufficient data, as mentioned above.

The main part of the ore deposit above the G_2 level has been mined out. Therefore, the places where the minable ore remains are at the southern end of the ore deposit and in the northern part of the G_2 level.

The proved ore reserve mentioned above seems to include the ore reserves remaining in these parts, and there is a possibility of overestimate.

Since the lower limit of the ore deposit is around the G_2 level, as evidently shown in Fig. II–1–6, it is difficult to expect an increase of ore reserve above this level. It is, therefore, necessary to develop the lower part of the deposit without delay to continue a stable operation of the Perau mine.

Although tunneling exploration was carried out on the G_4 level (Fig. II–1–4) about 300 m north of the mouth of the G_2 level, it is being suspended without encountering any promising deposit.

A drill survey in the neighborhood the Perau mine was conducted in the past, and the mineralized zones in the holes of sp–4, sp–17 and sp–8 were hit. However, spacing of these holes ranged from 50 m to 100 m, which seems too wide to take the bonanza of the Perau deposit (30 m x 50 m) into consideration, with a possibility of failure in intersecting bonanza. It will be necessary to confirm the correct position of bonanza by a detailed drill survey with a spece of 20 to 30 m underground as well as on the surface. When continuing the prospecting by tunneling

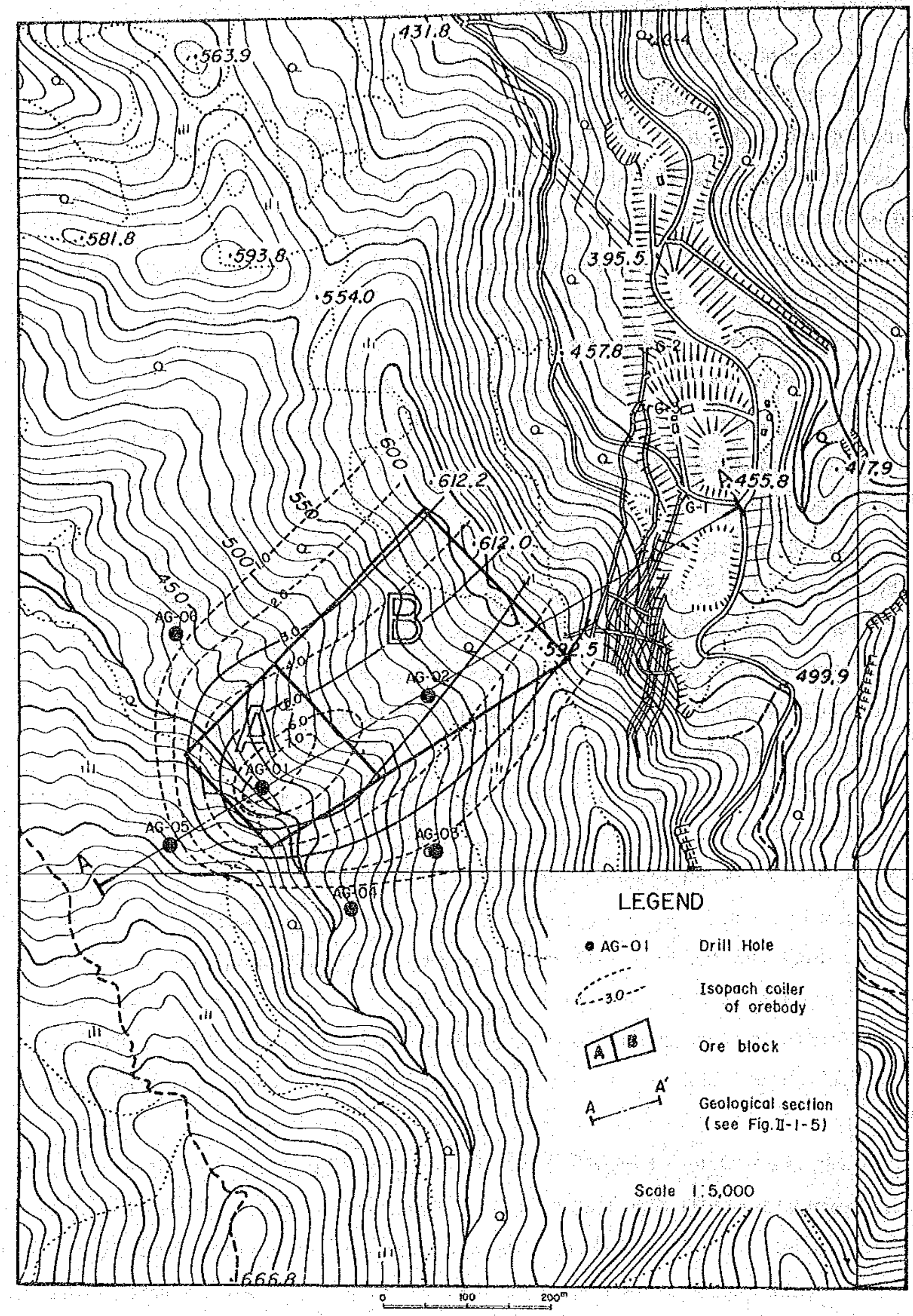


Fig. II–1–4 Isopack Map of Ore Body and Block of Ore Reserve

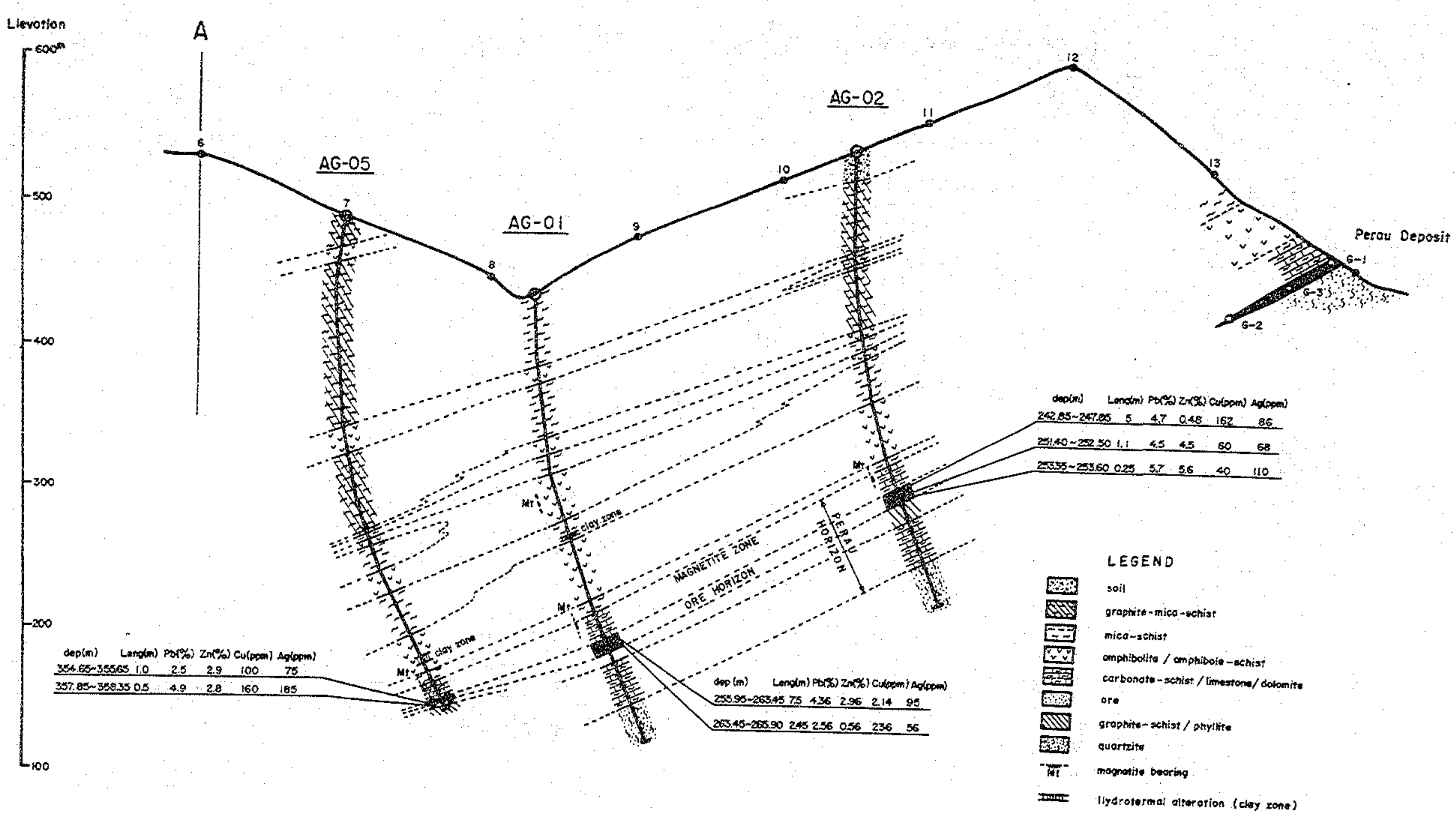


Fig. II–1–5 Geological Profile of Perau Deposit

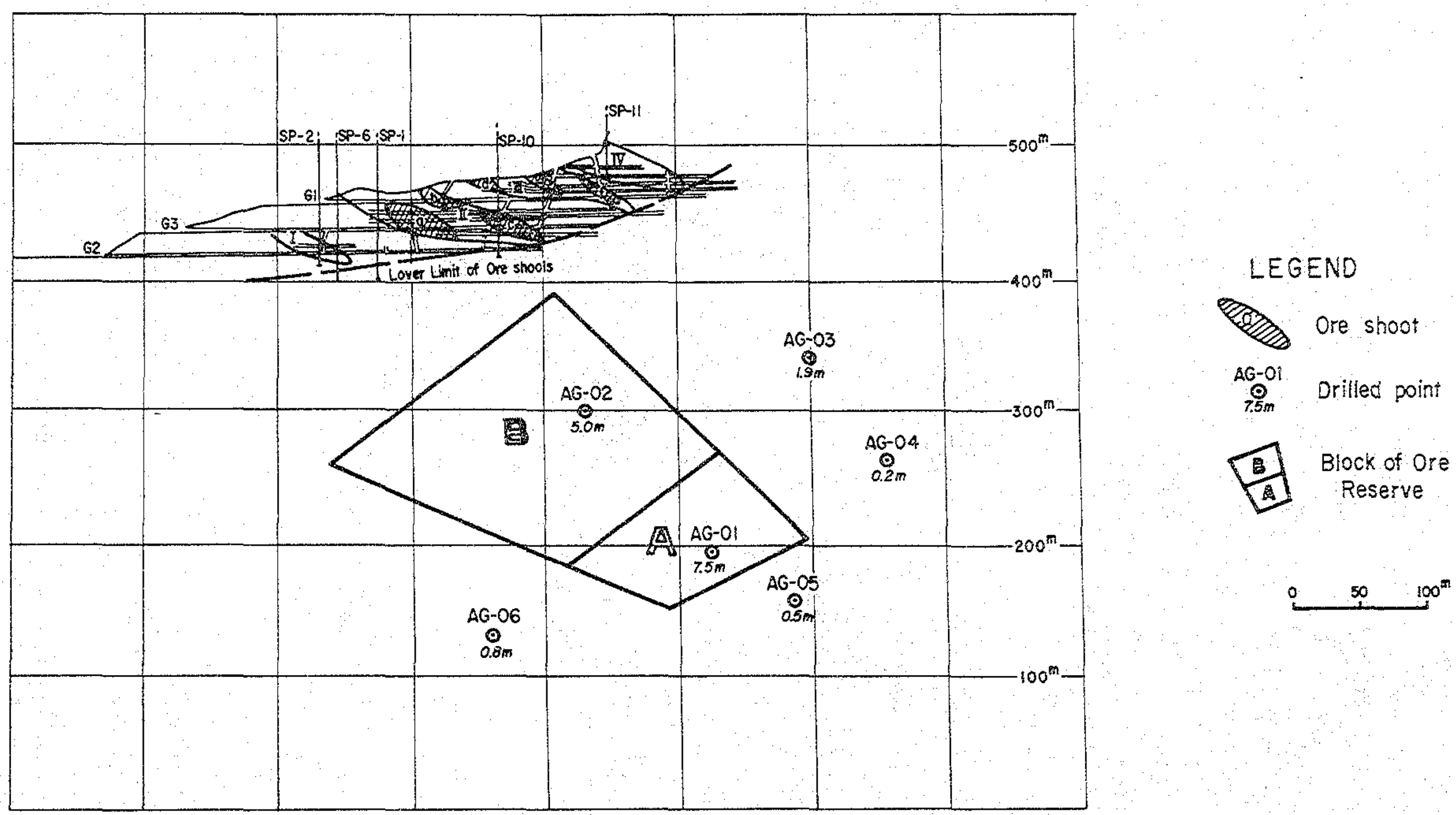


Fig. II–1–6 Longitudinal Section of Perau Deposit on the G_4 level, it is important to drift the tunnel after clarifying the accurate ore horizon by carrying out the geological survey underground.

It is expected that the proved and probable ore reserves will increase and the accuracy of ore reserves will be improved by the above mentioned exploration.

(2) Potential and Ore Reserve of New Ore Deposit

The ore reserves of the new ore deposit of the Perau mine were tentatively calculated, by referring to existing drilling data. The new ore deposit was discovered by six drilling holes, conducted by the collaborative survey of Japan for Brazil, over four years from 1980 to 1983.

All the six holes intersected the ore body. Among these, the holes AG–01 and AG–02 drilled the central part of the ore deposit, and the rest, the peripheral part of the deposit.

The isopach map of the deposit, drawn on the basis of the data of these holes, is hown in Fig. II–I–6. The map indicates that the ore shoot extends northeasterly with the holes AG–01 and AG–02 as the center and that both the grade and the thickness become poor toward the other holes.

The space of these drill holes is as wide as 150 to 200 m, and even if the deposit keeps a sufficient persistence from the nature of strata-bound deposit, more drilling data are necessary for evaluation of the ore deposit and calculation of the ore reserve. Therefore the calculation at this time is no better than a tentative trial calculation.

The method of calculation applied this time is as follows.

1) Ore Block

The ore block was established in the extention of the ore deposit more than 3 m thick, referring to the isopach map (Fig. II–1–4), and it was divided into two blocks, A (a more probable, level distance = 60 m) and B (a probable, level distance = 120 m).

The widths and grades used for the calculation were selected from the better part of the mineralized zones which were encountered in the drill holes.

The details are shown in Table II–1–2.

Table II–1–2 Ore Grades of Drilling Cores

Hole No.	Depth (m)	Thickness (m)	Pb %	Zn %	Ag g/t	BaO %
AG–01	255.95 ~ 263.45	7.5	4.36	2.96	95	18.9
AG–02	242.85 ~ 247.85	5.0	4.70	0.48	86	20.5
AG–03	190.70 ~ 296.20	1.9	2.50	0.90	25	4.8
AG–04	196.95 ~ 197.15	0.2	1.60	0.46	26	–
AG–05	358.35 ~ 359.50	0.5	4.90	2.80	185	–
AG–06	328.60 ~ 329.40	0.8	1.80	4.40	38	–

2) **Thickness**

The thickness (T) of the ore body was determined by an arithmetic mean of the averages which were calculated from four thicknesses (tx) at the corners of the block and drilling width (h_1 or h_2) in the block.

$$T = 1/4 \sum_{i=1}^{4} \frac{tx + h_1 \text{ (or } h_2)}{2}$$

The average thicknesses of the A and B blocks were thus calculated as 5.7 m and 4.3 m, respectively.

3) **Grade**

The ore grades were calculated by the mean of 2-weighed grade (V_1 or V_2) of the drilling core in the block and other grade of each hole ($V_3 \sim V_6$).

$$\text{Ore grade of A block} = 1/5 \left(\frac{2V_1 + V_2}{2} + \sum_{x=3}^{6} \frac{2V_1 + Vx}{3} \right)$$

$$\text{Ore grade of B block} = 1/3 \left(\frac{2V_2 + V_1}{2} + \sum_{x=1,6} \frac{V_2 + Vx}{2} \right)$$

Data regarding the grade of BaO, were obtained only from the three holes AG–01, AG–02 and AG–03. Accordingly, the weighed average of these was applied.

4) **Specific Gravity**

The specific gravities of the host rock (calco-silicate rock), measured by the Anta Gorda survey, range from 2.91 ~ 2.94, of which the ores of 2 ~ 5 % Pb range from 2.92 ~ 3.10. The theoretical value of ore of 4 % Pb – 2 % Zn is about 3.15, so that 3.0 is used for the calculation to avoid over-estimation.

5) **Ore Reserve**

Based on these data, and taking a 90 % rate of ore existence into account, the following ore reserve (Table II–1–3) can be obtained.

Table II–1–3 Ore Reserve of Perau New Deposit

Ore Block	Level (m)	Area(m^2)	Thickness (m)	Specific Gravity	Rate of Existence %	Ore Reserve (t)	Ore Grade			
							Pb %	Zn %	Ag g/t	BaO %
A	230 ~ 170	190 x 130	5.7	3.0	90	380,000	3.95	2.49	87.69	17.60
B	350 ~ 230	215 x 250	4.3	3.0	90	620,000	3.96	1.59	73.83	17.60
Total	350 ~ 170	78450	4.74	3.0	90	1,000,000	3.96	1.93	79.60	17.60

The grades calculated by the thickness-weighed average method are as follows.

Pb = 4.09 %, Zn = 1.97 %, Ag = 84.09 g/t and BaO = 17.60 %.

Therefore, the grades in Table II–1–3 were rounded as following:

Ore reserved	Pb %	Zn %	Ag g/t	BaO %
1,000,000 t	4.0	2.0	80	18

Section 2. Mining

2–1 Precondition of Plan

2–1–1 Minable Ore Reserves (Crude Ore) and Grade

In connection with the minability and dilution, which are the base for the calculation of the minable ore reserves (crude ore), the following values have been adopted, taking into consideration the shape, lithologic character and mining method of the Perau deposit:

– 84 % in minability and 12% in dilution.–

On the basis of the inferred 1,000,000 tons of ore reserves, the application of the above conditions gives the minable ore reserves (crude ore) and the grades as shown in Table II–2–1.

Table II–2–1 Minable Crude Ore and Grade

	Tonnage (t)	Grade			
		Pb(%)	Zn(%)	Ag(g/t)	BaO(%)
Ore Reserves	1,000,000	4.00	2.00	80	18
Minable Crude Ore	924,000	3.64	1.82	72.7	16.36

2–1–2 Production Schedule and Mine Life

If it is determined that the minable crude ore of 924,000 tons is mined in at least the 10 year period of the mine life, the production rates will be 90,000 tons per year or 7,500 tons per month.

2–1–3 Mill Head Grade

The mill head grade will be kept the same for each year by keeping the balance in setting up the working faces.

2–1–4 Working Hour and Shift

The working hours will be eight hours per shift, while the actual working hours at the working face will be six hours excluding for the walk-in time and lunch time.

ment.

2–2 Exploitation Plan

2–2–1 Outline of Plan

(1) Since the ore body is emplaced at a depth between 150 m and 300 m below the surface of the ground, three hauling methods such as truckless, winding by inclined and vertical shaft could be considered. The truckless method needs a long distance appraoch to the mining place, and, furthermore, it requires another ventilation shaft. The inclined shaft method requires a long construction period, and is not convenient for transportation of materials during transportation of crude ore. So, the vertical shaft winding was planned, because it is superior for the conditions at the site and the cost and time required for the exploitation work.

(2) The vertical shaft will be sunk at a point, 350-m away from the entrance of a cross cust 400-m long to be cut from the vicinity of the G–2 entrance of the Perau mine, extending in a N45°E direction. The height of the raise from the cross cut is 25 m, and the depth of sinking is 300 m, giving 325 m total length (cf. Fig. II–2–1).

(3) The exploitation drifts are to be cut at nine levels, with the vertical shaft used as the point of origin, and a vertical interval of 20 m each. Two vertical chutes for both ore and waste are to be excavated at 20 m and 25 m respectively from the shaft.

(4) In order to improve the environmental conditions underground, vertical airways are to be cut from the main adit to the upper level, and from there level to the surface (cf. Fig. II–2–1).

2–2–2 Winding Machine and Wire Rope

(1) Capacity of Winding Machine Required

1) Capacity of Winding:

By using a production rate of 7,500 tons per month and wastage of 1,000 tons per month from the exploitation, giving 8,500 tons per month in total, a capacity of 340 tons per day is required.

2) Time spent for winding:

By using the following estimates, such as;
two hours for personnel charges (three shifts),
three hours for the haulage of materials,
three hours for lunch time (three shifts), and
one hour for others,
the time spent for winding ore and waste amounts to 15 hours.

3) The rope speed per hour necessary to wind up 23 tons (340 t ÷ 15 h = 23 t):

winding time ; $\frac{320m}{V}$ x 60 sec,

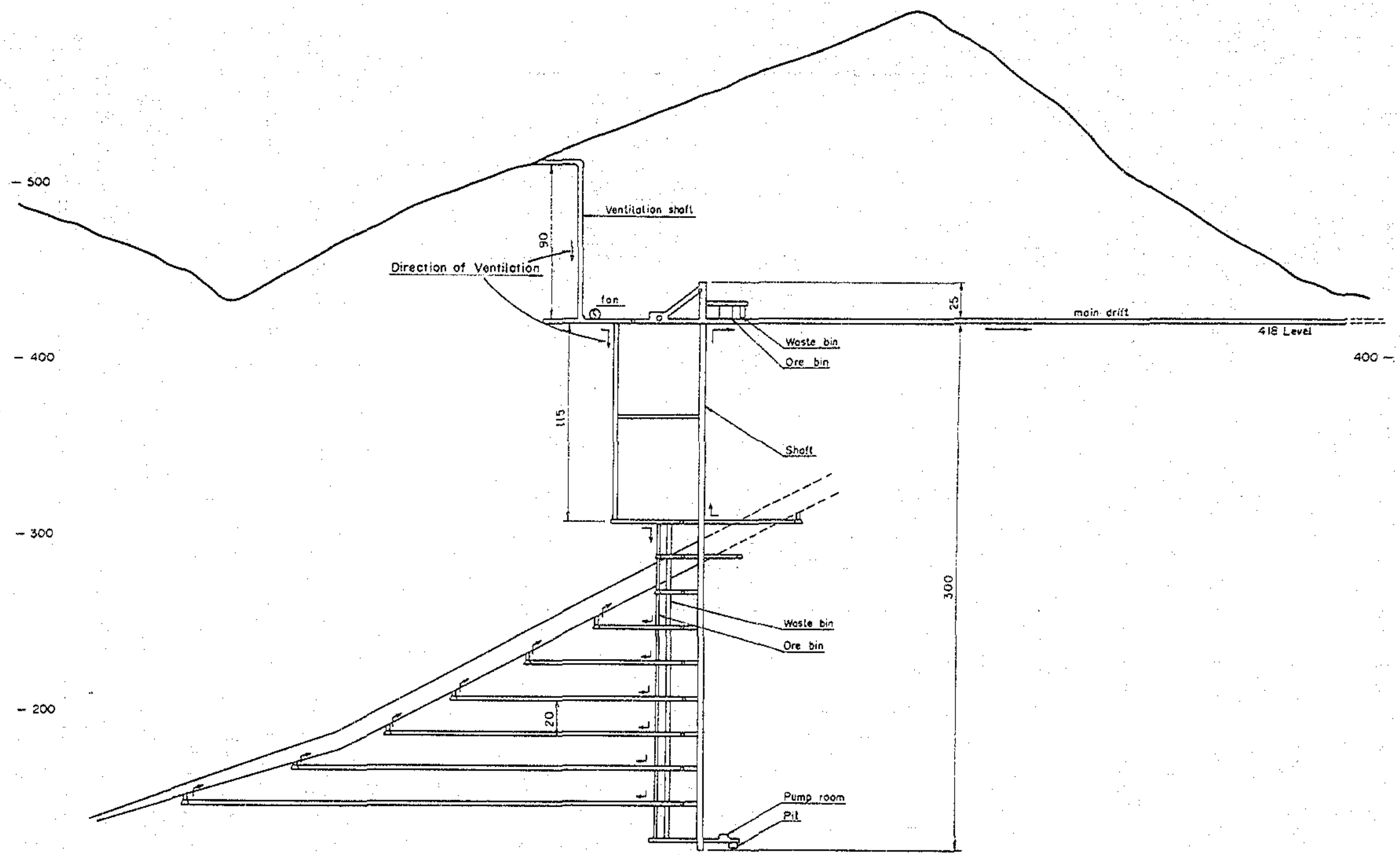


Fig. II–2–1 Section of Mine Exploitation

Therefore, wire rope of right-hand rope of 24 millimeters rung is to be used.

2–2–3 **Vertical Shaft Sinking**

(1) Structure of Vertical Shaft

Fig. II–2–3 shows the structure of the vertical shaft.

(2) Machinery and Tool Used for Shaft Sinking

The machinery and tools used for shaft sinking are shown in Table II–2–2.

Table II–2–2 Machinery and Tools Used for Vertical Shaft Sinking

Machinery and tools	Number	Specification	Note
Rock Drill	3	Atlas Copco RH-656-4W Air consumption: 2.8 m^3/min	
Sump pump		5 HP, Q=0.3 m^3/min, H=25 m	
Turbine pump		KSB WK-50-4 30 HP, Q=0.5 m^3/min, H=150m	
Winding machine		200 HP, rope speed: 200 m/min	
Scaffold		W L H 1.80^m x 4.50^m x 1.30^m	cf. Fig. II–2–2
Kibble		0.65 m^3	cf. Fig. II–2–2
Dumper			cf. Fig. II–2–2
Fan		7.5 HP, Q=200 m^3/min, H=80 mm	

(3) Method of Shaft Sinking

1) Scaffold

The scaffold will be used for a depository of drill equipment, footing for the vertical shaft work and for the prevention of falling matter. Although the up-and-down movement of the scaffold will be done by the winding machine, it is suspended by chair from the above bunton and fixed to the bedrock by braces while at work.

2) Drilling and Blasting

A RH-656-4W leg drill will be used for drilling. The planned number of drill holes is 40 (4 x 10). A center cut will be done by V-cut method. Electric blasting will be used. A drill rod with carr-bit of 1.20 meter long will be used and the actual drifting length will be 1.00 meter.

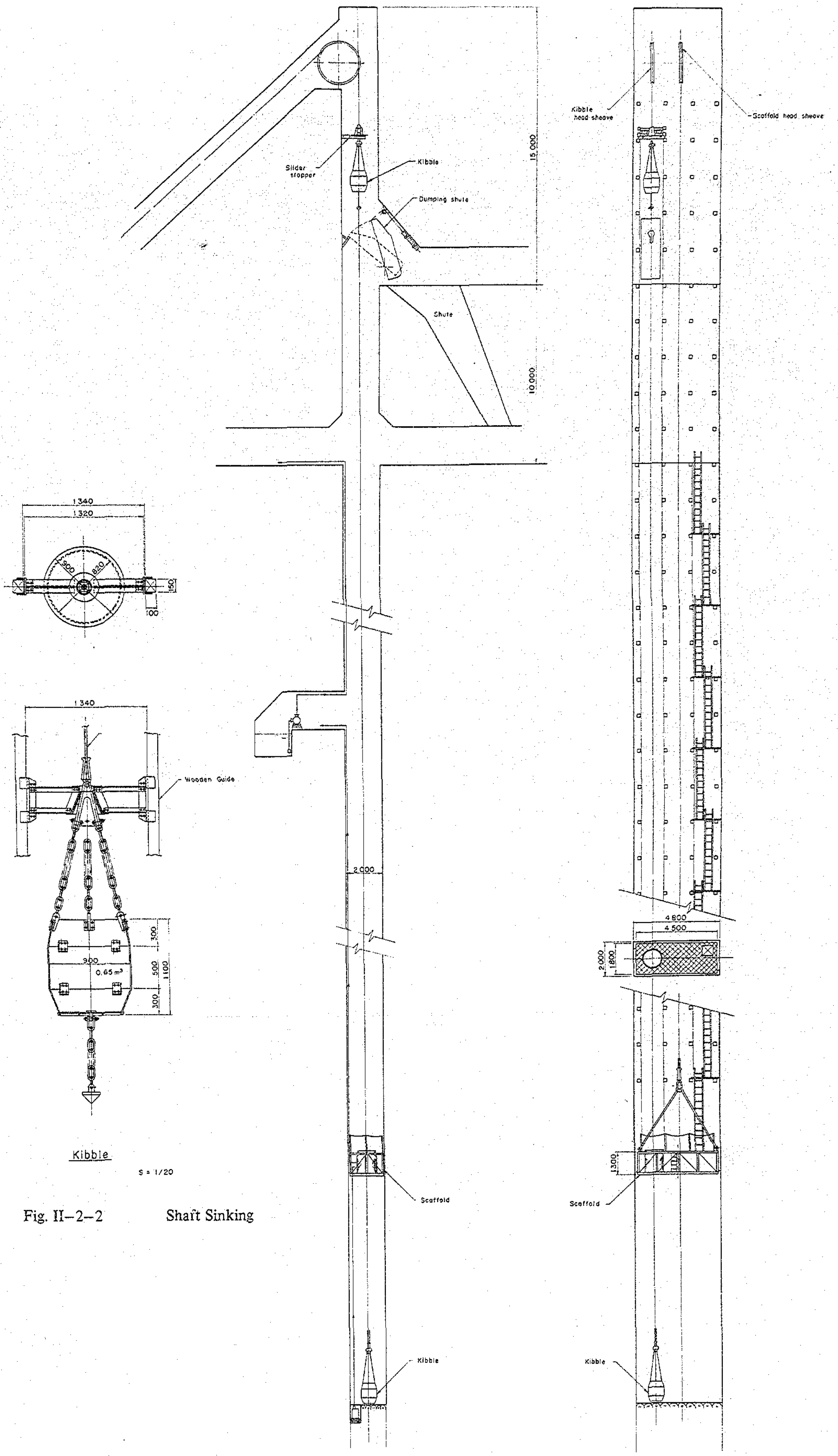


Fig. II–2–2 Shaft Sinking

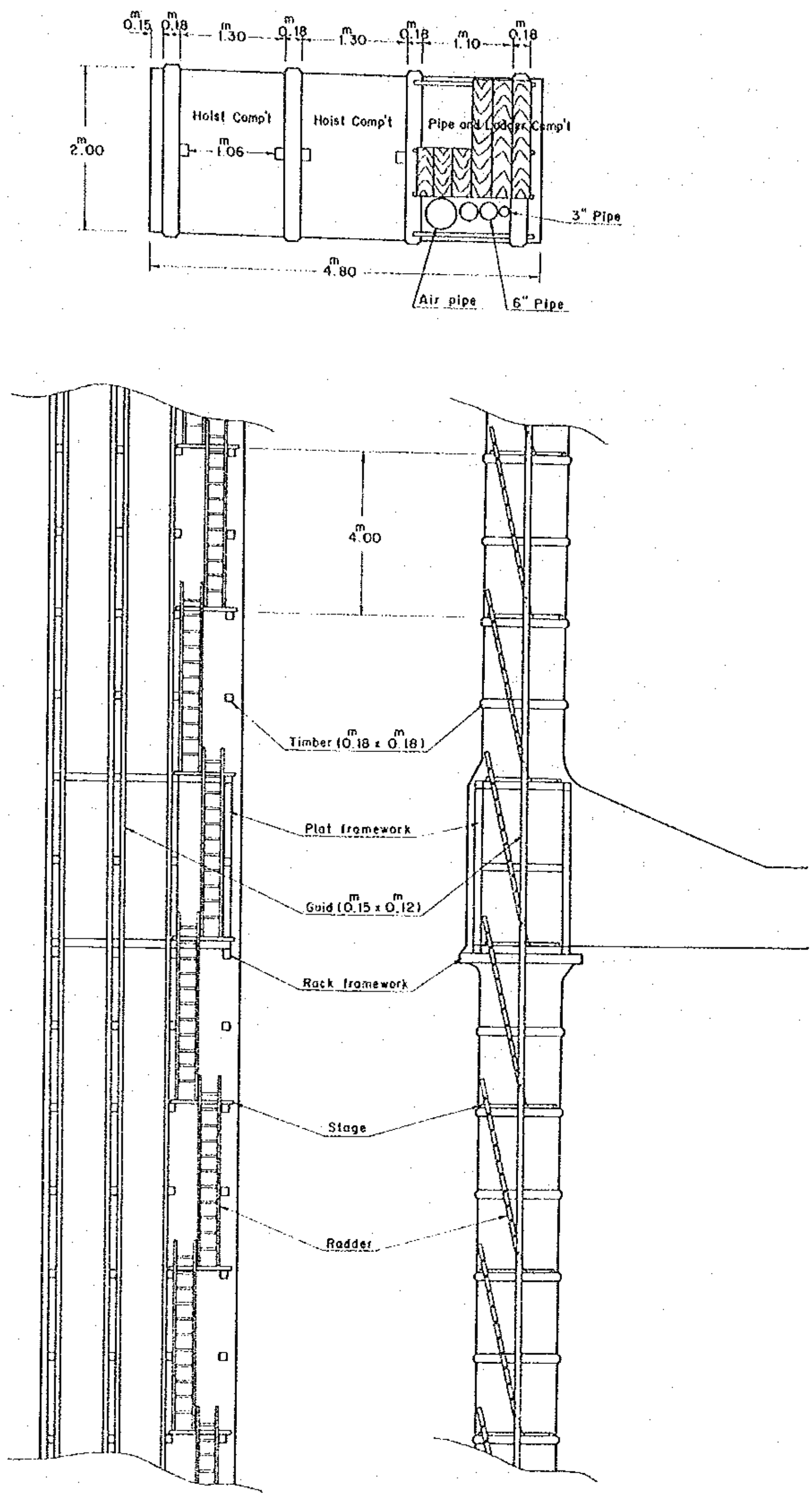


Fig. II–2–3 Structure of Shaft

time for acceleration and deceleration ; 7 sec x 2, and

time for marshaling ; 40 sec, make

the rope speed ; 195 m/min

(2) **Horsepower Required for Winding Machine**

Horsepower is obtained from the formula $HP = \frac{PV}{4500 \times \eta}$ where;

P = the maximum load placed on winding machine ...... 3,046 kg comprised of:

weight of cage ; 900 kg

weight of mine tub ; 450 kg

loaded weight ; 1,000 kg

weight of rope (24 mm) ; 2.14 kg/m x 325 = 696 kg

V = rope speed ; 200 m/min

η = overall efficiency of winding machine ; 0.8

$$HP = \frac{3046 \times 200}{4500 \times 0.8} = 169.2$$

The capacity of winding machine will be 200 HP, leaving some allowance.

(3) **Wire Rope and Safety Factor**

The safety factor of the wire rope of the winding machine used for the transportation of personnel is required to be more than 10 against the maximum static load, and more than 5 against the maximum dynamic load.

The safety factors of a wire rope (24 mm) are:

1) against the maximum static load $F_1 = \frac{Sr}{W_1} > 10$

where; Sr = guaranteed breaking load ; 34,900 kg

W_1 = maximum static load ; 3,046 kg

$$F_1 = \frac{34,900}{3,046} = 11.4 > 10,$$

providing an adequate safety factor against the maximum static load.

2) against the maximum dynamic load $F_2 = \frac{Sr}{W_1 + W_1 \frac{a}{g} + E \frac{\sigma}{D} A} > 5$

a = acceleration of rope (m/sec²) .... 0.476 m

g = acceleration of gravity (m/sec²) ...... 9.8 m

E = Coefficient of elasticity (kg/mm²) ..... 10,000 kg

A = effective cross sectional area (mm²) .... 230 mm²

σ = diameter of wire (mm) .... 2.66 mm

D = minimum diameter of sheave or drum (mm) .... 2,000 mm

$$F_2 = \frac{34,900}{3,046 + 3,046 \frac{0.476}{9.8} + 10,000 \frac{2.66}{2,000} \times 230} = 5.58 > 5$$

3) Haulage

The fragmentized waste rock will be mucked into the kibble by hand and the kibble wound up. The waste will be dumped into the chute through the dumping chute set up in the upper chute. The waste in the bin will be loaded into mine tubs and hauled by diesel locomotive to the surface.

4) Timbering

Rectangular timers of 18 cm x 18 cm in size are to be used for the bunton. The bunton will be fixed at its end to the bedrock by scooping out the rock to the depth of more than 6 cm. The planned vertical interval between the adjacent buntons is 2.00 m. Rectangular timbers of 15 cm x 12 cm x 4.00 in size are to be used for the guide rail, which will be fixed to the metal fixtures on the bunton by bolts. Footpaces are to be set up every 4 m along the man way, and 5 m long ladders will be used. The partition wall between the cage space and man way space are to be made of wooden boards of 3 cm x 12 cm x 4.00 m in size, nailed to the bunton at an equal interval. The six-inch air pipe and six-inch drainage pipe are to be installed in the man way space (cf. Fig. II–2–3).

5) Drainage

Water at the bottom of shaft will be pumped by sump pump up to the upper relay water tank in the man way. Since the maximum head of the sump pump is 30 m, the tank and pump will be moved downwards every 10 to 15 m.

6) Ventilation

In order to help the work of shaft sinking, a fan will be set up at the upper part of the shaft (adit level) to promote the removal of smoke, and to improve the working environment. The capacity of the fan is 7.5 kW and the quantity of airflow is 200 m^3/min. The mine tube will be 400 mm in diameter, and installed through the man way.

7) Manpower

Manpower required for shaft sinking is shown in Table II–2–3.

8) Progress of Shaft Sinking

Progress of the shaft sinking is shown in Table II–2–4.

2–2–4 Tunneling

(1) Machinery and Tool Used

The machinery and tools used for tunneling are shown in Table II–2–5.

(2) Level

1) Haulage Level

① Main haulage level: it is 350-m long between the entrance and shaft, and is utilized as a passage for workers going in and out as drainageway (0.4 m x 0.4 m in section) and for the haulage by locomotives. The section size of the adit is 2.4 m x 2.4 m. A 15 kg/m rail is to be used. The sleepers are 0.15 m x 0.12 m x 1.20 m in size, and will be laid at intervals of 0.60 m.

② Haulage level of working face: The size is 1.8 m x 2.0 m. A 10 kg;m rails is to be used. The sleepers are 0.12 m x 0.09 m x 1.20 m in size, and laid at intervals of 0.70 m.

2) Method of Drilling

① Main haulage level: A 600B bucket loader will be used for loading, with a 2.0-

Table II–2–3 Manpower for Shaft Sinking

	Kind						Note
	Drill-ing	Timber-ing	Haulage	Miscel-laneous	Wind-ing	Total	
1st shift	4			2	1	7	Drainage, drilling, blasting
2nd shift		2	3	2	1	8	Scaffold setting, muching, transporting water, waste haulage
3rd shift		2	3	2	1	8	Move scaffold, mucking, transporting water, waste haulage
Total	4	4	6	6	3	23	

Table II–2–4 Progress of Shaft Sinking

Works	Amount of work	m/ blasting	m/ day	Total man days	Person/ m	Days to be required
Shaft sinking	300 m	100	0.90	7,667	25.6	334
Shaft stopping	25 m	100	0.90	603	24.1	30
Bunton setting	132frames			3,036		132
Frame work of platform	10 frames			460		20
Total	325 m			11,766	36.2	516
Note	Actual blasting is assumed to be 90%, because of possible of failure of equipment and confusion of cycle of works.					

Table II–2–5 Machinery and Tools for Tunneling

Name of equipment	Specification		Note
Leg drill	Air consumption	28 m^3/min	Atlas Copco RH-656-4W
	Diameter of piston	65 mm	
	Piston stroke	60 mm	
	Whole length	630 mm	
	Weight	22.4 kg	
Bucket loader	Volume of bucket	0.15 m^3	Taiku 600-B type
	Air consumption	4.5 ~ 6.0 m^3/min	
	Weight	1,900 kg	
Diesel Locomotive	Tractive force	250 kg-m	Homemade in the mine
	Weight	2,000 kg	
	Whole length	2,000 mm	
	Width	1,000 mm	
Mine tub	Volume	0.6 m^3	
	Weight	350 kg	

Table II–2–6 Amount of Exploitation Work

Kinds of works	Section	Amount of work	Note
Shaft sinking	2.00 ^{m} x 4.80 ^{m}	300 m^3	
Shaft stopping	2.00 x 4.80	25 m^3	
Level (A)	2.40 x 2.40	400 m^3	
Level (B)	1.80 x 2.00	2,100 m^3	
Chute stopping	1.50 x 3.00	180 m^3	
Air way stopping	1.50 x 3.00	205 m^3	
Ripping		1,050 m^3	
Winding room	10 x 5 x 12	600 m^3	
Ropeway	2.00 x 3.50	40 m^3	
Pump station	5.00 x 3.5 x 7.0	123 m^3	
Pit	4.0 x 3.5 x 20.0	280 m^3	
Powder magazine	5.0 x 3.0 x 10.0	150 m^3	

ton diesel locomotive for haulage. The work is to be carried out by a three-crew drilling system (note: the crew drilling system is a method of tunneling, in which all the work, including drilling blasting, mucking and laying rail and pipe are carried out by the members of the crew).

Two sets of RH–656–4W leg drills are to be used for drilling. The center cut is to be made by the burn cut method. Bit rods of 1.60-m length are to be used to drill the hole of 1.50 m length.

② Haulage level of working face: a hauling system by hand mucking and hand pushing is to be used. Bit rods of 1.60-m length are to be used to drill the hole of 1.30-m length.

3) Efficiency of Drilling

① The crew drilling is to be conducted at a rate of one cycle per shift. When a drill length of 1.30-m per blast is assumed, the drill efficiency will be 0.43-m per person and 3.90 m per day. If a timbering rate of 10 % is assumed (one frame per two persons), the overall efficiency will be 0.40 m per person.

② Excavation of the haulage level of the working face is to be carried out by drilling, blasting and hand mucking for two shifts. With a three-crew system, the drill efficiency will be 0.37-m per person. When taking the timbering and laying of rail and pipe into consideration, the overall efficiency will be 0.31-m per person.

4) Explosives

① Main level: when 30 holes, on average, for a face of 2.4 m x 2.4 m section and an average charge of 0.65 kg are assumed, the amount of explosives will be 0.65 kg x 26 ÷ 1.3 = 13 kg/m, with 20 caps per meter to be used (note: among six holes of burn cut, only two holes are charged with explosives).

② When 26 holes on average for a face of the level of working place and an average charge of 0.50 kg are assumed, the amount of explosives will be 22 holes x 0.50 kg ÷ 1.10 m = 10 kg/m.

(3) Raise

The excavation of the raise will be carried out for the central chute in the vicinity of the vertical shaft, the chute at the working face and the air shaft. Each section is to be 1.50 m x 3.00 m in size.

1) Method of Drilling

A BBD 46 stoper drill is to be used for drilling. The center cut will be made by V-cut method. Two kinds of drill rods which are 0.8 and 1.60-m length are to be used. The drill length is to be 1.30 m.

The excavation of raise is to be made in the following order, as shown in Fig. II–2–4.

- Three-slice stoping is to be done from the level.
- An ore chute is to be installed after removal of the waste.
- Drilling and blasting are to be made upon the shelf.
- After throwing the waste on the shelf into the chute, timbers are to be set laterally to set up the footing.
- A partition wall between the chute and the man way, and ladders will be set up.

2) Efficiency of Drilling

Excavation of the raise is to be carried out for two shifts by a three-crew system for drilling, blasting and setting of footing and man way.

When 1.00-m of drill length per blasting is assumed, the drill efficiency will be 0.33-m per person.

3) Quantity of Explosive Used

When 1.00-m of drill length per blasting is assumed, the drill efficiency will be 0.33-m per person.

2–2–5 Amount of Exploitation Work

Amount of exploitation work is shown in Table II–2–6.

2–2–6 Period of Exploitation

The period of exploitation is five years as shown in Table II–2–7.

2–3 Production Plan

2–3–1 Exploration Plan

(1) Amount of Exploration Work and Production of Ore

On the basis of the scale of the Perau deposit and the rate of the production, the standard length of the exploration tunnel is to be 2.0 cm per ton of the production, that is, the proper length of tunneling for the exploration will be 150 *m per month*.

The production of the ore from the exploration tunnel is to be 800 tons per month on the assumption that 50 percent of the length of the tunnel (150 m x 0.5 m x 3.6 m^2 x 3) remain ore.

(2) Method of Tunneling

Refer to Section 2–2–4–(2)–(ii)

(3) Efficiency of Drilling

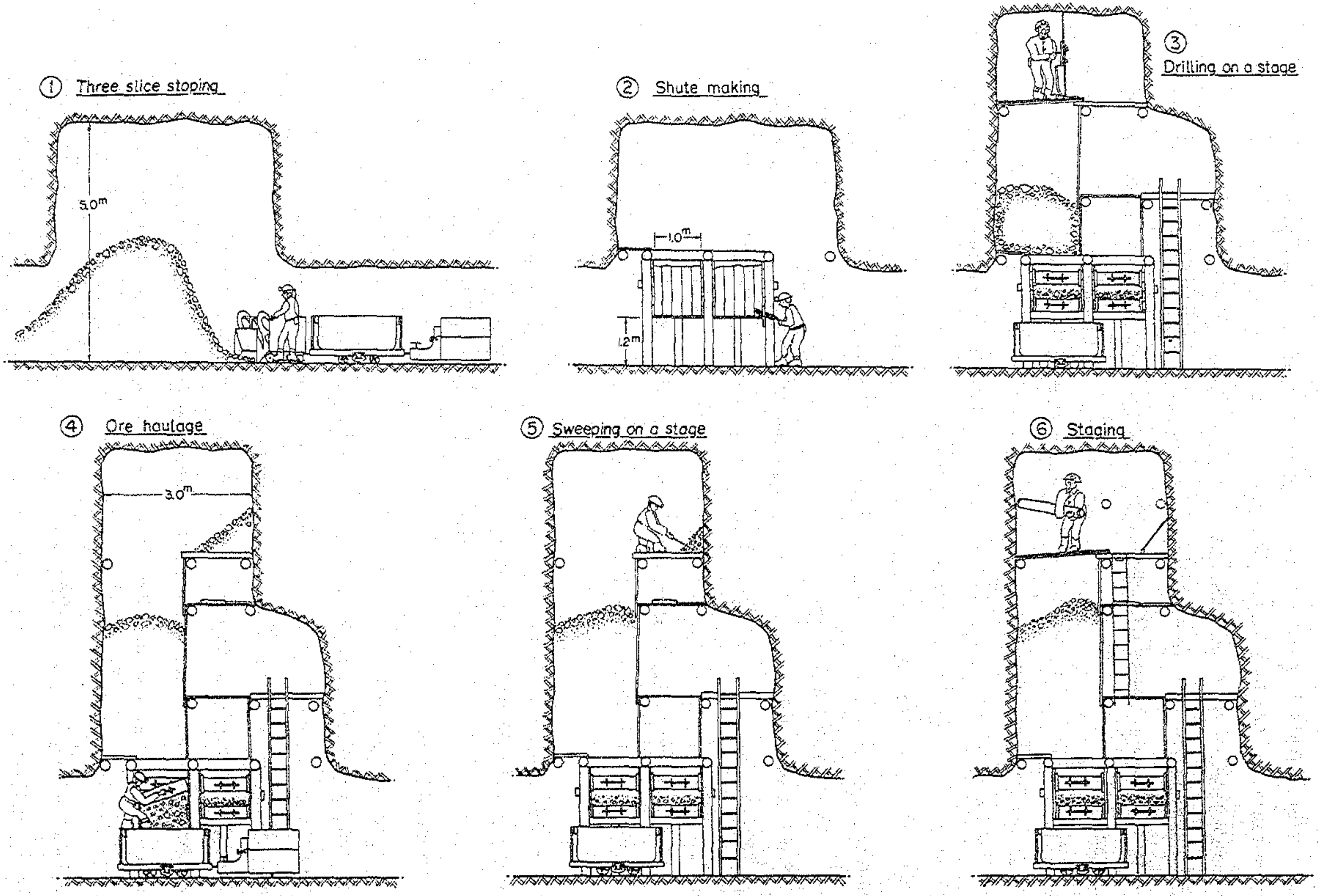


Fig. II–2–4 Raise Stoping

Table II–2–7 Plan of Exploitation Work

	1st year												2nd year												3rd year					
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6
Construction of ore bin on the surface	—	—																												
Leveling of ground from adit mouth to mill site	—	—																												
Excavation of adit level			—	—	—	—	—																							
Excavation of winding room								—	—																					
Excavation of ropeway																														
Installation of winding machine											—	—	—																	
Shaft stoping										—	—																			
Shaft sinking														—	—			—	—	—		—	—		—	—	—	—		—
Excavation of platform																—	—				—	—		—		—	—		—	
Excavation of airway																														
Excavation of central chute																														
Excavation of pump room																														
Excavation of pit																														
Excavation of cross cut																														

	3rd year						4th year												5th year											
	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12
Construction of ore bin on the surface																														
Leveling of ground from adit mouth to mill site																														
Excavation of adit level																														
Excavation of winding room																														
Excavation of ropeway																														
Installation of winding machine																														
Shaft stoping																														
Shaft sinking	—	—	—		—	—	—	—		—	—	—	—	—																
Excavation of platform		—		—		—			—		—	—		—	—															
Excavation of airway																		—	—	—	—									
Excavation of central chute																		—	—	—	—									
Excavation of pump room																—														
Excavation of pit																	—	—												
Excavation of cross cut																			—	—	—	—	—	—	—	—	—	—	—	—

Refer to Section 2–2–4–(2)–(iii)

(4) Quantity of Explosives Used

Refer to Section 2–2–4–(2)–(iv)

(5) Manpower

The manpower required for the excavation of the levels for the preparation of mining will be:

Drilling	6 persons
Hauling	12
Timbering	1
Total	19

(6) *Waste Disposal*

The waste rock from exploration tunnel is to be dumped into the waste bin, which will be would up through the vertical shaft and hauled to the surface, and then transported by dump truck to the waste dump.

2–3–2 Mining Plan

(1) Selection of Mining Method

Since the Perau deposit consists of the veins dipping as gently as 25° to 30° and often swelling and pinching from 1.50 m up to 10 m, a mining method by cut and filling with filling slime or waste rock is considered to be suitable. However,

1) the Perau deposit has a gentle dip and reaches to 10 m thick, which leads to the necessity of high technical skill for adopting the filled stop method.

2) Mining cost will be high.

3) The ore body and the country rocks are relatively hard and compact.

Judging from these facts, the following methods are to be adopted. Pillar stoping method for mining of thick bedded ore, and timber supported stopes or partly waste-filled stopes for thinly bedded ore are planned.

(2) Mining Method

1) *Mining Method for Thick Bedded Ore (more than 4 m in thickness) (cf. Fig–II–2–5)*

Pillar stoping method is to be used. The width of the pillar between the working faces varies from 2.50 m to 3.00 m depending on the conditions of the wall rock and the thickness of the ore

The order of mining is as follows.

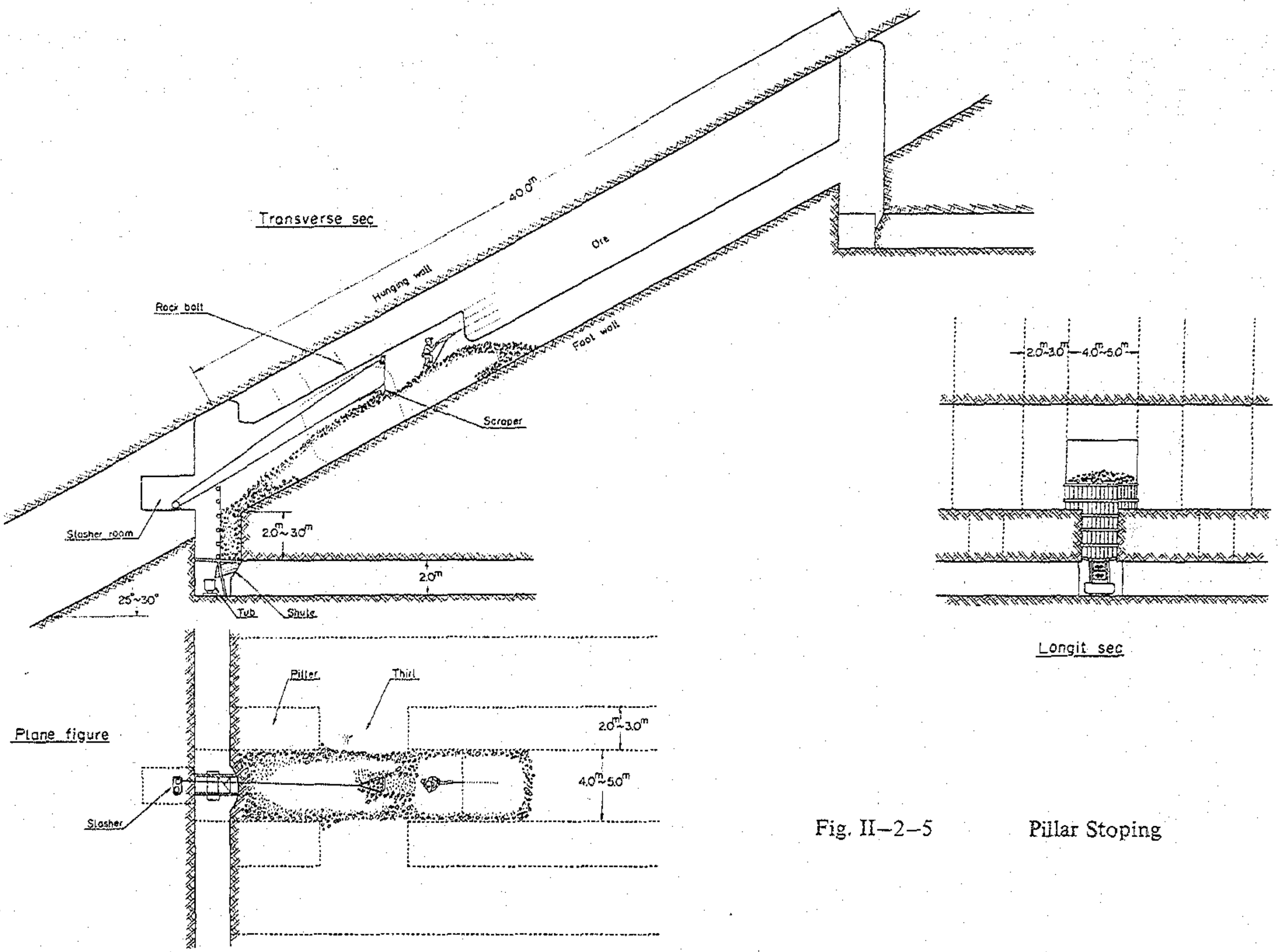


Fig. II–2–5 Pillar Stoping

① a raise of 2.00 m x 2.50 m in size will be excavated from the haulage level on the footwall of the ore body at a right angle to the level, which is separated by a partition wall into the chute and the manway.

② The raise will be 2.50-m in height, after encountering the ore, and will be ripped on both sides along the strike of the ore, 4.00 m to 4.50 m width.

③ A slasher room (2.50 m x 3.00 m x 2.00 m) will be excavated (slasher to be set up at the time when the blasting will not effect the equipment).

④ A raise along the dip of ore body will be excavated with a section of 4.00 m to 4.50 m in mining width and 2.20 m to 2.50 m in height (rock bolts or timbers are to be set from the wall condition).

⑤ Fragmented ore will be shoveled into the chute by hand or slashers.

⑥ If the condition of the wall is favorable, the wall will be ripped to widen the mining width. A thirl of 4.00 m to 5.00 m width will also be opened.

⑦ After completion of excavating the raise, the portion above the lower chute will be stoped (to a height of 2.50 m).

⑧ Ore is then, stoped overhand.

⑨ The third and the fourth slices will be mined in a similar way to the second slice.

⑩ After completing mining, the ore at the foot (mined ore) will be shoveled into the chute, drawn out and hauled.

2) Thin Bed Mining Method (1.50 to 4.00 m in width)

The whole face is mined by the longwall mining method. Rock-bolting, timbering or waste piling will be made if necessary from the wall condition.

The mining method is as follows.

① Mining is done in the same way as 1)– ① ~ ⑤ in the Section for "Thick Bed Mining".

② Proceed to longwall mining method after completing the excavation of the raise.

③ The chutes will be set up at proper intervals.

(3) Production by Mining

As mentioned in Section 2–1–2, the production will be 7,500 tons per month, and the ore production from the exploration will be 800 tons per month as in Section 2–3–1–(1), totalling, 6,700 tons per month.

(4) Efficiency of Mining

The efficiency of mining is estimated to be 5.35 tons per person as shown in Table II–2–8 of the trial calculation.

Table II–2–8 Trial Calculation of Mining Efficiency

(a) In the case of thick-bed mining (6.00 m in thickness of vein, 4.00 m in mining width, and 40.00 m in dip length)

	Amount of excavation		Number of person				Days required	Efficiency	Production
	M^3	t	Drilling	Timbering	Haulage	Total		t/person	t/month
Raise (chute)	83	180	21	20	18	54	10		
Mining (operating)	900	2,700	174	100	100	374	50		
Mining (mined out)		(1,700)		40	80	120	20		
Total		2,880	195	160	193	548	80	5.25	900

(b) In the case of thin-bed mining (2.00 m in thickness of vein, 7.00 in mining width, and 40.00 m in dip length)

	Amount of excavation		Number of person				Days required	Efficiency	Production
	M^3	t	Drilling	Timering	Haulagw	Total		t/person	t/month
Raise (chute)	43	60	13	12	11	36	5		
Mining (operating	525	1,575	102	64	64	230	34		
Mining (mined out)		(300)		10	20	30	10		
Total		1,635	115	86	95	296	49	5.52	834

(c) Overall Efficiency and Production from Working Face When the production from thick-bed mining and thin-bed mining be carried out in ratio of 60 : 40, the overall efficiency is 5.35 t/person. The production from working face is 870 t/month.

(5) Number of Working Face Required

The production per working face is to be 870 tons per month as shown in Table II–2–8, but it will be 780 tons per month when the operating rate is assumed to be 90 %.

Therefore, the number of working faces required are (6,700 t/M ÷ 780 t/M) = 8.6. If some spare working faces are taken into account, 10 working faces will be necessary for preparation.

(6) Manpower Requirement

The direct manpower required for the production of 6,700 tons per month is (6,700 t/M ÷ 5.35 t ÷ 25) = 50 persons, but the actual manpower required will be 60, taking into consideration a 90 % rate of attendance and 7 % other requirements including moving the slasher, transportation of materials and equipment problems.

Manpower required for each work is as follows:

Drilling	22 persons
Timbering	18
Hauling	20
Total	60

2–4 Planning for Each Section

2–4–1 Timbering

The condition of the wall rock seems to be favorable, judging from the existing levels and the working faces, but it will be necessary to ensure to maintain the hanging wall of the working faces, because mining will be done in a wide space and the roof of a working face tends to become very high in thick bed mining.

A three-piece tunnel set is to be generally used for timbering on the level, but prop post or rock bolt is to be determined from the wall condition.

The following materials shall be provided for timbering in order to maintain a smooth operation.

Material	Unit	Quantity	Specification	
			Diameter at the top	Length
Timber	m^3	10	12 ~ 14 cm	1.8 m
	"	15	14 ~ 16	2.4
	"	10	16 ~ 18	3.0
	"	10	16 ~ 18	4.0
	"	5	Thickness 30 mm	1.8
Rock bolt	Piece	500	Dia. 19 mm	1.5

2-4-2 **Haulage**

(1) Haulage by Vertical Shaft

As regarding the haulage by vertical shaft, a mine tub of 0.6 m^3 (1 t) will be placed in the cage and wound up to the adit-sublevel, where the ore will be dumped into the ore bin. Two haulage men are to be posted at both the upper and the lower levels.

(2) Haulage by Locomotive

A eight-car train consisting of 0.6 m^3 (1 t) mine tubs will be hauled by the 2.0 t diesel locomotive from the ore bin on the adit level to the mill plant, where the ore will be dumped into the mill head hopper.

The capacity of haulage is 136 tons per shift.

$$N = \frac{T}{\frac{2 \, l}{S} \times 60 + nt} = 17$$

where; T = Actual working hours .... 360 min.

l = Hauling distance .... 600 m.

S = Hauling speed .... 8 km/hr

t = Time for drawing ore .... 1.5 min per tub

n = Number of tubs 8

N = Time of haulage

Thus haulage by locomotives is done 17 times per shift.

(3) Haulage at Working Face

The fragmented ore will be raked into the lower chute by the 36-in scraper using a 10 HP electric-powered slasher. The ore will be drawn into the 0.6 m^3 (1 t) mine tub on the level, which is then hauled by hand pushing to the central chute and dumped.

(4) Gradient of Levels

The ideal gradient of rail for haulage by hand pushing is given by the following formula:

$$(W_1 + W_2) f \cos\alpha - (W_1 + W_2) \sin\alpha = W_1 f \cos\alpha + W_1 \sin\alpha$$

where; W_1 = Empty weight of min tub .... 450 kg

W_2 = Loaded weight of mine tub .... 1.000 kg

α = Gradient

f = Coefficient of friction .... 0.15 (ordinary bearing)

Since the value of α is very small, $\cos\alpha = 1$

$$\sin = \frac{W_2}{2W_1 + W_2} f$$

Thus the suitable gradient of 1/126 is obtained.

2–4–3 Compressed Air

(1) Compressed Air Required

Since the working faces are located in the deeper part of the mine, it is that the atmosphere will be warm and humid. Therefore it will be necessary to calculate an additional 10 % air consumption for the air blower and other losses.

The equipment and the air consumption are shown in Table II–2–9.

(2) Number of Compressors Required

Three compressors shown in the following Table II–2–10 are to be installed.

2–4–4 Ventilation

(1) Quantity of Airflow Required

It is anticipated that the temperature at the working faces will become higher by oxidizing heat, heat generated by electric machinery and terrestrial heat. It is necessary, therefore, to ensure a quantity of airflow of 800 m^3/min in order to improve the environment of the com- exhaust gas promptly.

(2) Ventilation Plan

Two vertical air shafts are to be excavated as shown in Fig. II–2–1. They will be the intake shafts through which the air is sent down to the working faces by the fan installed on the adit level. The exhaust air which passes the working faces will be discharged to the adit level through the vertical shaft.

Note: If the exhaust gas from the diesel locomotive was low enough in concentration, and no problem occurred, the passage of the intake air and return air could be reversed.

(3) Horsepower Required for Fan

The horsepower required is calculated by the depression of ventilating air, obtained from the formula:

$$h = K \cdot \frac{L \times P \times Q^2}{S^3}$$

where; h = Depression

L = Length of air channel (m) .... 1,000 m

P = Length of circumference of tunnel (m) .... 7.6 m

S = Area of section of tunnel (m^2) .... 3.6 m^2

K = Coefficient of friction 0.002

Q = Quantity of airflow (m^3/S) .... 800 m^3/min, 13.3 m^3/sec

A value of h = 58 mm is obtained. The horsepower required is calculated from the formula:

$$HP = \frac{hQ}{75 \times \eta_1 \times \eta_2}$$

where; η_1 = Mechanical efficiency .... 65 %

η_2 = Motor efficiency .... 80 %

Although the actual horsepower required for the fan is 19.8 HP, 25 HP should be used to leave some margin.

2–4–5 Drainage

(1) Quantity of Spring Water and Drainage

The quantity of underground spring water is estimated to be 1.6 m^3 at maximum, judging from the topography and lithology of the Perau area and the depth of the deposit. The spring water will be led by piping and gathered in a pit at the bottom level. It will then be pumped up to the adit level.

The volume of the sump will be 200 m^3 which is a quantity about three times that of the spring water flow per hour. A pump with a capacity of 1.5 times the quantity of spring water is to be installed together with an other spare set of the same type, kept ready for trouble and maintenance.

A 6 inches pipe, coupled by victualic jointing, is to be used for the drain pipe, set up in two series in the man way of the vertical shaft.

(2) Horsepower Required for Pump

The horsepower of motor of the pump is calculated from the formula:

$$Hp = \frac{qQ\,(H + h)}{75 \times \eta \times Pf}$$

where; Q = Pumping water (m^3/sec) .... 1.50 m^3/min, 0.025 m^3/sec

q = Density of liquid (kg/m^3) .... 1,000 kg

H = Actual head (m) .... 300 m

h = Loss-of-head .... hf + hb

hf = Loss-of-head inside the pipe $f \times \frac{L}{D} \times \frac{V^2}{2g}$

hb = Loss-of-head by bend and valve (m) .... 2.00 m

η = Mechanical effect .... 80 %

pf = Motor effect .... 85 %

f = Factor 0.07

$$hf = 0.07 \times \frac{300}{0.15} \times \frac{1.42^2}{9.8 \times 2} = 2.9 \text{ m}$$

$$h = 2.9 \text{ m} + 2.0 \text{ m} = 4.9 \text{ m}$$

Table II–2–9 Equipments and Air Consumption

Equipment	Air consumption (m^3/min)	Number of equipment	Availability (%)	Total
Leg drill	2.8	23	50	32.2
Air slasher	6.5	3	40	7.8
Bucket loader	6.0	2	40	4.8
Others and loss				5.0
Total				59.8

Table II–2–10 Specification of Compressor

Type	GA-1207
Discharge	21.2 m^3/min
Pressure	7 kg/cm^2
Horsepower of motor	200 HP
Weight	2,480 kg

Table II–2–11 Electric Power Consumption

Electric machinery	kW unit	Number of unit	Capacity (kW)	Availability (%)	Maximum power (kWh)	Load ratio(%)	Electric energy		
							kW/H	kWh/D	kWh/M
Compressor	150	3	450	100	450	80	360	8,640	216,000
Drainage pump	130	2	260	50	130	60	78	1,872	46,800
Main fan	22.5	1	22.5	100	22.5	100	22.5	540	16,200
Local fan	7.5	3	22.5	100	22.5	60	13.5	323	8,063
Winding machine	150	1	150	100	150	60	90	2,160	54,000
Electric slasher	7.5	7	52.5	100	52.5	35	18	441	11,025
Electric welding machine	15	2	30	100	30	20	6	144	3,600
Light and heater	1	–	15	100	15	70	105	252	7,560
Others and losses		4 %			35		30	720	21,600
Total					907.5		628.5	15,092	384,848

$$HP = \frac{1000 \times 0.025 \times (300 + 4.9)}{75 \times 0.8 \times 0.85} = 149.5$$

Although the actual horsepower required for a pump is 149.5 HP, a horsepower of 175 HP should be used to leave some margin.

2–4–6 Electric Power

The electric power to be used for mining is shown in Table II–2–11.

Electric power consumed per ton of crude ore will be (384,869 Kw ÷ 7,500 t) = 51.3 Kw. Kw.

2–4–7 Water Requirement

Drilling, spray at working faces and other uses will require approximately 50 m^3 of water. Water in the water tank at the mill plant site is available for the use underground, and will be pumped up by the pump used for shaft sinking. A water storage tank of 20 m^3 volume is to be made of steel.

2–4–8 Ancillary Facility

Ancillary facilities required for operation are as shown in Table II–2–12. (cf. Fig. II–2–6) 2–6)

2–4–9 Safety and Sanitation

Matters of special attention in respect to safety and sanitation are as follows.

(1) Since due to the accidents related to blasting might happen, the increase, of adjacent working faces as a result of these mining method, it will be necessary to establish a control system on blasting hour.

(2) Timbering of the hanging wall of working faces should be fully secured because the roof of the working faces tends to become very high at the part where the thick-bed mining method is applied.

(3) The control of ventilation should be fully secured to remove the exhaust gas of diesel locomotives.

(4) In order to prevent troubles caused by vibration, drill machines with a vibration-preventive handle must be used.

(5) Dust-proof masks should be worn for the prevention of silicosis. Instructions to spray water at the working faces before starting work should be given.

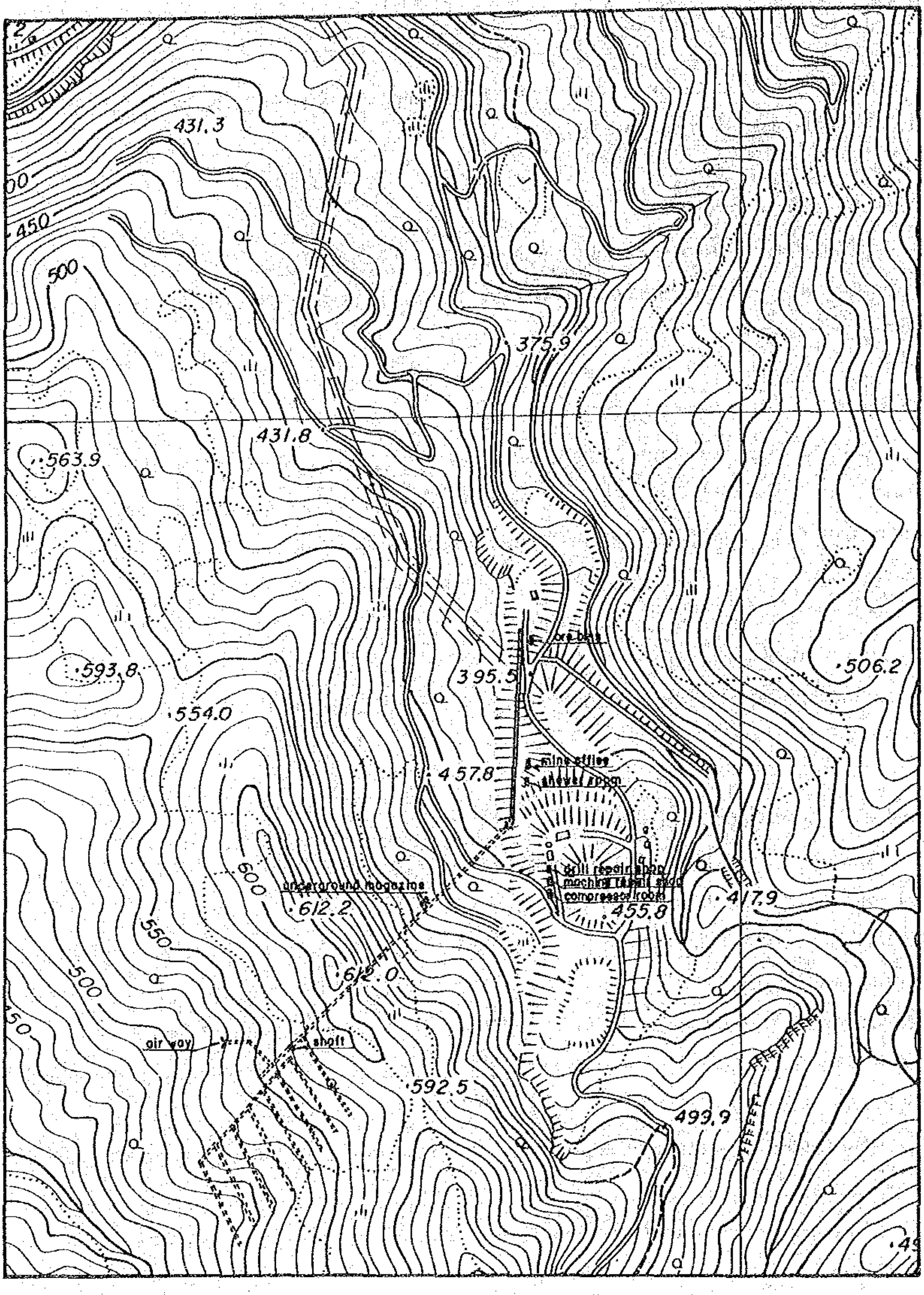


Fig. II–2–6 Layout of Ancillary Facilities

2–5 Organization and Manpower Requirement

2–5–1 Organization

(1) Organization in Exploitation Stage

The organization in the stage of exploitation is depicted in the following chart. The figures in parentheses are the number of personel.

Superintendent	Senior Personnel	Junior Personnel	Foreman
Exploitation Superintendent (1)	Chief of Mining Section (1)	Mining Engineer (1)	Mine Foremen (2)
		Mechanical and Electrical Engineer (1)	
			Electrician (1)
	Secretary (1)		
Total 1	2	2	3

(2) Organization in Operation Stage

The organization in the stage of the operation is as follows. The figures in parentheses are the number of personnel.

Superintendent	Senior Personnel	Junior Personnel	Foreman
	Chief of Safety Section (1)		
Mine Superintendent (1)	Chief of Mining Section (1)	Mining Engineer (1) Geologist (1) Mechanical and Electrical Engineer (1)	Mine foremen (3)
			Electrician (1)
		Clerk (1)	
1	2	4	4

2–5–2 Manpower Required

Manpower required in the stage of exploitation and operation is as shown in Table II–2–13.

Table II–2–12 Ancillary Facility

Facilities	Note
Powder Magazine in underground	Amount of excavation 150 m³, wooden building (50 m²). Capacity : blasting powder 12,000 kg, caps 24,000 pieces
Drill repair shop	Wooden building (45 m²), concrete floor (5.0 m³)
Equipment repair shop	Steel-frame building (72 m²), concrete floor (8.0 m³)
Change room Shower room	Wooden building (96 m²), concrete floor (110 m³), 100 lockers, shower
Compressor room	Steel-frame building (105 m²), concrete floor (12.0 m³)
Water tank	Make of steel, volume 20.0 m
Office	Wooden building (72.0 m²), concrete floor (8.0 m³), 10 desks, furnished with shelves

Table II–2–13 Manpower Required for Exploitation and Operation

Occupation \ Year		Exploitation					Operation	
		1	2	3	4	5	6	
	Salaried Personnel	4	8	8	8	8	11	
Mining	Drilling	4	4	4	4	15	28	
	Timbering	3	4	4	4	10	19	
	Haulage	3	6	6	6	30	32	
	Maintenance	1	1	1	1	1	2	
	Sharpener					1	2	
	Miscellaneous	3	6	6	6	4	4	
Geology	Survey and Measuring	2	2	2	2	2	3	
Mechanic Electricity	Repair		3	3	3	3	4	
	Electrician		2	2	2	2	2	
	Operator		3	3	3	6	6	
	Clerk	1	1	1	1	1	2	
Total	Salaried	(4)	(8)	(8)	(8)	(8)	(12)	
	Houred	17	32	32	32	75	104	

2–6 Investment Cost

2–6–1 Investment Equipment

The amount of investment in equipment and the yearly amount of equipment are shown in Table II–2–14.

2–6–2 Exploitation Cost

The exploitation cost are shown in Table II–2–15 ~ II–2–21.

2–6–3 Personnel Expenses

The personnel expenses during the exploitation period are shown in Table II–2–22.

2–6–4 Cost for Construction of Facility

The construction cost for the facilities and buildings on the surface and underground are shown in Table II–2–23.

2–6–5 Power Cost

(1) The power cost during the period of exploitation by year is shown in Table II–2–24, 25.

(2) The power cost for every unit during the period of exploitation is shown in Table II–2–25.

2–6–6 Investment Cost Summary

The investment cost for exploitation is shown in Table II–2–26.

2–7 Operating Cost

2–7–1 Material Cost

The material cost required for exploration and mining is shown in Table II–2–27.

2–7–2 Personnel Expenses

The expenses for manpower required in operation are shown in Table II–2–28.

2–7–3 Power Cost

The power cost used for operation is as shown in Table II–2–29.

2–7–4 Depreciation Cost

The depreciation cost is as described in Table II–2–30. It is allotted equally depending on the durability of the equipment.

2–7–5 Summary of Operating Cost

The operating cost per month is as shown in Table II–2–31.

The mining cost is about US$ 13.00 per ton including depreciation.

2–8 Technical Problems and Recommendations

(1) A thoroughgoing control and education of workers as a daily program is indispensable to make the mining work regular and to raise the mining recovery rate.

(2) It is anticipated that the ventilation system might be disturbed because of the connecting openings formed with the progress of mining. Therefore, disused tunnels have to be sealed off as soon as possible.

(3) A locker room is to be set up on the ground surface in order to secure the actual working time. Therefore, it is necessary to give guidance to take lunch at the working place, without setting up a resting room underground.

(4) In order to improve efficiency, it will be required to perform thorough on-the-job training, and at the same time, it will be essential to examine the time of employment and the adaptability of personnel who work underground.

2–9 Summary

(1) Exploitation by vertical shaft was planned because the ore body is emplaced at a depth of 150 to 300 m below the surface, which leads to the necessity of a little extra investment for the quantity of ore reserves so far confirmed.

(2) Wages and salary are assumed to be lower than the international standard, which results in a small ratio of labor cost to mining cost.

(3) Judging from point (2), it is not necessary to mass-produce the ore by mechanization. Also it will be impossible to plan a mass production because of the small quantity of the inferred ore reserves.

(4) It is essential to complete the depreciation of the invested capital by summing up the profit during the operation period.

(5) On the other hand, it is necessary to invest the development cost of irreducible minimum of demand by the reason mentioned in (1). An extremely small production rate, on the contrary,

will make little progress in depreciation, resulting in remaining bed assets at the time of closure of the mine.

(6) A plan drown up, on the basis of the points mentioned above, with the following concrete measures.

1) The production rate is determined to be 7,500 tons per month for the object of the inferred ore reserves of 1,000,000 tons, calculated at the moment.

2) The quantity of the exploration and mining works and the purchase of hauling equipments were held down to a minimum, in the plan, by increasing the work of hand mucking and hand pushing of the tub.

3) Some equipment will be home-made at the mine site after evaluating the mechanical capability of mechanics.

4) It is planned to purchase used winding machines.

(7) As a result, a mining cost of US $ 12.68 per ton on average was obtained in the draft plan. Thus it is thought that there is a strong recommendation to warrant development of the mine as far as the ratio of mining cost to revenue is concerned, although it wholly depends on the amount of the investment in other sections.

Table II–2–14 Amount of Investment Equipments Cost for Exploration and Mining (1)

(Unit : US$)

Equipments	Unit price	Investment equipments for exploitation		Investment equipment for mining		Initial investment equipments (Total)		Initial investment				
		Quantity	Amount	Quantity	Amount	Quantity	Amount	1	2	3	4	5 year
Leg drill	2,600	10	26,100	30	78,300	40	104,400	13,050	5,220	5,220	2,610	78,300
Stoper drill	5,320	5	26,600	–		5	26,600	10,640	5,320	5,320	5,320	–
Coal pick	209	5	1,045	5	1,045	10	2,090	418	418	209	–	1,045
Bucket loader	26,028	1	26,028	1	26,028	2	52,056	26,028	–	–	–	26,028
Mine tub	1,234	10	12,340	30	37,020	40	49,360	12,340	–	–	–	37,020
Diesel locomotive	4,433	1	4,433	1	4,433	2	8,866	4,433	–	–	–	4,433
10 HP electric slasher	15,446	–	–	7	108,122	7	108,122	–	–	–	–	108,122
10 HP air slasher	12,372	2	24,744	1	12,372	3	37,116	–	24,744	–	–	12,372
36" scraper	1,296	2	2,592	8	10,368	10	12,960	–	2,592	–	–	10,368
Compressor	73,904	1	73,904	2	147,808	3	221,712	73,904	–	–	–	147,808
Main fan	5,734	–	–	1	5,734	1	5,734	–	–	–	–	5,734
Local fan	2,600	1	2,600	4	10,400	5	13,000	2,600	–	–	–	10,400
Pump (1.5 m^3/min x 300 m)	5,964	–	–	2	11,928	2	11,928	–	–	–	–	11,928
Pump (0.5 m^3/min x 150 m)	2,830	2	5,660	–	–	2	5,660	–	2,830	2,830	–	–
Sump pump (0.3 m^3/min x 25 m)	860	3	2,580	–	–	3	2,580	–	2,580	–	–	–
Vertical shaft winding machine* (200 HP)	164,214	1	164,214	–	–	1	164,214	164,214	–	–	–	–
Wire rope (25 mm)	5,923	1,000	5,923	–	–	1,000	5,923	–	5,923	–	–	–
Cage	5,613	2	11,226	–	–	2	11,226	–	–	–	11,226	–
Scaffold	4,084	1	4,084	–	–	1	4,084	4,084	–	–	–	–
Kibble, rider, dumper	5,231	1	5,231	–	–	1	5,231	5,231	–	–	–	–
Dump truck	309	4	1,236	–	–	4	1,236	1,236	–	–	–	–
Chain block	45,346	1	45,346	–	–	1	45,346	45,346	–	–	–	–
6" pipe	13,077	1,000	13,077	–	–	1,000	13,077	6,538	–	–	6,539	–
High-voltage cable	772	10	7,720	–	–	10	7,720	2,316	–	–	–	5,404
Transformer	354	10	3,540	10	3,540	20	7,080	1,062	–	–	–	6,018
Blasting machine	468	1	468	1	468	2	936	468	–	–	–	468
Welding machine	1,749	1	1,749	–	–	1	1,749	1,749	–	–	–	–
Concrete mixer	1,532	1	1,532	–	–	1	1,532	1,532	–	–	–	–
Grinder	1,435	750	10,763	–	–	750	10,763	5,740	2,153	2,153	717	–
Tools		1 set	25,275	1 set	5,055	1 set	30,330	10,110	5,055	5,055	5,055	5,055
Total			510,010		462,261		972,631	393,039	56,835	20,787	31,467	470,503

*Note : It is planned to purchase uses winding machine.

Table II–2–14 Amount of Investment Equipment for Exploitation and Mining (2)

(Unit : US$)

Additional Investment									
6	7	8	9	10	11	12	13	14	15 year
				26,100					
				2,090					
				12,340					
			5,923						
			45,346						
			51,269	40,530					

Table II–2–15 Exploitation Cost

(Unit : US$)

Works	Amount of works	Unit price	Amount	Note
Shaft sinking	300 m	587.85	176,355.00	
Shaft stopping	25 m	588.60	14,715.00	
Level (A)	400 m	159.81	63,924.00	
Level (B)	2,100 m	141.98	298,158.00	
Chute stopping	180 m	143.36	25,805.00	
Air shaft stopping	205 m	143.36	29,389.00	
Ripping	1,050 m^3	41.67	43,754.00	
Excavation of winding room	600 m^3	41.67	25,002.00	
Excavation of ropeway	40 m	143.36	5,734.00	
Excavation of pump room	123 m^3	41.67	5,252.00	
Excavation of pit	280 m^3	41.67	12,244.00	
Excavation of powder magazine	150 m^3	41.67	6,251.00	
Total			706,583.00	

Table II-2-16 Exploitation Unit Cost (Main Level) (2.4 x 2.4 m) (Unit : US$)

	Items	Quantity	Unit	Unit price	Amount	Note
Materials	Explosives	13.5	kg	1.26	17.01	Excavation of side drainageway is included.
	Cap	25.0	piece	0.41	10.25	
	Fuse	50.0	m	0.30	15.00	
	Bit rod	0.2	piece	89.00	17.80	Bit life: 200 m/piece
	Iron pipe	5.3	kg	0.83	4.40	2" pipe (6" pipe is summed up separately)
	Rail	30.0	kg	0.95	28.50	15 kg rail is used
	Steel materials	13.0	kg	0.58	7.54	
	Timber	0.04	m^3	62.39	2.50	
	Sleeper	0.03	m^3	109.71	3.30	
	Other materials	5 %			5.32	
	Total				111.62	
Labor cost	Wage in underground	3.5	person		21.23	Driller 3÷1.3=2.3 @ 7.22 Timbering 0.2 @ 5.06 Haulage 1.0 @ 3.61
	Bonus, Reserve for retirement allowance, Legal welfare cost				12.74	Wage x 60 %
Total					33.97	
Expense	Power cost	625			14.22	
	Total				14.22	
Grand total					159.81	

Table II–2–17 Exploitation Unit Cost (Haulage Level) (1.8 x 2.0 m) (Unit : US$)

	Items	Quantity	Unit	Unit price	Amount	Note
Materials	Explosives	10.0	kg	1.26	12.60	
	Cap	20	piece	0.41	13.20	
	Fuse	44	m	0.30	17.80	
	Bit rod	0.2	piece	89.00	17.80	
	Iron pipe	11.2	kg	0.84	9.41	1" and 3" are used
	Rail	20.0	kg	0.97	19.40	
	Steel Materials	5.5	kg	0.58	3.19	
	Timber	0.01	m³	62.39	0.62	
	Sleeper	0.02	m³	109.71	2.19	
	Other materials	5 %			4.33	
Total					90.91	
Labor cost	Wage in underground	2.93			14.15	Driller 0.91 person/m @ 7.22 US$ Timbering 0.2 p/m @ 5.06 US$ Haulage 1.82 p/m @ 3.01 US$
	Bonus, Reserve for retirement allowance, Legal welfare				8.49	
Total					22.64	
Expense	Power cost	(467) 1,250			(10.62) 28.43	
	Total				(10.62) 28.43	
Grand total					(124.17) 141.98	

Note: Figures in parentheses show those in the period of operation.

Table II–2–18 Exploitation Unit Cost (Shaft Stopping) (2.0 x 4.8 m)

(Unit : US$)

	Items	Quantity	Unit	Unit price	Amount	Note
Materi-als	Explosives	20.0	kg	1.26	25.20	
	Cap	40.0	piece	1.81	72.40	
	Fuse	–	m	–	–	
	Bit rod	0.5	piece	89.00	44.50	
	Iron pipe	–	kg	–	–	
	Rail	–	kg	–	–	
	Steel Materials	25.0	kg	0.58	14.50	
	Rectangular Timber	0.55	m^3	109.71	60.34	
	Timber	0.32	m^3	62.39	19.96	
	Other materials	10 %			23.69	
Total					260.59	
Labor cost	Wage in underground	24.12			108.33	Driller 4.44 p/m @ 7.22 US$ Timbering 6.58 p/m @ 5.06 US$ Haulage 6.58 p/m @ 3.61 US$ Miscellaneous 6.58 p/m @ 2.89 US$
	Bonus, Reserve for retirement allowance, Legal welfare				65.00	Wage x 60 %
Total					173.33	
Expense	Power cost	6,800			154.68	
Total					154.68	
Grand total					588.60	

Note: p/m . . . . . . person/meter

Table II–2–19 Exploitation Unit Cost (Shaft Sinking) (2.0 x 4.8 m)

(Unit : US$)

	Items	Quantity	Unit	Unit price	Amount	Note
Materi-als	Explosives	24.0	kg	1.26	30.24	
	Cap	40.0	piece	1.81	72.40	
	Fuse	–	–	–	–	
	Bit rod	0.5	piece	89.00	44.50	
	Iron pipe	14.0	kg	0.83	11.62	2" pipe and 3" pipe are used (6" pipe is separately summed up)
	Rail	–	–	–	–	
	Steel Mate-rials	25.0	kg	0.58	14.50	
	Wood	0.43	m^3	109.71	47.18	
	Timber	–	–	–	–	
	Other materials	15 %			33.07	
Total					253.51	
Labor cost	Wage in underground	25.55			112.29	Driller 4.44 @ 7.22/p Timber-ing 4.44 @ 5.06 " Haulage 6.67 @ 3.61 " Miscel. 6.67 @ 2.89 " Winding 3.33 @ 4.33 "
	Bonus, Re-serve for retirement allowance, Legal wel-fare	....	....	....	67.37	Wage x 60 %
Total					179.66	
Expense	Power cost	6,800			154.68	
	Total				154.68	
Grand total					587.85	

Note: p . . . . . person

Table II-2-20 Exploitation Unit Cost (Raise) (1.5 x 3.0 m)

(Unit : US$)

	Items	Quantity	Unit	Unit price	Amount	Note
Materials	Explosives	12.5	kg	1.26	15.75	
	Cap	28	piece	0.41	11.48	
	Fuse	56	m	0.30	16.80	
	Bit rod	0.2	piece	89.00	17.80	
	Iron pipe	–	kg	–	–	
	Rail	–	kg	–	–	
	Steel Materials	–	kg	–	–	
	Timber	0.34	m^3	62.39	21.21	
	Sleeper	–	m^3	–	–	
	Other materials	5 %			4.15	
Total					87.19	
Labor cost	Wage in underground	3.0	person		17.34	Driller 1.0 p/m @ 7.22 US$/p Timbering 2.0/m @ 5.06 US$/p
	Bonus, Reserve for retirement allowance, Legal welfare				10.40	Wage x 60 %
Total						
Expense	Power cost	(467) 1,250			(10.62) 28.43	
Total					(10.62) 28.43	
Grand toral					(125.55) 143.36	

Note: Figures in parentheses are those of raise during operation.
p: person, m: meter

Table II–2–21 Unit Costs for Mining (per cubic meter)

(Unit : US$)

	Items	Quantity	Unit	Unit price	Amount	Note
Materials	Explosives	2.2	kg	1.26	2.77	
	Cap	3.6	piece	1.86	6.70	
	Fuse	9.0	m	0.30	6.70	
	Bit rod	0.03	piece	89.00	2.67	
	Iron pipe	–	kg	–	–	
	Rail	–	kg	–	–	
	Steel materials	1.0	kg	0.58	0.58	
	Timber	0.01	m^3	62.39	0.62	
	Board	0.002	m^3	109.71	0.22	
	Other materials	7 %			1.14	
Total					17.40	
Labor cost	Wage in underground	0.6			3.22	Driller 0.22 person @ 7.22 US$/person Timbering 0.18 person @ 5.06 US$/person Haulage 0.20 person @ 3.61 US$/person
	Bonus, Reserve for retirement allowance, Legal welfare				1.93	Wage x 60 %
Total					5.15	
Expense	Power cost	141	Kwh		(3.21) 19.36	
Total					(3.21) 19.36	
Grand total					(25.76) 41.91	

Table II-2-22 Personnel Expenses

(Unit : US$)

	Unit price month	1st Year	2nd Year	3rd Year	4th Year	5th Year	Total
(Salaried)							
Superintendent	780	(1) 780	(1) 780	(1) 780	(1) 780	(1) 780	3,900
Senior personnel	578	(2) 1,156	(2) 1,156	(2) 1,156	(2) 1,156	(2) 1,156	5,780
Junior personnel	462	–	(2) 924	(2) 924	(2) 924	(2) 924	3,696
Subtotal		(3) 1,936	(5) 2,860	(5) 2,860	(5) 2,860	(5) 2,860	13,376
(Houred)							
Foreman	317	(2) 634	(3) 951	(3) 951	(3) 951	(3) 951	4,438
Sruvey	260	(2) 520	(2) 520	(2) 520	(2) 520	(2) 520	2,600
Mechanician	260	–	(3) 780	(3) 780	(3) 780	(3) 780	3,120
Electrician	260	–	(2) 520	(2) 520	(2) 520	(2) 520	2,080
Operator	173					(3) 519	519
Shapener	116					(1) 116	116
Clerk	202	(1) 202	(1) 202	(1) 202	(1) 202	(1) 202	1,010
Subtotal		1,356	2,973	2,973	2,973	3,608	13,883
Total		3,292	5,833	5,833	5,833	6,468	27,259
(Forereference)							
Personnel expenses in exploitation cost		(14) 13,732	(24) 23,544	(24) 23,544	(24) 23,544	(60) 58,860	143,224

Note
- Unit price = Salary or wage x 160 %
- Figures in parentheses are the number of personnel

Table II–2–23 Construction Cost of Facility

(Unit : US$)

Facilities	Items	Quantity	Unit cost	Amount	Note
Winding machine	Foundation concrete	30.0 m³	153.00	4,590	Construction cost of head sheave and wiring are included
	Floor concrete	12.0 m³	87.00	1,044	
	Transpotation and assembling			3,000	
	Wiring of signal and wire rope			3,500	
	Building	120 m²	36.00	4,320	
	Total			16,454	
Compressor	Foundation concrete	12.0 m³	153.00	1,836	For three units of compressors
	Floor concrete	12.0 m³	87.00	1,044	
	Transportation and assembling			3,450	
	Wiring			1,750	
	Building	105 m²	108.00	11,340	
	Total			19,420	
Pump room	Foundation concrete	2.0 m³	87.00	174	For two sets of pumps
	Floor concrete	4.0 m³	87.00	348	
	Transportation and assembling	50 @	7.22	361	@ .... Manpower
	Wiring	50 @	7.22	361	
	Piping	650 m		2,250	
	Total			3,494	
Powder magazine	Building	50 m²	72.00	3,600	Cost for excavation is described in Clause 2–6–2
	Total			3,600	
Drills repair shop	Floor concrete	5 m³	87.00	435	
	Building	45 m²	54.00	2,430	
	Total			2,865	
Equipments repair shop	Floor concrete	8 m³	87.00	696	
	Building	72 m²	108.00	7,776	
	Total			8,472	
Change and shower room	Floor concrete	11 m³	87.00	957	
	Building	96 m²	72.00	6,912	
	Total			7,869	
Office	Floor concrete	8 m³	87.00	696	
	Building	72 m²	72.00	5,184	
	Total			5,880	

Table II–2–24 Power Cost for Exploitation

(Unit : US$)

	1st year	2nd year	3rd year	4th year	5th year	Total
Power to be consumed Kwh/M	50,000	83,000	133,000	175,000	187,500	
Power to be consumed Kwh/Y	600,000	996,000	1,560,000	2,100,000	2,250,000	75,060,000
Unit price of power	0.0227	0.0227	0.0227	0.0227	0.0227	
Power cost	13,620	22,610	35,412	47,670	51,070	170,382

Table II–2–25 Units for Electric Power

(Unit : US$)

	Amount of excavation	Electric energy to be consumed	Electric energy to be consumed	Unit price of power	Power cost	
					Cr$/m,m³	US$/m,m³
Cross cut (A)	80 m	Kwh/M 50,000	Kwh/m,m³ 625	Cr$/Kwh 62,987	39,367,000	14.22
Cross cut (B)	200 m	250,000	1,250	"	78,734,000	28.43
Shaft sinking	23 m	170,000	6,800	"	428,312,000	154.68
Ripping	200 m³	170,000	850	"	53,539,000	19.34
Note	Conversion rate: 1 US$ = 2,769 Cr$ Electricity rates (62,987) = basic rate (13,832 Cr$/Kwh) + power rate (49,155 Cr$/Kwh) + power rate (49,155 Cr$/Kwh)					

Table II–2–26 Summary of Investment Cost

(Unit : US$)

Items	1st year	2nd year	3rd year	4th year 1	5th year	Total
Personael Expenses						
Salaried	1,936	2,860	2,860	2,860	2,860	13,376
Houred	1,356	2,973	2,973	2,973	2,973	13,883
Mining equipments	354,690	51,663	20,787	31,467	470,503	929,110
Facilities and construction cost	41,274	–	–	25,086	3,494	69,854
Cost for underground excavation	67,352	116,154	128,956	141,214	252,907	706,583
(Breakdown)						
Materials	40,000	70,000	70,000	70,000	142,977	392,977
Personnels	13,732	23,544	23,544	23,544	58,860	143,224
Power	13,620	22,610	35,412	47,670	51,070	170,382
Contingency	3,000	5,000	4,000	4,000	4,000	200,000
Total						1,752,806

Table II–2–27 Materials Cost for Operation

(Unit : US$)

	Exploration (m) Mining (m^3)	Fundamental unit		Unit price	Amount	Note
		Quantity	Unit			
Explosives	150 m 2,223 m^3	10 2.2	kg	1.26	1,890.00 (6,190.00)	Upper row ... Exploration Lower row ... Mining ( )
Cap	"	20 3.6	piece	1.86	5,580.00 (14,952.00)	
Fuse	"	44 9.0	m	0.30	1,980.00 (6,029.00)	
Bit rod	"	0.2 0.03	piece	89.00	2,670.00 (5,962.00)	
Iron pipe	"	11.2 –	kg	0.84	1,411.00 (–)	
Rail	"	20.0 –	kg	0.97	2,910.00 (–)	
Steel materials	"	5.5 1.0	kg	0.58	479.00 (1,295.00)	
Timber	"	0.01 1.01	m^3	62.39	94.00 (1,393.00)	
Sleeper, board	"	0.02 0.002	m^3	109.71	329.00 (490.00)	
Other materials	"	5 7	%		867.00 (2,542.00)	
Total					18,210.00 (38,853.00)	

Table II-2-28 Personnel Expenses for Operation

(Unit : US$)

	Number	Unit price	Amount	Note
Salaried personnel				
Superintendent	1	780	780	Unit price=Salary, wage x 160 %
Senior personnel	2	578	1,156	
Junior personnel	4	462	1,848	
Total	7		3,784	
Houred Workers				
Foreman	4	317	1,268	Foreman belongs to the personnel in the organizational structure
Drilling (A)	20x90%	289	5,202	Rate of attendance = 90 % is assumed
Drilling (B)	8x90%	260	1,872	
Timbering	19x90%	202	3,454	
Haulage (A)	22x90%	144	2,851	
Haulage (B)	10x90%	116	1,044	
Maintenance	2	116	232	
Sharpener	2	116	232	
Miscellaneous	4	116	464	
Survey	3	260	780	
Repair	4	260	1,040	
Electrician	2	260	520	
Operator	6	173	1,038	
Clerk	2	202	404	
Total	108		20,401	
Grand total	115		24,185	

Table II–2–29 Power Cost for Operation

(Unit : US$)

	Amount of Excavation	Power to be consumed	Power per unit	Unit price	Power cost per unit	Power cost
Prospecting tunnel	150 m	Kwh/M 70,000	Kwh/m,m³ 467	0.0227	10.60	US$ 1,589
Mining	(6,700ᵗ) 2,233m³	315,000	(47) 141	0.0227	(1.07) 3.20	7,151
Total		38,500				8,740

Note:
. The figures in parentheses are the tonnage of ore mined per month.
. Unit price of power (62,987 Cr/Kwh) = fundamental rate (13,832 Cr/Kwh) + power rate (49,155 Cr/Kwh)
. Conversion rate: I US$ = 2,769 CR$

Table II–2–31 Summary of Operation Cost

(Unit : US$)

Items / Year	Materials	Personnel	Power	Expense	Depreciation	Total	Cost per ton
1	57,063	24,185	8,740	1,150	11,398	102,536	13.67
2	57,063	24,185	8,740	1,150	10,621	101,759	13.57
3	57,063	24,185	8,740	1,150	10,534	101,672	13.56
4	57,063	24,185	8,740	1,150	10,116	101,254	13.50
5	57,063	24,185	8,740	1,150	10,116	101,254	13.50
6	57,063	24,185	8,740	1,150	7,121	98,259	13.10
7	57,063	24,185	8,740	1,150	7,121	98,259	13.10
8	57,063	24,185	8,740	1,150	6,719	97,857	13.10
9	57,063	24,185	8,740	1,150	5,651	96,789	12.90
10	57,063	24,185	8,740	1,150	6,651	96,789	12.90

Table II–2–30 Depreciation

(Unit : US$)

Equipments	Depreciation Number of year	US$ Amount	Depreciation by year 1(6)	2(7)	3(8)	4(9)	5(10)	6(11)	7(12)	8(13)	9(14)	10(15)	Note
Leg drill	5	104,400	20,880	20,880	20,880	20,880	20,880	* 5,220	5,220	5,220	5,220	5,220	* Additional Depreciation
Stopper drill	5	26,600	5,320	5,320	5,320	5,320	5,320						
Coal pick	2	2,090	1,045	1,045				* 1,045	1,045				
Bucket loader	10	52,056	5,206	5,206	5,206	5,206	5,206	5,026	5,206	5,206	5,206	5,202	
Mine tub	5	49,360	9,872	9,872	9,862	9,872	9,872	* 2,468	2,468	2,468	2,468	2,468	
Diesel locomotive	7	8,866	1,267	1,267	1,267	1,267	1,267	1,267	1,264				
10 HP electric slasher	10	108,122	10,812	10,812	10,812	10,812	10,812	10,812	10,812	10,812	10,812	10,814	
10 HP air slasher	10	37,116	3,712	3,712	3,712	3,712	3,712	3,712	3,712	3,712	3,712	3,708	
36" scraper	5	12,960	2,592	2,592	2,592	2,592	2,592						
Compressor	10	221,712	22,171	22,171	22,171	22,171	22,171	22,171	22,171	22,171	22,171	22,173	
Main fan	10	5,734	573	573	573	573	573	573	573	573	573	577	
Local fan	10	13,000	1,300	1,300	1,300	1,300	1,300	1,300	1,300	1,300	1,300	1,300	
Pump (1.5 m^3/min x 300 m)	7	11,928	1,704	1,704	1,704	1,704	1,704	1,704	1,704				
Pump (0.5 m^3/min x 150 m)	7	5,660	809	809	809	809	809	809	806				
Sump pump (0.3 m^3/min x 25 m)	3	2,580	860	860	860								
Vertical shaft winding machine (200 HP)	10	164,214	16,421	16,421	16,421	16,421	16,421	16,421	16,421	16,421	16,421	16,425	
Wire rope (25 mm)	4	5,923	1,481	1,481	1,481	1,480	* 1,481	1,481	1,481	1,480			
Cage	3	11,226	3,742	3,742	3,742								
Scaffold	1	4,084	4,084										
Kibble, rider, dumper	1	5,231	5,231										
Dump truck	3	1,236	412	412	412								
Chain block	4	45,346	11,337	11,337	11,337	11,335	11,335	11,337	11,337	11,335			
6" pipe	10	13,077	1,308	1,308	1,308	1,308	1,308	1,308	1,308	1,308	1,308	1,305	
High-voltage cable	10	7,720	772	772	772	772	772	772	772	772	772	772	
Transformer	10	7,080	708	708	708	708	708	708	708	708	708	708	
Blasting machine	10	936	94	94	94	94	94	94	94	94	94	90	
Welding machine	10	1,749	175	175	175	175	175	175	175	175	175	174	
Concrete mixer	10	1,531	153	153	153	153	153	153	153	153	153	155	
Grinder	10	10,763	1,076	1,076	1,076	1,076	1,076	1,076	1,076	1,076	1,076	1,079	
Tools	5	30,330	6,066	6,066	6,066	6,066	6,066						
Total		*91,799 972,631	141,183	131,868	130,823	125,806	*12,818 112,991	*21,551 68,261	*21,551 68,255	*20,503 64,481	* 7,688 64,481	* 7,688 64,482	

Section 3. Dressing

The dressing plant is designed based on the result of geological survey of the ore deposit, the report on the metallurgical test, the result of site investigation, and the plan of mining production, with reference to the facilities and the result of operation of dressing plants inside and outside of the country which are processing similar ores.

3–1 Plant Facilities

3–1–1 Design Criteria

Since the underground mining will operate 300 days per year, three shifts per day and eight hours per shift (six hours for actual ore transportation) with an output of 300 tons per day, the dressing operation follows these criteria.

The duty of operators is to be a spell of eight hours a day with actual working hours of seven hours in three shifts.

The operating hours of each section are five hours for the crushing plant (15 hours per day, and 20 tons capacity per hour), while remaining process facilities, including grinding, will operate 24 hours per day per week continuously.

Some loss time, caused by suspension of operation, is anticipated to occur, leading to an estimated operating rate of 96 % (processing capacity being 13 tons per hour).

The dilution of crude ore is 9.09 % (by weight). However, a dressing, all-crushing system is to be adopted, although some hand of picking by spalling would be effective.

The characteristics of the crude ore are as shown in Table II–3–1.

Although it is possible to separate and recover four kinds of concentrates such as lead, zinc, pyrite and barite from the grades of crude ore, pyrite is to be disposed with the tailings, because pyrite cannot be sold at the Perau mine even if it is produced. Therefore, we plan to recover three kinds of concentrate, lead, zinc and barite. Silver, which may be recovered in the lead concentrate is to be separated from crude lead in the refining process.

The treatment method and specifications of each section are shown in Table II–3–2.

3–1–2 Major Process Equipment

The major process equipment, required for processing 300 tons of crude ore per /day is shown in Table II–3–3 and the plant arrangement in Fig. II–3–1 and Fig. II–3–2.

Table II–3–1 Characteristics of Crude Ore

	Ag	Cu	Pb	Zn	Fe	S	BaO
Assays	(g/t) 72.7	(%) 0.02	(%) 3.64	(%) 1.82	(%) 3.10	(%) 7.08	(%) 16.36
Specific gravity	3.3						
Moisture (%)	5.0						

Table II–3–2 Treatment method & specifications

Section	Item	Specifications
Crushing	Crushing method	Dry 2 stages, 1st open circuit 2nd closed circuit
	Feed size	220 mm Grate undersize
	Crushing product 80% size	1st stage 50 mm 2nd stage 12 mm
	Feed hopper	Capacity 50 t
	Product ore bin	Capacity 200 t
Grinding	Grinding & classification method	1 stage grinding by a cylindrical ball mill & 2 stages classification by a spiral classifier & 2 cyclones closed circuit
	Feed 80% size	12 mm
	Product 80% size	64 μ
	Work index	13.67
Flotation	Flotation method	Lead straight, Zinc & Pyrite bulk & differential flotation by using NaCN $ZnSO_4$, $SuSO_4$, $Ca(OH)_2$, and Barite flotation
	Flotation time	Pb flotation 20 min Zn, Py bulk flotation 20 min Zn, Py differential flotation 20 min $BaSO_4$ flotation 10 min
Thickening & filtration	Moisture content of Pb, Zn & $BaSO_4$ concentrates	Less than 10%
Tailing disposal	Treatment method Settling speed	Flocculation & precipitation method 262 mm/min
Waste water treatment	Decomposition method of CN ion.	Oxidation by sodium hypochlorite

Table II–3–3 Main Equipments of Ore Dressing Plant (1)

Section	Equipments	Specifications	Quantity	Motor Number	Motor kw/unt	kw	Note	Number in Flowsheet
Crushing	Grate	5000mmx2000mm opening 220x220mm	1					1
	Hopper	50t	1					2
	Apron feeder	750mmWx4500mmL	1	1	5.6	5.6	6.5t 12.4m³	3
	Grizzly	660mmWx2000mmL opening 60mm	1					4
	Single toggle jaw crusher	Type 6240 240 r.p.m.	1	1	22.5	22.5	7.15t 5.6m³	5
	Belt conveyor No.1	500mmW			3.75	3.75		6
	Vibrating screen	1000mmWx2500mL opening 12x12mm	1	1	3.75	3.75	0.9t	7
	Belt conveyor No.2	500mmW with magnet pulley	1	1	3.75	3.75		8
	Cone crusher	90-F coarse type 330 r.p.m.	1	1	56	56		9
	Belt conveyor No.3	450mmW	1	1	2.25	2.25		10
	Belt conveyor No.4	500mmW	1	1	3.75	3.75		11
	Belt conveyor No.5	500mmW	1	1	7.5	7.5		12
	Belt conveyor No.6	500mmW	1	1	2.25	2.25		13
Grinding	Bin	200t	1					14
	Disc feeder		1	1	0.75	0.75		15
	Belt conveyor No.7	400mmW with weight meter	1	1	1.5	1.5		16
	Cylindrical ball mill	9′φx10′ 18.4 r.p.m.	1	1	262	262	35t	17
	Spiral classifier	60″φ Akins type	1	1	3.75	3.75		18
	Slurry pump	SRL-C 5x4x14	1	1	15	15		19
	Cyclone	9″φ	2					20
	Slurry pump	SRL-C 3x3x10	1	1	7.5	7.5		21
Pb-flotation	Conditioner	1500mmφx1800mmH	1	1	3.75	3.75		22
	Flotator	#24 FW 1100mmx1100mmx990mm	8 cells 2 lines	8	15	120		23
	Flotator	# FW 610mmx610mmx910mm	8 cells 1 line	4	7.5	30		24
	Slurry pump	SRL 2x2x10	1	1	1.5	1.5		25
Bulk flotation	Slurry pump	SRL-C 3x3x10	1	1	7.5	7.5		26
	Conditioner	1500mmφx1800mmH	1	1	3.75	3.75		27
	Flotator	#24 FW 1100mmx1100mmx990mm	8 cells 2 lines	8	15	120		28
	Flotator	# FW 610mmx610mmx910mm	12 cells 1 line	6	7.5	45		29
	Slurry pump	SRL 2x2x10	1	1	1.5	1.5		30
	Slurry pump	SRL 2x2x10	2	2	3.75	7.5		31
	Cyclone	6″φ	1					32
	Ball mill	40″φx48″ 33 r.p.m.	1	1	11.25	11.25	6.19t	33
	Thickener	9mφ	1	1	3	3		34
Zn-flotation	Slurry pump	SRL 2x2x10	2	2	3.75	7.5		35
	Slurry pump	SRL 2x2x10	2	2	1.5	3		36
	Conditioner	1300mmφx1600mmH	1	1	3	3		37

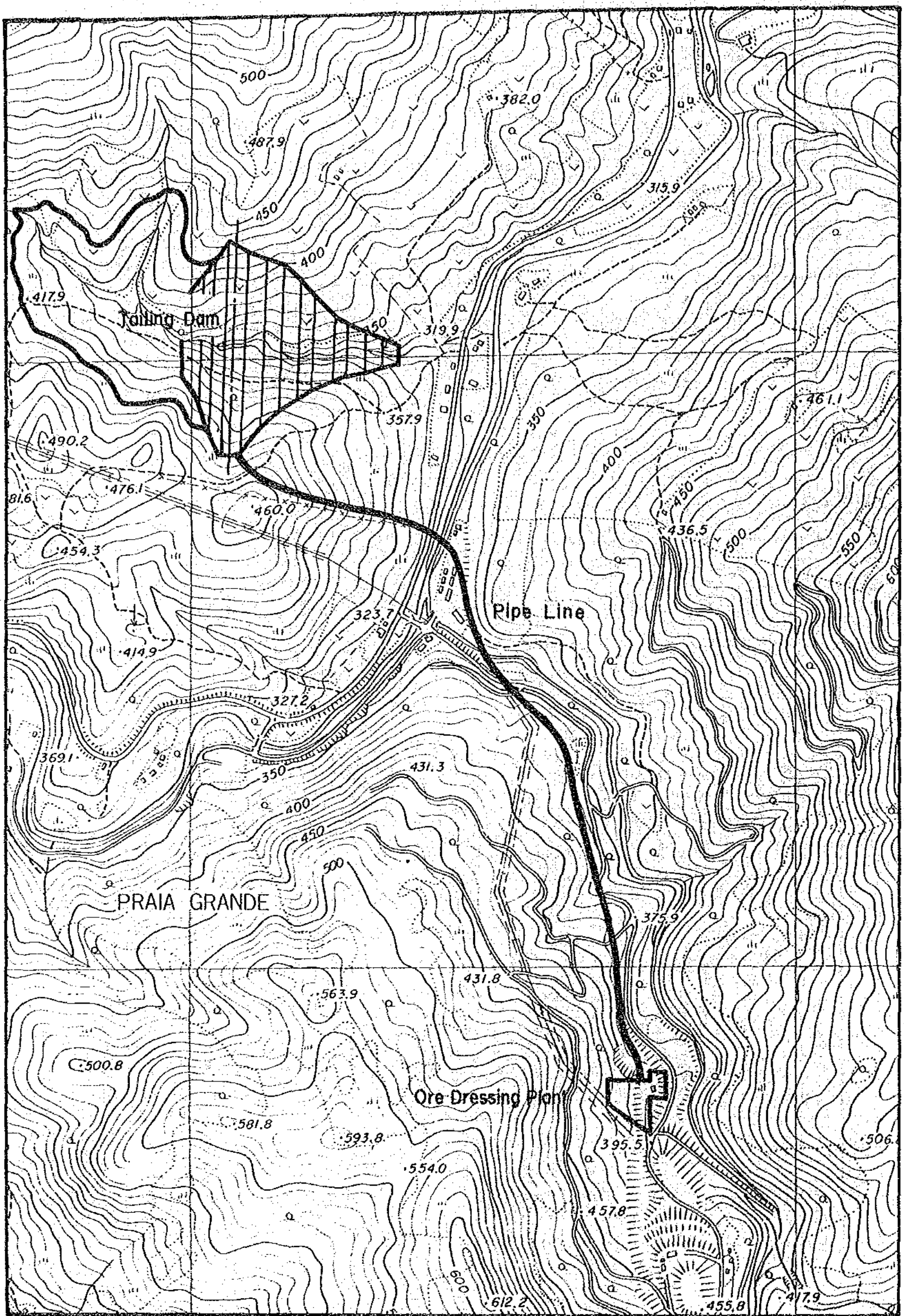


Fig. II–3–1 Location of Ore Dressing Plant Tailing Pipe Line and Tailing Dam

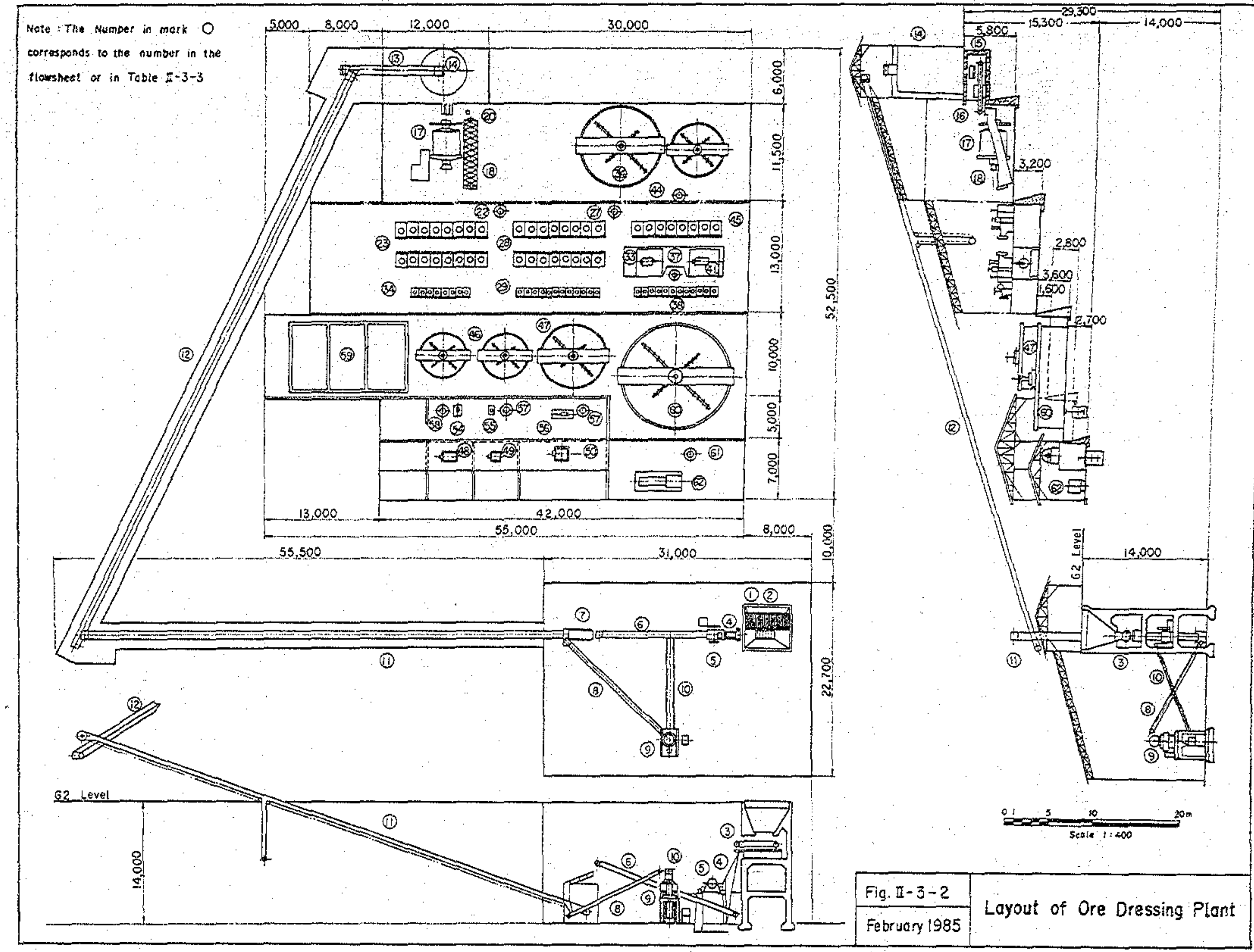


Fig. II–3–2 Layout of Ore Dressing Plant

3–2 Flowsheet

Fig. II–3–3 shows the flowsheet of the plant, Table II–3–4 manpower and labor rates for personnel, and Table II–3–5 the main materials consumption and cost.

3–3 Estimated Result of Operation

The estimated result of operation was worked out with reference to the result of metallurgical tests and the actual result of operation of the dressing plants in Japan, processing ores similar to that of Perau, which is shown in Table II–3–6.

3–4 Initial Capital Cost Estimate

Table II–3–7 shows the initial capital cost for a dressing plant of 300 tons/day.

3–5 Operating Cost Estimate

Table II–3–8 shows the operating cost estimates for the dressing plant and the tailing dam.

3–6 Summary

(1) The data obtained from the dressing test cannot be used as they are, because there was a considerable difference between the ratio of contents of galena, sphalerite, pyrite, barite and other gangue minerals in the feed, used in the dressing test, and those of the crude ore used in the plan for the dressing plant.

Therefore, the flowsheet for dressing, the estimated result of operation and the planning of dressing facilities, for the crude ore to be mined from the Perau new deposit, were produced by reference to (i) the results of dressing of the Perau ore processed in the Panelas dressing plant, which was studied at the site at the time of visit of the survey team, (ii) the result of the Hosokura dressing plant, which a representative dressing plant for lead and zinc in Japan, and (iii) results of the Matsumine dressing plant where barite is recovered by the flotation method.

(2) A preliminary design for a dressing plant, to be constructed in the vicinity of the existing dressing plant of the Perau mine, was attempted for the ore reserve of the Perau new deposit (one million tons in crude ore reserve, and 80 g/t Ag, 4 % Pb, 2 5 Zn, and 18 % BaO in grade) to recover concentrates from the mill head of 7,500 tons/month for grades such as 72.7 g/t Ag, 3.64 % Pb, 1.82 % Zn and 16.36 % BaO by processing with a three-shift operation. The concentrates include 382 tons per month of lead concentrate with 1213 g/t Ag and 67.18 % Pb and recovery rates of 85 % silver and 94 % lead; 210 tons per month of zinc concentrate with 53.30 %

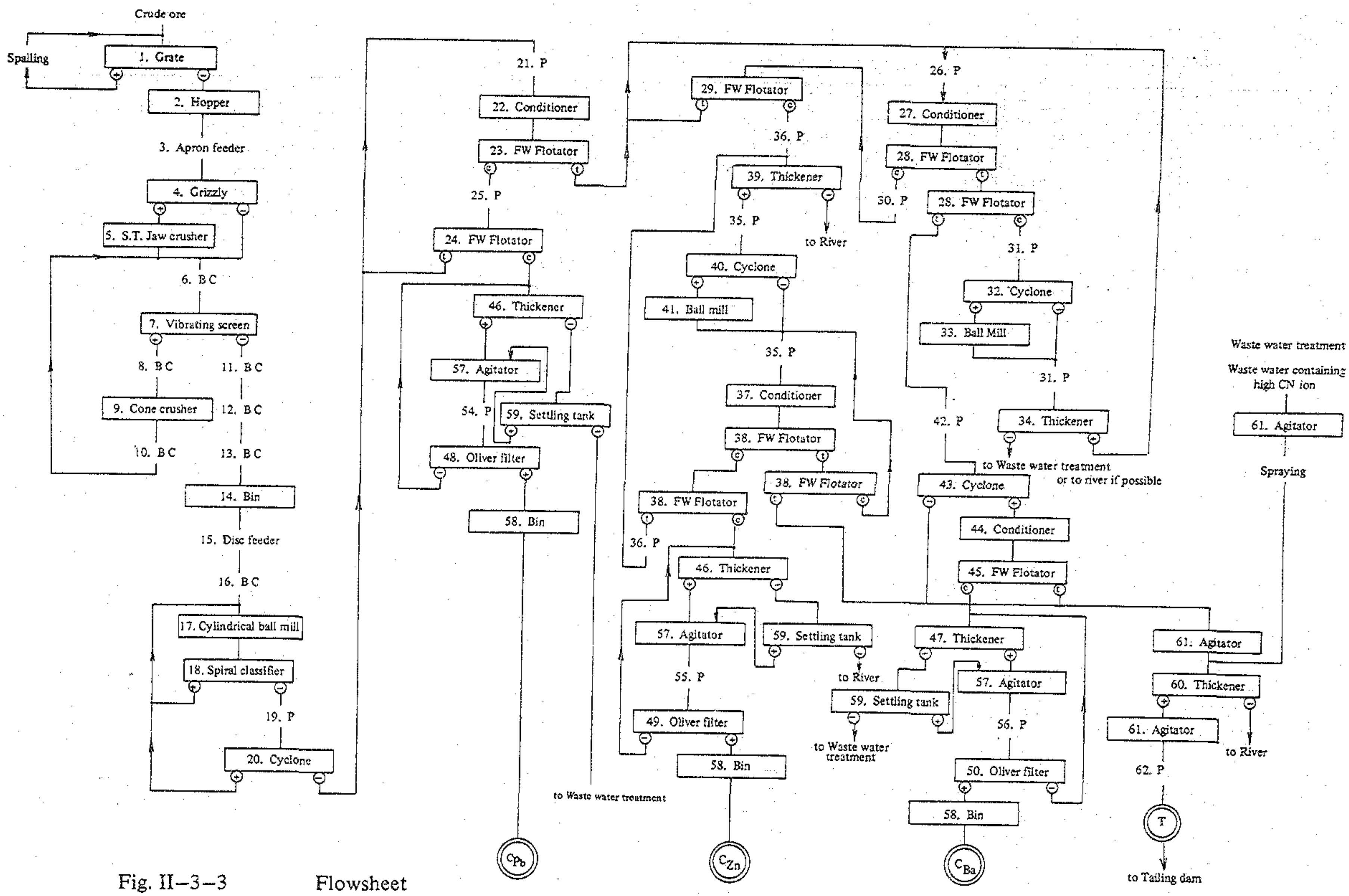


Fig. II-3-3 Flowsheet

Table II–3–3 Main Equipments of Ore Dressing Plant (2)

Section	Equipments	Specifications	Quantity	Motor Number	Motor kw/unit	kW	Note	Number in Flowsheet
Zn-flotation (continued)	Flotator	# FW 610 x 610 x 910	12 cells 1 line	6	7.5	45		38
	Thickener	6mφ	1	1	2.25	2.25		39
	Cyclone	6"φ	1					40
	Ball mill	34"φ x 60" 36 r.p.m.	1	1	7.5	7.5	7t	41
Barite flotation	Slurry pump	SRL-C 3 x 3 x 10	1	1	7.5	7.5		42
	Cyclone	9"φ	1					43
	Conditioner	1500mmφx1800mmH	1	1	3.75	3.75		44
	Flotator	#24 FW 1100mmx1100mmx990mm	8 cells 1 line	4	15	60		45
Filtration	Thickener	5mφ	2	2	1.5	3		46
	Thickener	7mφ	1	1	2.25	2.25		47
	Filter	1.0mφx1.5mL Oliver dram type	1	1	1.5	1.5		48
	Filter	1.0mφx1.0mL Oliver dram type	1	1	0.75	0.75		49
	Filter	1.5mφx1.5mL Oliver dram type	1	1 1	0.75 1.5	2.25		50
	Vacuum pump	15m³/min, 722 mmHg	1	1	18.75	18.75		51
	Compressor	1.5m³/min, 0.7 kg/cm²	1	1	1.875	1.875		52
	Filtrate pump	0.145m³/min	1	1	0.375	0.375		53
	Diaphragm pump	Single type 3"φx6"	1	1	0.75	0.75		54
	Diaphragm pump	Single type 2 1/2"φx5"	1	1	0.375	0.375		55
	Diaphragm pump	Double type 3"φx6"	1	1	1.5	1.5		56
	Agitator		3	3	3.75	11.25		57
	Bin		3					58
	Settling tank		3					59
Tailing and waste water disposal	Thickener	12mφx3m	1	1	3.75	3.75		60
	Agitator		3	3	3.75	11.25		61
	Mars pump	L-180 type 120x350x2	1	1	11	11		62
	Cyclone	9"φ	1					63
Others	Reagent dissolving tank		10	10	0.5	5		64
	Reagent feeder		10	10	0.5	5		65
	Turbine pump		2	2	20	40		66
	Sample crusher		1	1	1.5	1.5		67
	Sample grinder		1	1	1.5	1.5		68
Total				115		1019.475		

Table II–3–4 Personnel Arrangement and Personnel Expenses for Ore Dressing

	1st shift	2nd shift	3rd shift	Total	Unit pay*	Payment
Salaried personnel					US$/mo.	US$/mo.
Superintendent	1			1	780	780
Senior engineer or Junior engineer	1			1	520	520
Total	2			2		1,300
Wage workers						
Foreman	1	1	1	3	310	930
Operaters						
Crushing	1	1	1	3	260	780
Grinding Flotation Filtration	3	3	3	9	260	2,430
Tailing disposal	1	1	1	3	260	780
Total	5	5	5	15		3,900
Repair man	3			3	260	780
Test & Assay man	1			1	260	260
Clerk	1			1	202	202
Total	11	6	6	23		6,072
Grand Total	13	6	6	25		7,372

* These unit pays contain 60% of each pay as the insurance fee and others.

Table II–3–5 Consumption and Expenses of Main Consumable Supplies

Article	Unit Price US$/kg*	Consumption		Costs US$/mo
		g/t*	Kg/mo	
Crusher liner	2.	24	180	360
Mill liner	2.	240	1,800	3,600
Grinding ball	1.817	480	3,600	6,541
Methyl isobuthyl carbinol	2.047	110	825	1,689
Sodium isopropyl xanthate	2.404	110	825	1,983
Sodium oleate	2.221	380	2,850	6,330
Kerosene	0.8	190	1,425	1,140
Zinc sulphate	0.767	140	1,050	805
Copper sulphate	1.817	286	2,145	3,897
Sodium cyanide	3.300	40	300	990
Sodium silicate	0.311	140	1,050	327
Sodium hypochlorite	0.11	80	600	66
Calcium hydroxide	0.08	1,500	11,250	900
Sulphric acid	0.04	720	5,400	216
Poly-aluminum chloride	0.168	460	3,450	580
Poly-acrylamide	4.8	9.2	69	331
Total				29,755

* These unit prices include import tax, IOF, ICM and IPI but do not include domestic freight.

* g/t of crude ore

Table II–3–6 Anticipated Performance of Annual Production for 10 Years

	Dry weight	Assays												Recovery				
		Ag	Cu	Pb	Zn	Fe	S	BaO	CaO	MaO	Al_2O_3	SiO_2	Weight	Ag	Cu	Pb	Zn	BaO
	t/year	g/t	%											%				
Crude ore	90,000	72.7	0.02	3.64	1.82	3.10	7.08	16.36	12.14	7.85	2.40	15.98	100.00	100.00	100.00	100.00	100.00	100.00
Lead concentrate	4,584	1,213	0.12	67.18	3.57	2.14	14.91	2.32	1.72	1.11	2.34	2.27	5.09	85.00	30.00	94.00	10.00	
Zinc concentrate	2,520	82	0.14	1.30	53.30	3.01	30.09	2.36	1.75	1.13	0.35	2.30	2.80				83.00	
Barite concentrate	9,336	4	0.01	0.11	0.08	0.15	0.15	63.08	0.67	0.44	0.13	0.89	10.37				40.00	

Tabel II–3–7 Initial Investment Cost of Ore Dressing Plant (1)

Unit : US$

Section	Equipments	Unit Price	Quantity	Amount of cost	FOB price	Overseas freight and insurance	CIF price or domestic price	Taxes								Domestic freight	Construction cost	Depreciation	
								Import duties	%	IOF	%	ICM	%	IPI	%			Years	Cost/Year
Crushing	Grade	1,467	1	1,467			1,136					193	17	106	8	32		10	147
	Hopper	7,293	1	7,293													7,293	10	729
	Apron feeder	44,529	1	44,529			36,144					6,144	17	2,114	5	127		10	4,453
	Grizzly	295	1	295			288					39	17	21	8	7		10	30
	Jaw crusher	83,421	1	83,421			67,784					11,523	17	3,965	5	149		10	8,342
	Belt conveyor	9,810	1	9,810			7,594					1,291	17	888	10	37		10	981
	Vibrating screen	14,490	1	14,490			11,242					1,911	17	1,315	5	22		10	1,449
	Belt conveyor	8,171	1	8,171			6,328					1,076	17	740	10	27		10	817
	Cone crusher	87,043	1	87,043			70,580					11,999	17	4,129	5	335		10	8,704
	Belt conveyor	4,659	1	4,659			3,607					613	17	422	10	17		10	466
	Belt conveyor	13,078	1	13,078			10,125					1,712	17	1,185	10	47		10	1,308
	Belt conveyor	16,345	1	16,345			12,656					2,151	17	1,481	10	57		10	1,635
	Belt conveyor	4,903	1	4,903			3,797					645	17	444	10	17		10	490
	Total			295,504			231,221					39,306		16,810		874	7,293	10	29,550
Grinding	Bin	26,254	1	26,254													26,254	10	2,625
	Dics feeder	6,167	1	6,167			5,009					852	17	293	5	13		10	617
	Belt conveyor	4,413	1	4,413			3,416					581	17	400	10	16		10	441
	Ball mill	226,597	1	226,597			183,912					31,265	17	10,759	5	661		10	22,660
	Spiral classifier	38,994	1	38,994			31,620					5,375	17	1,850	5	149		10	3,899
	Slurry pump	4,378	1	4,378			3,554					604	17	208	5	12		10	438
	Cyclone	3,470	2	6,940			5,632					958	17	330	5	20		10	694
	Slurry pump	3,721	1	3,721			3,021					513	17	177	5	10		10	372
	Total			317,464			236,164					40,148		14,017		881	26,254	10	31,746
Pb-flotation	Conditioner	6,776	1	6,776			5,467					929	17	320	5	60		10	678
	Flotator (2 cells 1 unit)	8,275	8	66,200			53,457					9,088	17	3,127	5	528		10	6,620
	Flotator (2 cells 1 unit)	6,162	4	24,648			19,904					3,384	17	1,164	5	196		10	2,465
	Slurry pump	3,283	1	3,283			2,665					453	17	156	5	9		10	328
	Total			100,907			81,493					13,854		4,767		793		10	10,091
Bulk flotation	Slurry pump	3,721	1	3,721			3,021					513	17	177	5	10		10	372
	Conditioner	6,776	1	6,776			5,467					929	17	320	5	60		10	678
	Flotator (2 cells 1 unit)	8,275	8	66,200			53,457					9,088	17	3,127	5	528		10	6,620
	Flotator (2 cells 1 unit)	6,162	6	36,972			29,856					5,075	17	1,747	5	294		10	3,697
	Slurry pump	3,283	1	3,283			2,665					453	17	156	5	9		10	328
	Slurry pump	3,373	2	6,746			5,477					931	17	320	5	18		10	675
	Cyclone	2,134	1	2,134			1,732					294	17	101	5	7		10	213
	Ball mill	19,498	1	19,498			15,750					2,678	17	921	5	149		10	1,950
	Thickener	33,976	1	33,976			27,414					4,660	17	1,604	5	298		10	3,398
	Total			179,306			144,839					24,621		8,473		1,373		10	17,931

Table II–3–7 Initial Investment Cost of Ore Dressing Plant (2)

Unit : US$

Section	Equipment	Unit Price	Quantity	Amount of cost	FOB price	Overseas freight and insurance	CIF price or domestic price	Taxes: Import duties	%	IOF	%	ICM	%	IPI	%	Domestic freight	Construction cost	Depreciation: Years	Cost/Year
Zn-flotation	Slurry pump	3,373	2	6,746			5,477					931	17	320	5	18		10	675
	Slurry pump	3,283	2	6,566			5,330					906	17	312	5	18		10	657
	Conditioner	6,419	1	6,419			5,191					882	17	304	5	42		10	642
	Flotator (2 cells 1 unit)	6,162	6	36,972			29,856					5,075	17	1,747	5	294		10	3,697
	Thickener	22,651	1	22,651			18,276					3,107	17	1,069	5	199		10	3,265
	Cyclone	2,134	1	2,134			1,732					294	17	101	5	7		10	213
	Ball mill	11,813	1	11,813			9,530					1,620	17	557	5	106		10	1,181
	Total			93,301			75,392					12,815		4,410		684		10	9,330
Ba-flotation	Slurry pump	3,721	1	3,721			3,021					513	17	177	5	10		10	372
	Cyclone	3,470	1	3,470			2,816					479	17	165	5	10		10	347
	Conditioner	6,776	1	6,776			5,467					929	17	320	5	60		10	678
	Flotator (2 cells 1 unit)	8,275	4	33,100			26,728					4,544	17	1,564	5	264		10	3,310
	Total			47,067			38,032					6,465		2,226		344		10	4,707
Filtration	Thickener	18,874	2	37,748			30,460					5,178	17	1,782	5	328		10	3,775
	Thickener	26,424	1	26,424			21,322					3,625	17	1,247	5	230		10	2,642
	Filter	19,685	1	19,685			15,885					2,700	17	929	5	171		10	1,969
	Filter	13,077	1	13,077			10,552					1,794	17	617	5	114		10	1,308
	Filter	29,530	1	29,530			23,828					4,051	17	1,394	5	257		10	2,953
	Vacuum pump	12,050	1	12,050			9,768					1,661	17	571	5	50		10	1,205
	Compressor	2,017	1	2,017			1,628					277	17	95	5	17		10	202
	Filtrate pump	808	1	808			651					111	17	38	5	8		10	81
	Diaphragm pump	2,836	1	2,836			2,279					388	17	133	5	36		10	284
	Diaphragm pump	2,430	1	2,430			1,954					332	17	114	5	30		10	243
	Diaphragm pump	4,872	1	4,872			3,907					664	17	229	5	72		10	487
	Agitator	6,598	3	19,794			15,988					2,718	17	935	5	153		10	1,979
	Bin	5,000	3	15,000													15,000	10	1,500
	Settling tank	2,500	3	7,500													7,500	10	750
	Total			193,771			138,222					23,499		8,084		1,466	22,500	10	19,377
Tailing and waste water disposal	Thickener	56,072	1	56,072			45,167					7,778	17	2,733	5	394		10	5,607
	Agitator	6,736	3	20,208			16,401					2,787	17	960	5	60		10	2,021
	Mars pump	7,589	1	7,589	(4,000)	(1,000)	5,000	–		1,250	25	903	17	313	5	123		10	759
	Cyclone	3,470	1	3,470			2,816					479	17	165	5	10		10	347
	Total			87,339	(4,000)	(1,000)	69,384	–		1,250		11,947		4,171		587		10	8,734
Others	Reagent dissolving tank	1,205	10	12,050			9,768					1,660	17	572	5	50		10	605
	Reagent feeder	1,205	10	12,050			9,768					1,660	17	572	5	50		10	605
	Turbine pump	3,020	2	6,040			4,884					830	17	286	5	40		10	614
	Sample crusher	2,850	1	2,850			2,315					393	17	136	5	6		10	285
	Sample grinder	3,220	1	3,220			2,616					445	17	153	5	6		10	322

Table II—3—7　Initial Investment Cost of Ore Dressing Plant (3)

Unit : US$

Section	Equipment	Unit Price	Quantity	Amount of cost	FOB price	Overseas freight and insurance	CIF price or domestic price	Tax								Domestic freight	Construction cost	Depreciation	
								Import duties	%	IOF	%	ICM	%	IPE	%			Years	Cost/Year
	Test machines and materials			16,080			13,024					2,214	17	762	5	80		10	1,608
	Instrument			12,870			10,419					1,771	17	610	5	70		10	1,287
	Assay materials			28,077			22,000					3,740	17	2,059	8	278		10	2,808
	Piping materials			13,715			10,800					1,836	17	1,011	8	68		10	1,372
	Cranes			11,342			8,800					1,496	17	824	8	222		10	1,134
	Tools			47,422			37,492					6,374	17	3,509	8	47		10	4,742
	Spare stores		kg	197,470			155,613					26,455	17	15,291	8	111		10	19,747
	Liners	2,025	30,000	60,741			46,620					7,926	17	5,454	10	741		10	6,074
	Balls	1,842	30,000	55,254			42,356					7,201	17	4,956	10	741		10	5,525
	Greases and oils	1,025	1,500	1,537			1,166					198	17	136	10	37		10	154
	Total			480,718			377,641					64,199		36,331		2,547		10	48,072
Total cost of equipments				1,795,377	(4,000)	(1,000)	1,392,388	–		1,250		236,854		99,289		9,549	56,047	10	179,538
Equipments installation cost				324,901			179,986					30,598	17	16,847	8	720	96,750	10	32,490
Cleaning, excavation, foundation&building				1,185,557			549,387					93,396	17	51,422	8	2,198	489,154	10	118,556
Electric work cost				175,447			97,193					16,523	17	9,097	8	389	52,245	10	17,545
Other expense				235,057														10	23,506
Emergency fund				12,000														10	1,200
Grand total				3,728,339	(4,000)	(1,000)	2,218,954	–		1,250		377,371		176,655		12,856	694,196	10	372,834

Table II–3–8 Annual Operating Cost of Ore Dressing Section

Item of Expenditure	Unit Price	Annual Quantity	Annual Amount	FOB Price	Overseas Freight and Insurance Fee	CIF Price or Domestic Price	Tax: Import Duties	%	IOF	%	ICM	%	IPI	%	Domestic Freight
	US$/kg	kg	US$	US$	US$	US$	US$		US$		US$		US$		US$
Supplies Expense															
Liners	2.0247	23,760	48,107			36,923					6,277	17	4,320	10	587
Grinding ball	1.8417	43,200	79,560			60,990					10,368	17	7,136	10	1,066
Methyl isobutyl carbinol	2.0176	9,900	20,509			15,746					2,677	17	1,842	10	244
Sodium isopropyl xanthate	2.4286	9,900	24,043	(10,935)	(1,980)	12,375	3,713	30	3,094	25	3,008	17	1,609	10	244
Sodium oleate	2.2457	34,200	76,802			59,020					10,033	17	6,905	10	844
Kerosene	0.8247	17,100	14,102			10,629					1,807	17	1,244	10	422
Zinc sulfate	0.7917	12,600	9,975			7,509					1,276	17	879	10	311
Copper sulfate	1.8417	25,740	47,405			36,340					6,178	17	4,252	10	635
Sodium cyanide	3.3247	3,600	11,969			9,231					1,569	17	1,080	10	89
Sodium silicate	0.3357	12,600	4,230			3,045					518	17	356	10	311
Sodium hypochlorite	0.1347	7,200	970			615					105	17	72	10	178
Calcium hydroxide	0.1047	135,000	14,133			8,392					1,426	17	982	10	3,333
Sulfric acid	0.0647	64,800	4,192			2,014					342	17	236	10	1,600
Poly-aluminum chloride	0.1927	41,400	7,977			5,404					919	17	632	10	1,022
Poly-acrylamide	4.8237	828	3,994			3,088					525	17	361	10	20
Greases and oils	1.0247	4,500	4,611			3,497					594	17	409	10	11
Others			18,361			14,267					2,425	17	1,669	10	
Total			390,940	(10,935)	(1,980)	289,085	3,713		3,094		50,047		33,984		11,017
	@ Average per mo.	Number of person													
Personnel Expense															
Salaried personnel	650	2	15,600												
Wage worker	264	23	72,864												
Total		25	88,464												
	US$/kWH	kWH													
Power Expense	0.0227	4,500,000	102,150												
Assay Expense			72,000												
Other Expense			9,600												
Depreciation			372,834												
Grand Total			1,035,988												
Average per month			86,332												

zinc and a recovery rate of 83 % for zinc, and 778 tons per month of barite concentrate with 63.8 % Bao (96.02 % in $BaSO_4$) with a recovery rate of 40 % BaO.

(3) The total construction cost is US$3,728,339, being US$3.73 per ton of ore reserve. The cost seems to be reasonable for the dressing facility to process 7,500 tons per month of mill head and to recover three kinds of concentrates.

The operation cost was calculated to be US$86,332 per month total direct cost, being US$11.51 per ton of ore, of which depreciation cost occupies 36 %.

(4) The main part of the operating cost consists of consumable materials such as 12.3 % ball mill and lining, 21.5% flotation reagents, 1.7 % agents for prevention of environmental pollution, and 2.2 % other materials, being 37.7 % in total.

Electric power cost occupies 9.9 % and personnel expenses 8.5 %.

The processing cost was calculated to be US$11.51 per ton including the depreciation, which seems to be rather low on the whole. The amount deducted for depreciation also shows a low cost.

(5) As a result, the figures obtained in the estimated result of operation were considerably better than those obtained by the use of the results of the dressing test. For confirmation of this point, more detailed dressing tests should be conducted in future, by securing sufficient samples for the test, when the fill-in drilling is planned to confirm the ore reserve.

(6) Especially, the work index of the above samples should be measured for confirmation, because the work index from the dressing test seems to be a little larger than the one for normal lead and zinc ore, and the cylindrical ball mill design is based on the measured value.

(7) It may be significant to test for recovery of liberated lead mineral particles with some mineral jigs etc. by gravity concentration before flotation.

(8) The zinc flotation process should be re-investigated by comparing bulk and differential flotation between zinc and pyrite, considering the following barite flotation, because pyrite cannot be utilized.

(9) Since the barite concentrate was apt to be contaminated by calcite, according to the ore dressing test's result, the barite flotation process should be further investigated for separation of calcite.

(10) The flowsheet, facilities, and the initial investment and the operation cost etc. should be reviewed, based on the above-mentioned re-investigation results.

Section 4. Tailings Dam

4–1 Location of Tailings Dam

The "tailings dam", in which the tailings from flotation are to be deposited, is necessary for pollution control, and is shown in Fig. II–4–1. It is to be formed at a proper site, selected in the neighborhood of the Perau new deposit.

The site is about twenty kilometers from the Perau new deposit. Since it is close to the road, it seems relatively convenient for construction work. The figure shows facilities such as dam, underdrain, hillside waterway and emergency drainage.

Fig. II–4–2 shows the catchment basin area which is 1,300,000 m^2. It will be necessary to design the waterway corresponding to the area.

4–2 Design of Tailings Dam

If it is assumed that the minable crude ore reserve is 900,000 tons and that 85 % of it is waste rock, the quantity of waste is 765,000 tons. If calculation is made assuming the tonnage of waste is deposited in one cubic meter is one ton, then total volume to be deposited is 765,000 m^3. This figure is determined to be the capacity of the tailing dam.

Table II–4–1 shows the specification of the tailing dam, and Fig. II–4–3 the projected dam section. Fig. II–4–4 shows the projected rise in the slime surface of tailings dam by year.

4–3 Other Facilities

Fig. II–4–5 ~ II–4–7 shows the sections of underdrain, emergency drainage and hillside waterway.

4–4 Cost for Construction of Tailing Dam

Table II–4–2 shows the cost for construction of Tailing dam.

Table II–4–1 Specification of Tailings Pond

Items	Specification
Volume	765,000 m^3
Area	82,000 m^2
Effective height of dam	88 m
Ultimate height of slimes surface	85 m
Grade of outside slope of dam	0.25 %
Grade of inside slope of dam	0.18 %
Protection of surface of outside slope of dam	Spray of three-kind mix and installation of concrete waterway on each bench

Table II–4–2 Cost for Construction of Tailings Dam

Name of facilities		Amount (US$)	Note
(1) Dam		933,115	
(2) Underdrain	mainstream	221,740	450 m
	tributary	38,418	150 m
(3) Emergency drainage	Underdrain	19,712	40 m
	Tunnel without lining	5,500	270 m
	Tunnel placed with concrete	60,000	130 m
	open waterway	16,468	120 m
(4) Hillside waterway		84,708	220 m
(5) Tailings pipeline		56,500	4" Steel pipe 1,500 m in length
Total		1,436,161	

Investment (Developing stage of 5 years) : : 287,232 US$/y
Depreciation (Operation stage of 10 years) : 1,436,161 US$/y

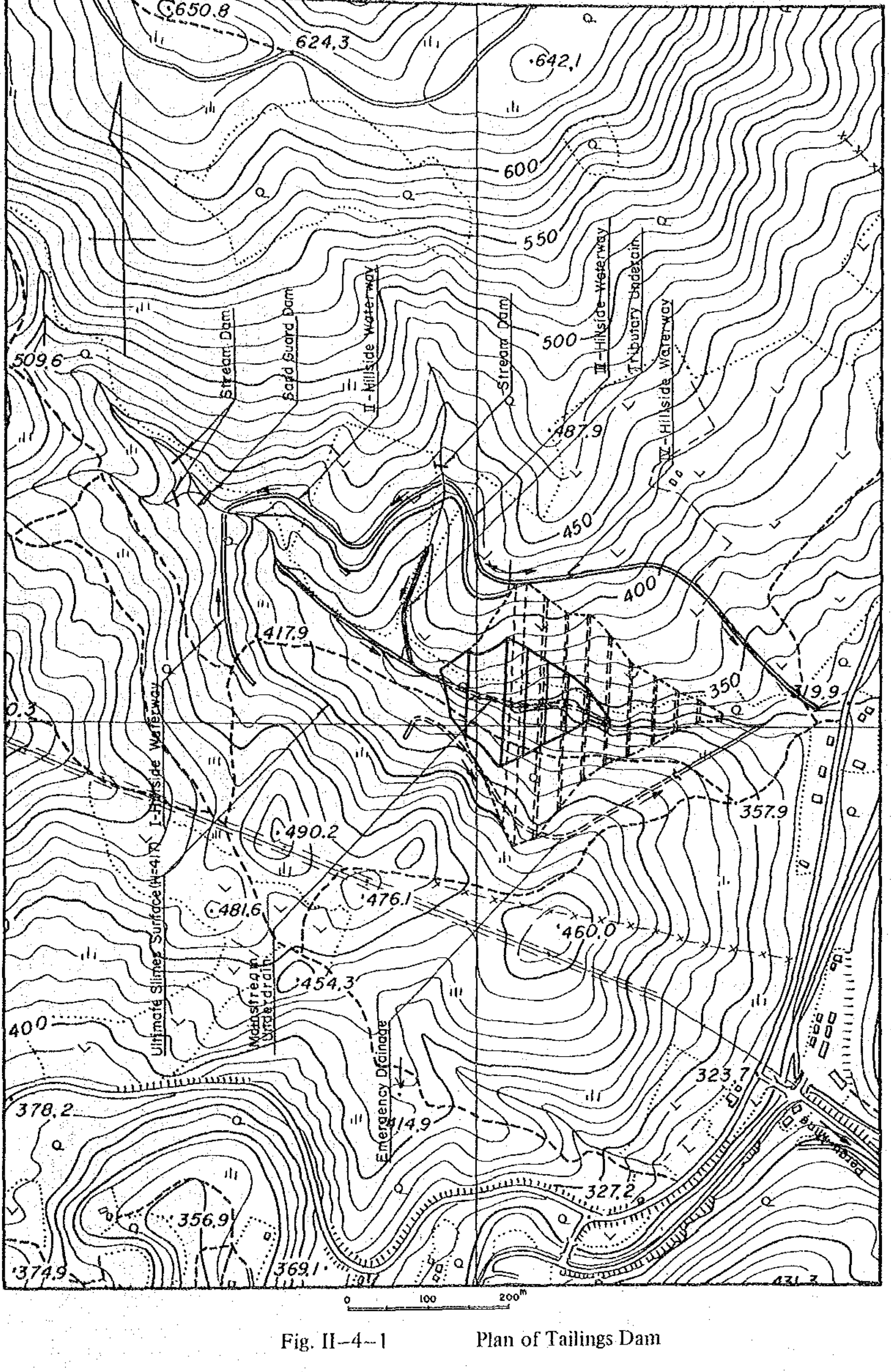
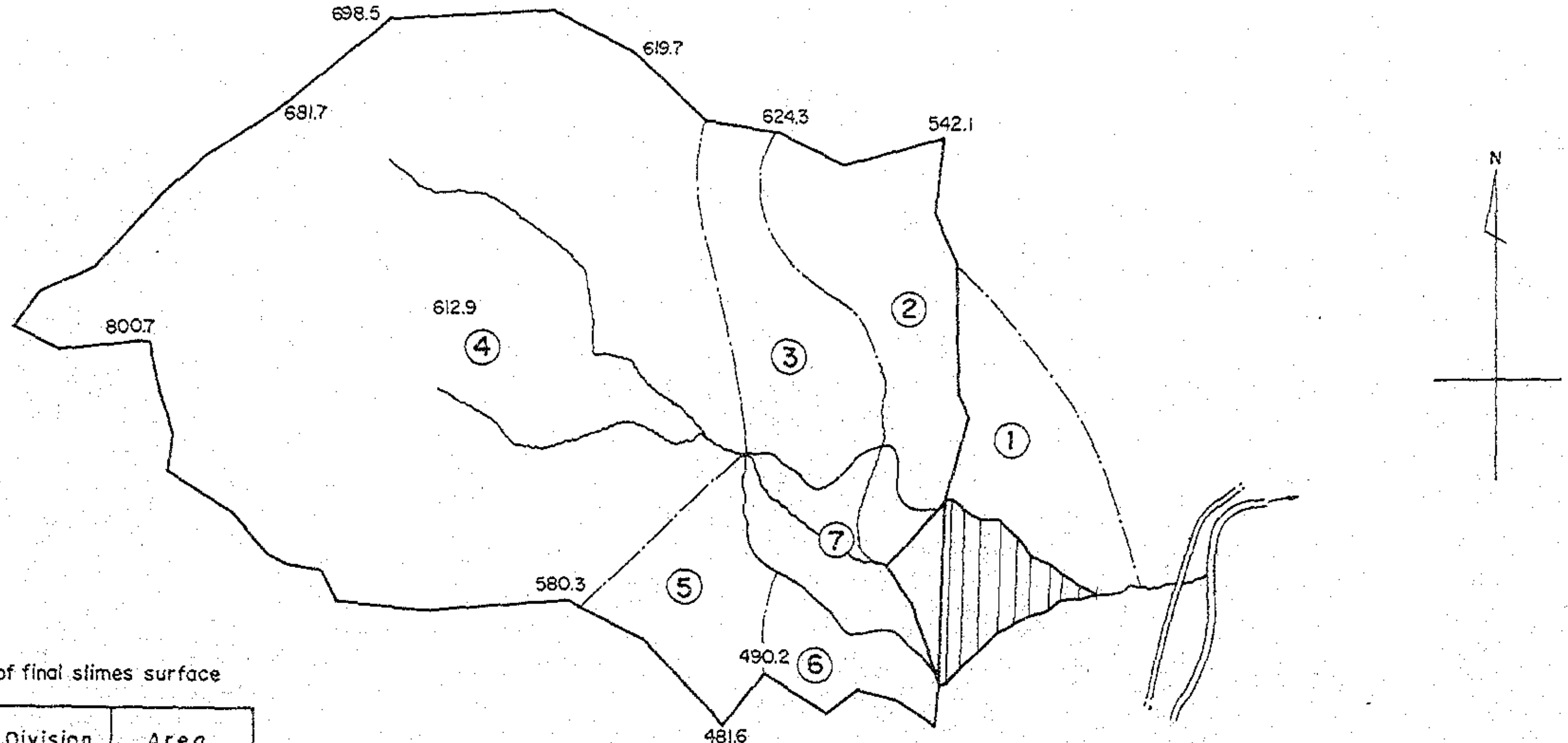


Fig. II–4–1 Plan of Tailings Dam



Area of final slimes surface

NO.	Division	Area (m²)
1	Hillside Waterway	90,000
2	〃	121,000
3	〃	105,000
4	Mainstreame Underdrain	876,000
5	Hillside Waterway	72,000
6	—	44,000
7	Underdrain	82,000

Area of the whole catchment basin except ① (for calculation of effluent volume through mainstream underdrain and emergency drainage)	1,300,000 m²
Area of catchment ① + ② (for calculation of effluent volume through I - Hillside waterway)	211,000
〃 〃 ③ (II - 〃 〃 〃)	105,000
〃 〃 ⑤ (III - 〃 〃 〃)	72,000

Fig. II–4–2 Map Showing Catchment Basin S= 1/10,000

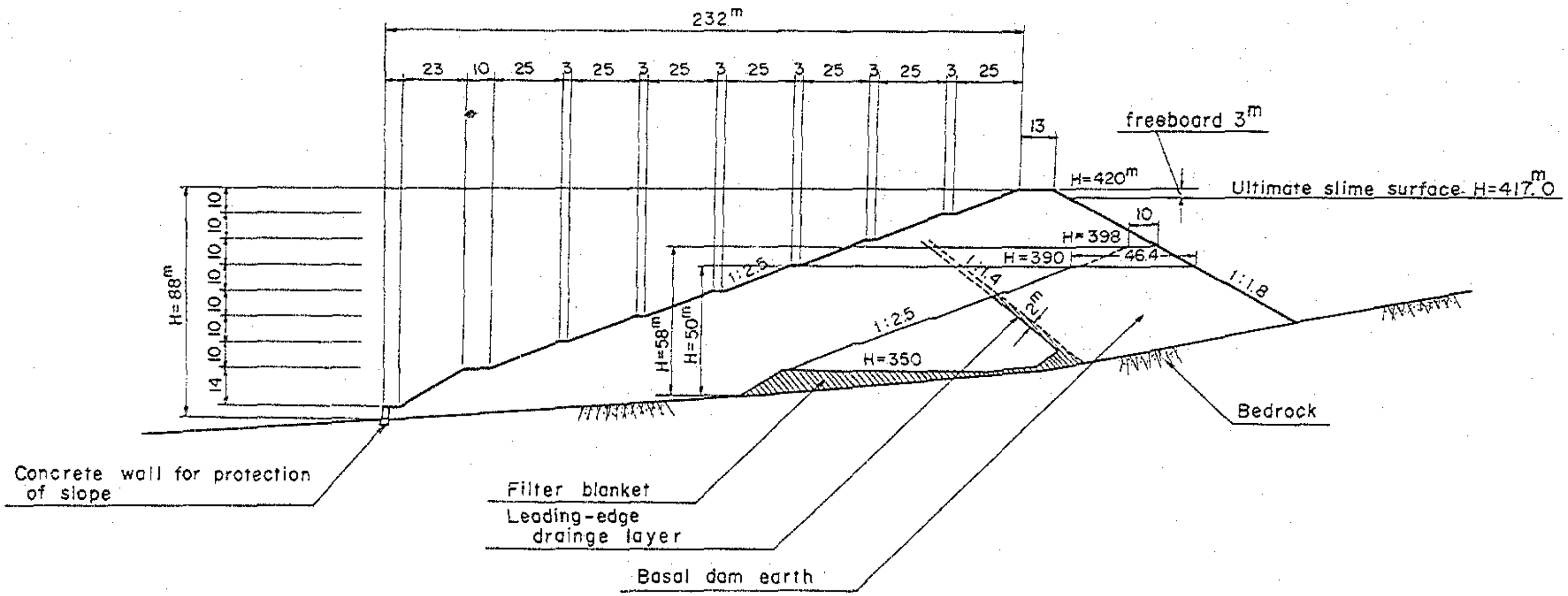


Fig. II–4–3 Projected Dam Section of Construction

S = 1 : 2,000

Projected tonnage to be processed per month	7,500^t	
Projected quantity of tailings to be disposed of	6,375^t ≒ 6,375m^3	(Calculation was made as 1 m^3=1t for safety sake)

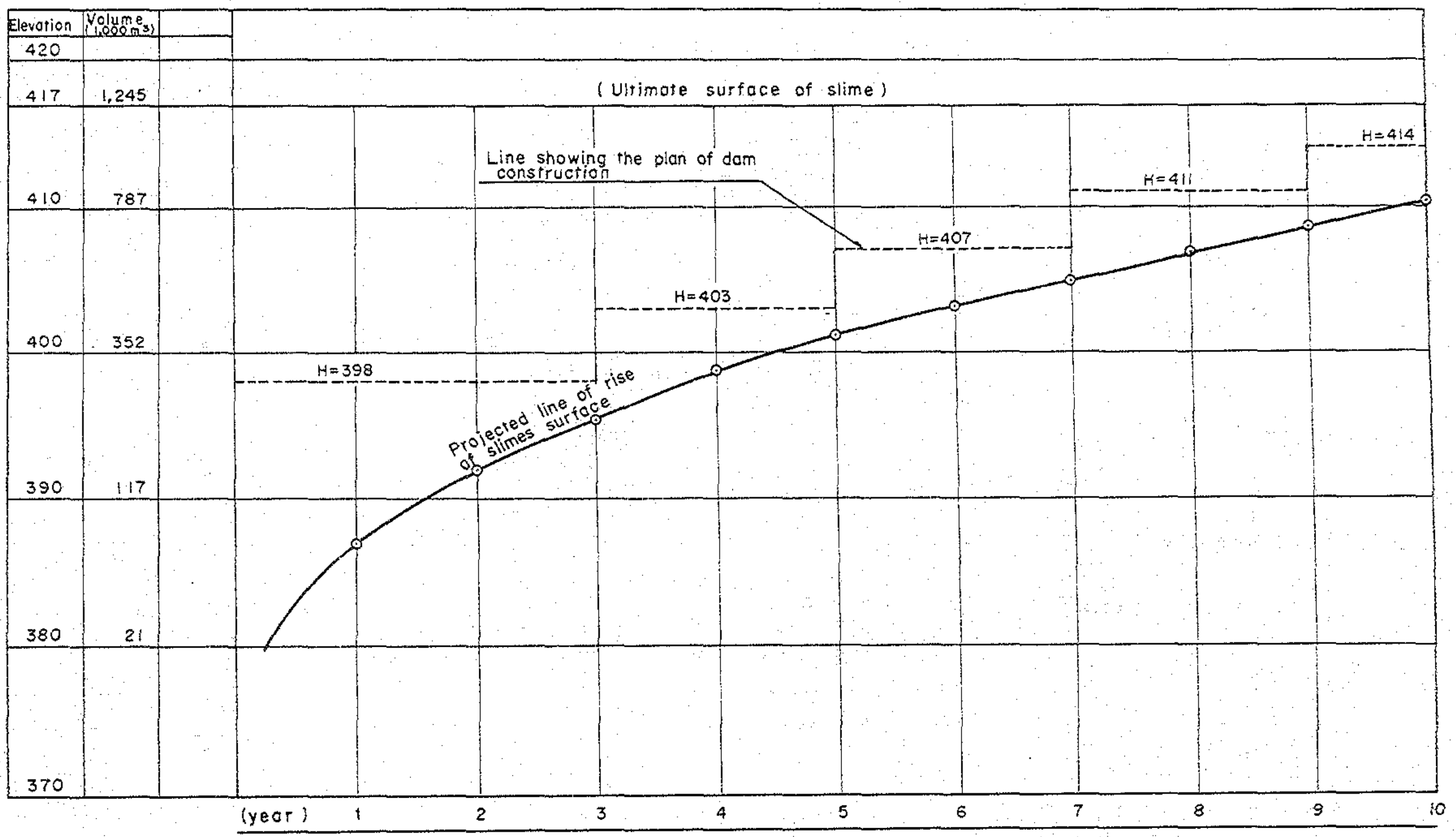
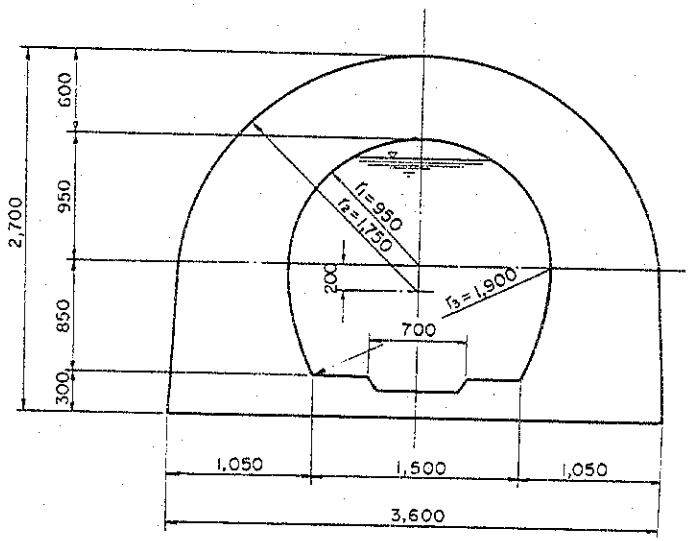


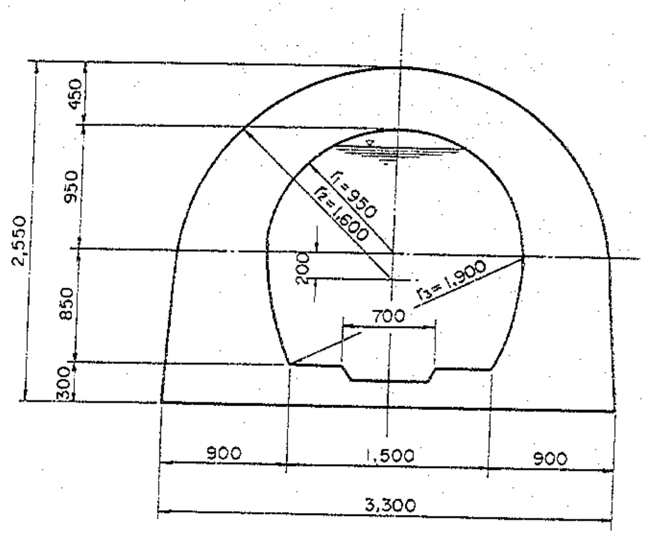
Fig. II–4–4 Plan for Tailings Disposal Level into Tailings Dam

Section of A-type



Section of B-type

Load height of deposited material:
less than 35m.



Projected amount of maximum permissible flowing Q_{max} 28 m^3/sec

(Planned grade of waterway 1/12)

S=1/40

Fig. II–4–5 Plan of Main Stream Underdrain

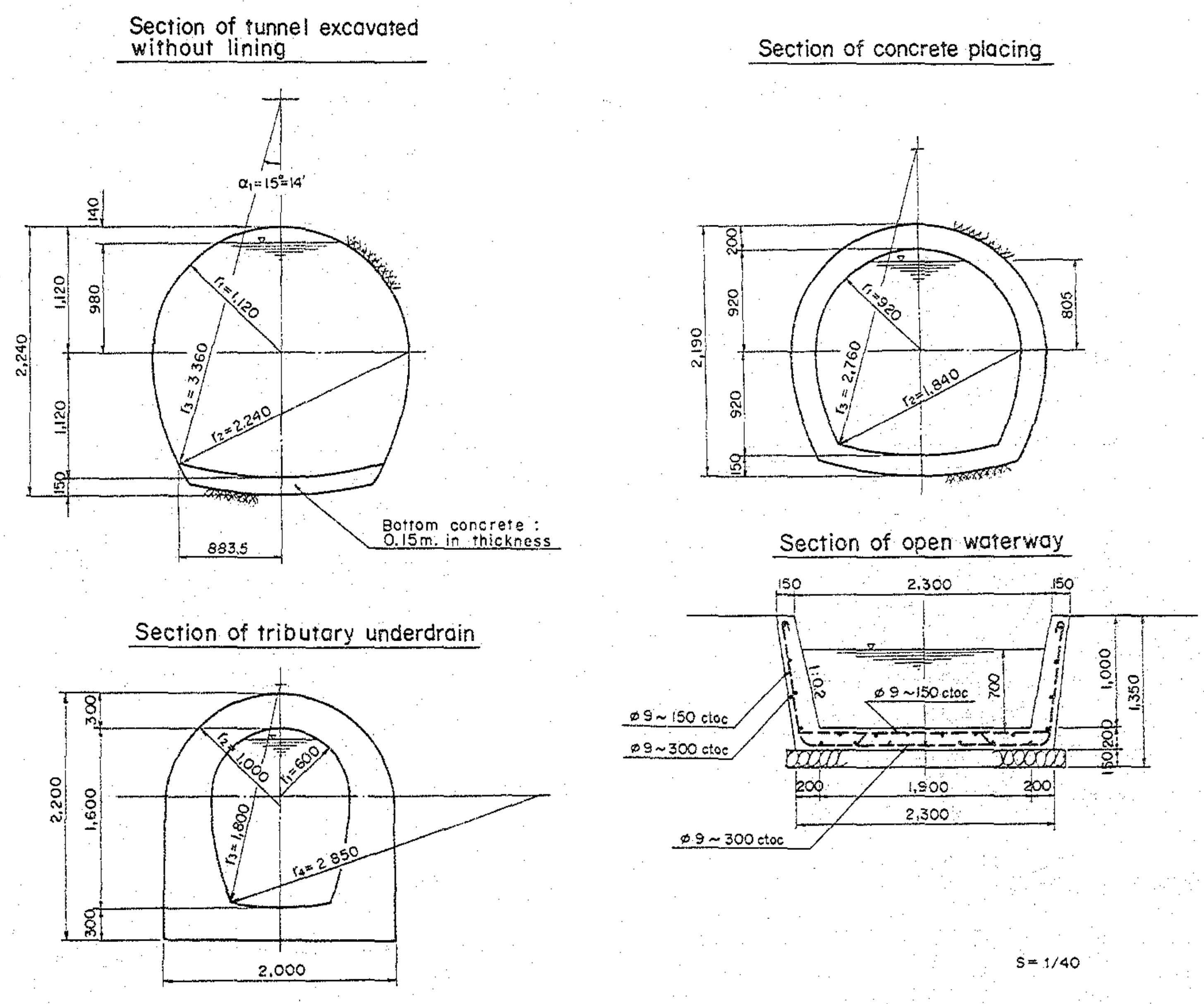


Fig. II–4–6 Plan of Tunneling for Emergency Drainage and Tributary Underdrain

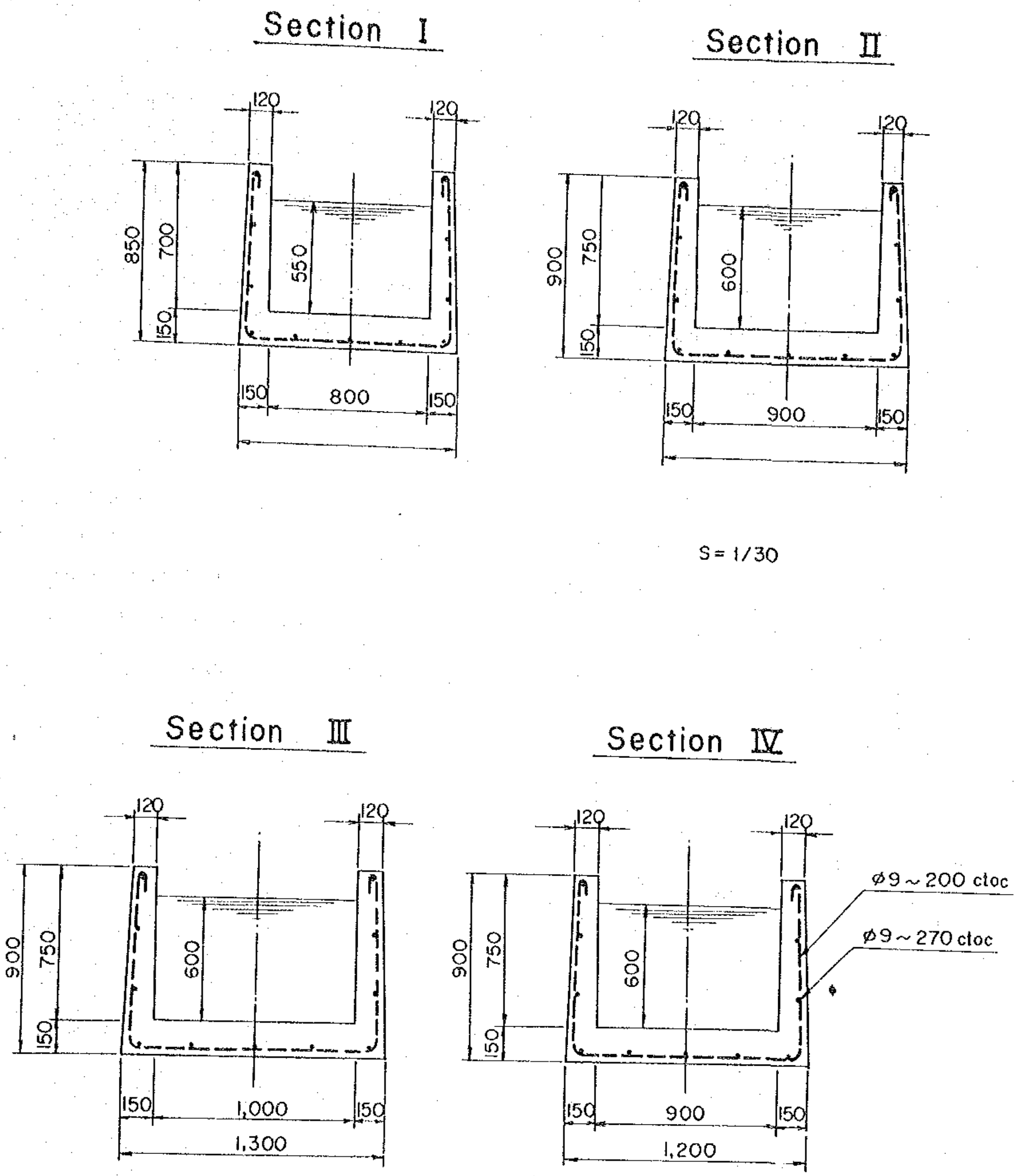


Fig. II–4–7 Section of Hillside Waterway

Section 5. Supporting and Administrative Facilities

5–1 Supporting Facilities

An office, repair shop and warehouse are to be constructed within the premises of the mine. The cost estimations for these facilities are shown in Table II–5–1.[1)]

The estimated cost of equipment for the supporting section, including equipment for the repair shop, is indicated in Table II–5–2.[2)]

As additional costs, the expenses of equipment and materials for maintenance and repairs are estimated at US$800 per month. Electric power tariff for these facilities (including the mine camp) is estimated at US$272 per month (12,000 kWh/month x US$0.0227/kWh), and fuel cost at US$800 per month.

5–2 Staff

Annual personnel expenses including wages and charges for the supporting and administration sections, and for the service section are shown in Table II–5–3. The cost for school teachers' wages are to be paid by Adrianópolis Municipality. For the medical doctor who will visit the mine once a week (four days a month), wages will be paid by the mining company.

Notes:

1) The construction cost is estimated by a survey in Paraná State and existing mines in the Ribeira area, and "Construção" magazine is also used for the estimation.

2) The prices were obtained by survey at DER/PR and in Japan. The magazine "Construção" was also used.

Table II–5–1 Housing Cost of Office and Other Facilities

(unit: US$)

Facility	Size	Unit Cost	Cost
Office	100 m^2	72/m^2	7,200
Repair shop	70 m^2	108/m^2	7,560
Warehouse	100 m^2	36/m^2	3,600
Laboratory	45 m^2	90/m^2	4,050
Total			22,410

Table II–5–2 Cost of Machinery and Equipment

Item	Size	Quantity	Unit Cost	Cost
Passenger Car		3	5,000	15,000
Bulldozer	140 HP	1	90,000	90,000
Shovel loader	100 HP, 1.7 m^3	1	51,400	51,400
Welding machine	200 V, 24 kVA	2	468	936
Laboratory equipments	–	1 set	–	700
Others				180
Total				188,566

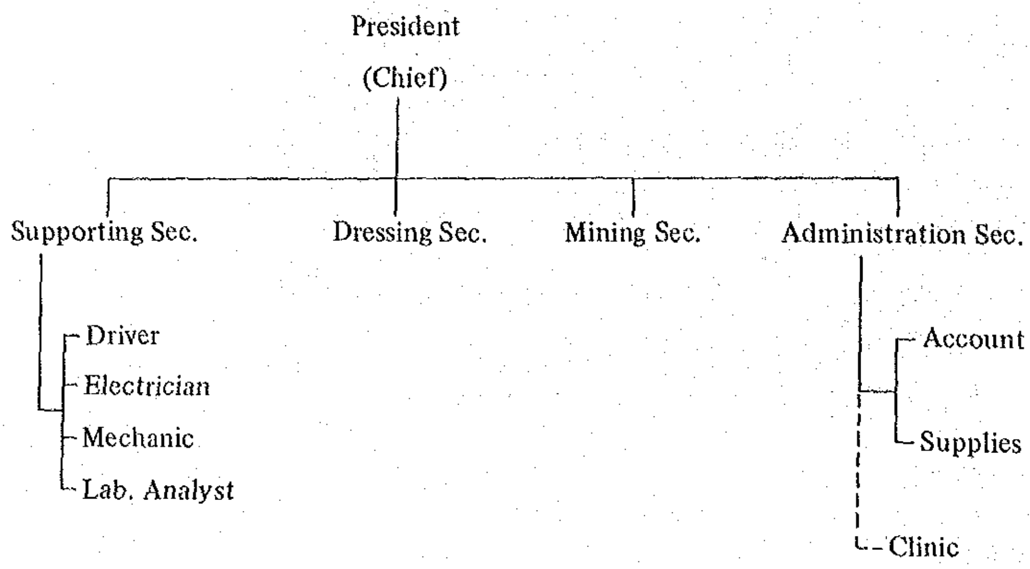
Table II–5–3 Annual Cost of Staff

(unit: US$)

Position	No.	Unit Cost [1]	Annual Cost
Chief	1	780	9,370
Manager	1	462	5,544
Staff	2	202	4,847
Driver	1	173	2,075
Electrician	1	261	3,131
Mechanic	2	261	6,263
Lab. Analyst [2]	2	202	4,847
School Teacher	3	144	5,184
Medical Doctor	1	217	2,604
Medical Staff	1	144	1,728
Total	16		45,593

1) Unit cost per person was calculated by multiplying 1.6 to a salary in order to include miscelaneous expenses other than the salary.
2) This laboratory analyst works on a routine work only, which is different from an analyst employed in the processing section.

Fig. II–5–1 Mining Company



CHAPTER Ⅲ INFRASTRUCTURE

CHAPTER III INFRASTRUCTURE

Section 1. Transportation

1–1 Existing Transportation Facilities

The transport infrastructure, related to the mining development in and around the Ribeira area, is principally roads, railroads and port facilities. The major transportation facilities are illustrated in Fig. III–1. The current condition of these facilities is described in the following sections.

1–1–1 Roads

There are federal roads, state roads and municipal roads, which are respectively maintained and managed by the Departmento Nacional de Estradas de Roadagem (DNER), Paraná or São Paulo states' Departamento de Estradas de Rodagem (DER/PR or DER/SP) and the municipalities (municipios) such as Adrianópolis, Cerro Azul, Apiaí and Iporanga. Of the roads shown in Fig. III–1, the São Paulo-Apiaí-Ribeira route is a state road maintained by DER/SP and the Ribeira-Adrianópolis-Curitiba route is a federal road maintained by DNER. Except for São Paulo State, however, the actual maintenance of federal road is often undertaken by DER with financing from DNER. For the municipal roads, the actual maintenance is mostly conducted using construction machinery owned by DER, under an agreement between DER and the municipalities.

In the Ribeira area there are several plans for the improvement of federal and state roads. One of plans related to the development of Perau mine is the asphalt paving of the 108-km unpaved portion of the road between Adrianópolis and Curitiba (122 km), for which a preliminary feasibility study was conducted by DER/PR in 1983. The plan can be implemented within four years from now, if an agreement between DER/PR and DNER is made. Incidentally, the number of wheeled traffic at Tunas on this road section is about 130 vehicles a day.

In addition, now under planning, is the construction of a road between Cerro Azul and Adrianópolis and the improvement of the Cerro Azul-Rio Branco do Sul road, which will be conducive to mining operations and the development of the Ribeira Region as a whole. The 37 km federal road between Adrianopólis and Apiaí is paved, making it possible for a passenger car to run at a speed of 45 km an hour. However, the shoulders of the road are collapsed in many places and require repairs. São Paulo State is studying repair of this road now.

There are many municipal roads in the western part of Adrianópolis municipality where many mines are located. The details of these municipal roads are shown in Fig. III–2.

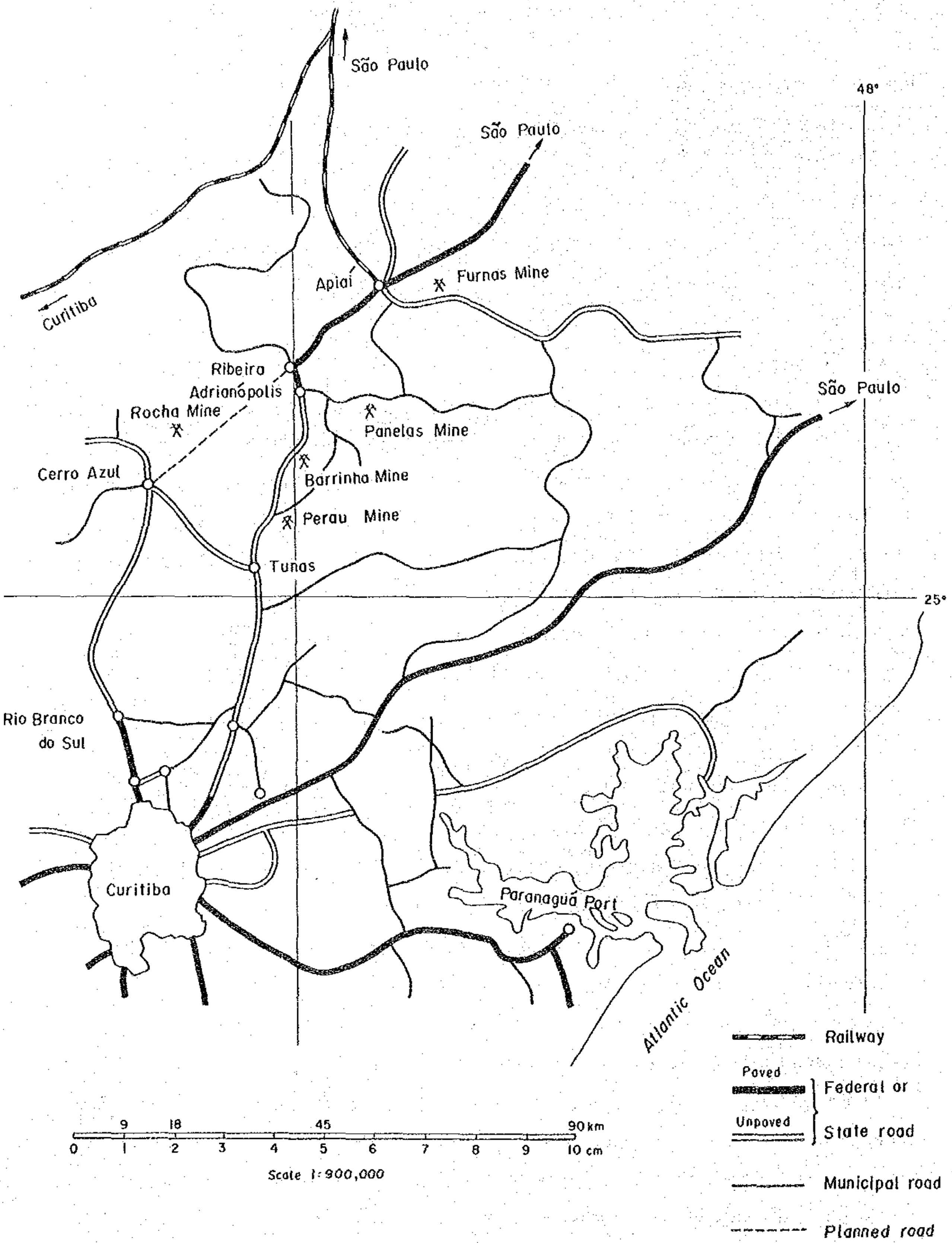


Fig. III–1 Transportation Facilities Near Ribeira Area

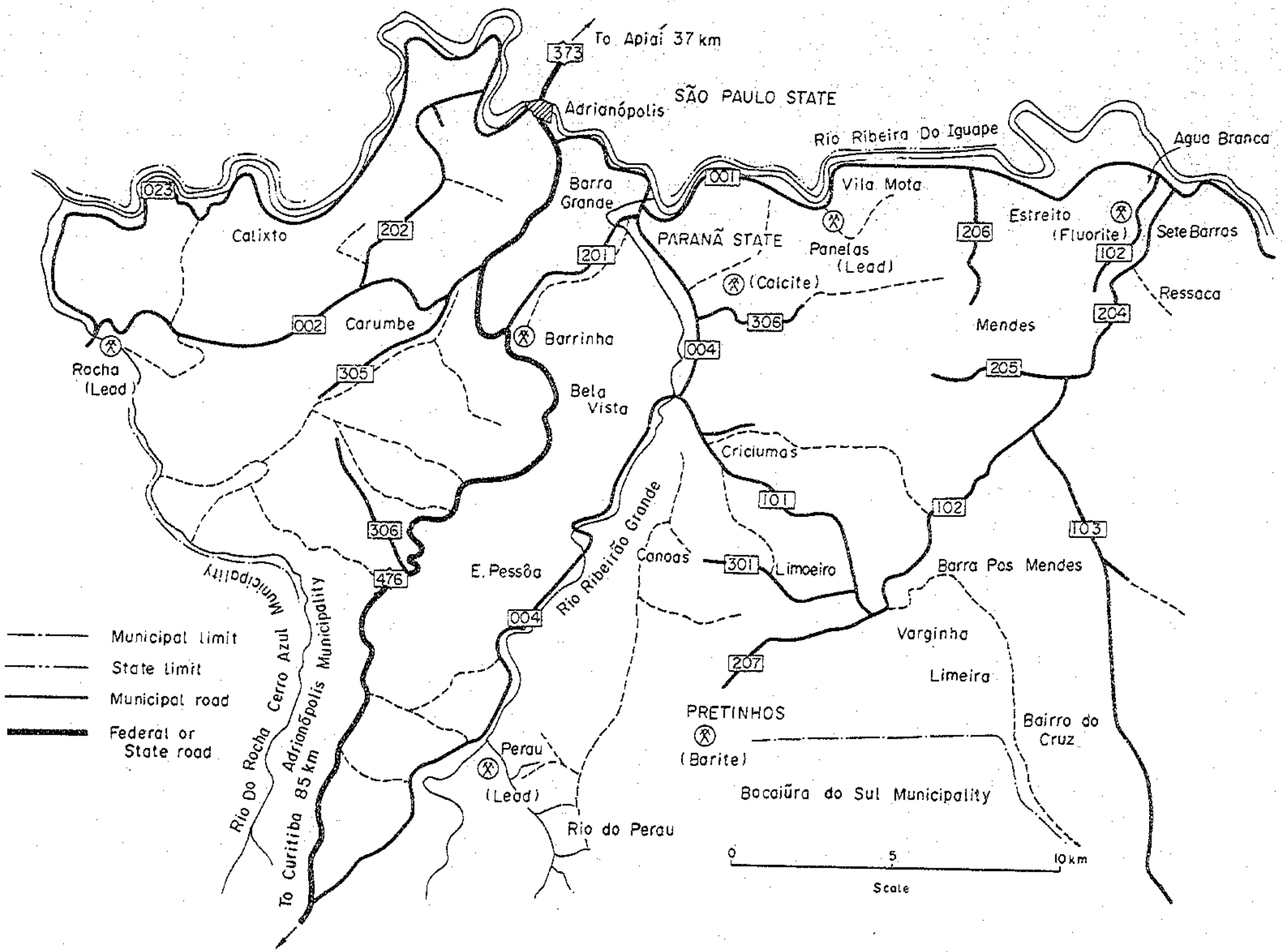


Fig. III–2 Road Network in Ribeira Area

A new 38-km road from Rocha mine to Adrianópolis is under construction by DER and also the 6-km road from Barrinha mine to Barra Grande is now being improved by the Barrinha mining company. The 30-km road between the Perau mine and—Adrianópolis can be used for the traffic of a few trucks per day in present road conditons but road conditions may worsen on rainy days. (The road traffic was disrupted for three months in 1984 because fo the heaviest rainfall in the last thirty years.)

Although there is an adequate road network for the transport of ores and concentrates to Panelas mine from mines such as Perau, Barrinha, Rocha and Furnas, which are located in the Ribeira area, it will be necessary to carry out planned improvements (by gravel pavement and drainage facilities) of the poor sections to ensure satisfactory development and economic activity in this area. The increase in transport volume which will result from further regional development will necessitate gravel pavement for some sections of unpaved roads.

1–1–2 Railway

There is a freight railway running between Curitiba and São Paulo, which is joined by the railway line from Apiaí at a point about 50 km northwest of Apiaí (see Fig. III–1). The railway is at present used for transport of cement from Apiaí. This railway can be utilized for the long-distance transport of concentrates from the Ribeira area to São Paulo, Rio de Janeiro and Minas Gerais.

The railway distance from Apiaí to Juiz de Fora in Minas Gerais State, where there is a zinc refinery, is 957 km, of which the 416-km section in São Paulo State is under the management of FEPASA (Ferrovias Paulistas S.A.), a corporation run by São Paulo State. The remaining 541-km line is run by REFESA (Rede Ferroviaria Federal S.A.) which is a federal company.

1–1–3 Port Facilities

The ports for the import of materials and equipment for the Ribeira area and the shipment of products from the area, are Paranaguá in Paraná State and Santos in São Paulo State. The distance from Perau mine to Paranaguá is 183 km[1]), much shorter than to Santos, i.e., 450 km. Furthermore, there is a possibility that the road between Adrianopólis and Curitiba may be improved in the future, under a plan to pave the whole section. At present, the Peruvian lead concentrate, imported for the lead refinery at Panelas mine in the Ribeira area is unloaded at Paranaguá for transportation by truck to the refinery. Paranaguá Port, though smaller than Santos, has the merit that it has few port congestions. In view of the above points, it is considered that Paranaguá will be the main port during the development of mines in the area.

Port facilities in Brazil are generally under the management of PORTOBRAS, a corporation run by the Federal Government. The management of Paranaguá, however, has been transferred to Paraná State and is now under the control of the Secretaria dos Transportes of the State Government.

Currently, Paranaguá is utilized chiefly for export of agricultural products such as soybeans. The cargo volumes handled are 10,355,026 tons for export and 926,423 tons for import in 1983.[2] Port[3] has transport and storage facilities adequate to handle imported machinery weighing up to 150 tons. (The heavy machinery imported for the Itaipu Hydropower Plant was unloaded at this port.) The port has a depth of 8 to 12 m capable of accommodating a ship of 100,000 tons.

1–2 Transportation Needs

The transport needs which will arise with the development and operation of mines are described below:

(1) The transport of construction materials for mining facilities from procurement locations (e.g., Curitiba or São Paulo) to mine sites.

(2) The transport of mining and processing equipment from the procurement locations (mainly São Paulo for domestic products and Paranaguá port for importend items) to mine sites.

(3) The transport of supplies for mining operations (such as machinery parts, equipment, tools and chemical materials) from procurement locations (São Paulo or Curitiba) to mine sites.

(4) The transport of lead concentrates, produced at the mines, to Panelas mine to which the concentrates are sold for smelting and refining.

(5) The transport of zinc concentrates, produced at the mines, to Juiz de Fora in Minas Gerais State where the concentrates will be sold.

(6) The transport of barite concentrate, produced at the mines, to Parangá Port from which the concentrate is exported abroad.

(7) The transportation of mine workers who do not reside at the mine camp but commute from Adrianópolis or neighboring villages.

Of the above-listed items, the major cargo is the concentrates with a transport volume amounting to about six 10-ton-truck loads a day. For this sort of transport volume, the existing Municipal Roads No. 4 and No. 1 and Federal Road No. 476 are adequate. For trucking from São Paulo, the existing State Road No. 373 can be used. On the whole, the existing roads can be used for transportation, except for the long-distance transport of zinc concentrates mentioned in item (5). For trucking materials, supplies and concentrates, the services of private transportation