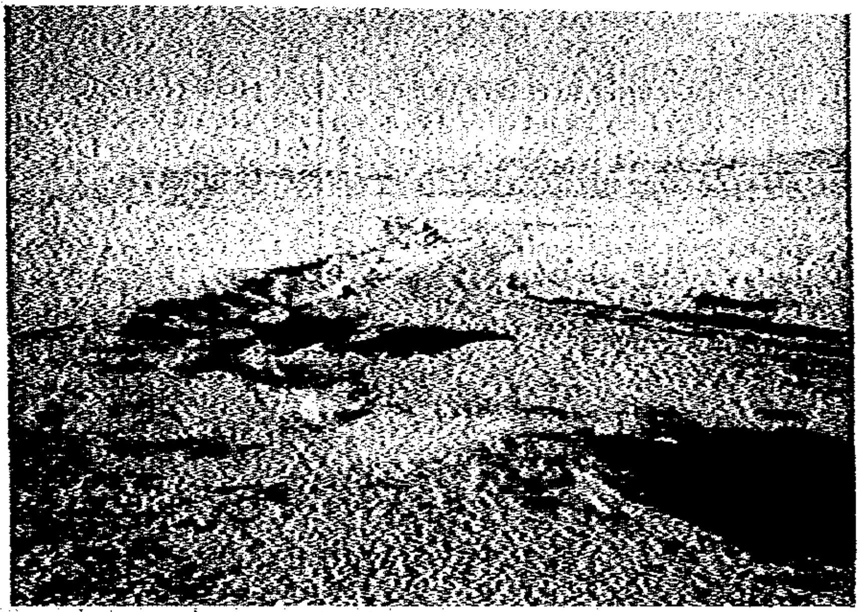
Photo 5 - 3 An Example of Damaged Road Owing to the Bad Drainage Works



Concerning the side-gutter, as geologically the ground consists mostly of gravel, a side-gutter simply dug finish map may be sufficient.

(3) Slope protection of cut

From the standpoint of geological and weather conditions, slope protection by planting is unthinkable, so most slopes will be without finish. Despite the danger of degradation, the possibility seems remote for there is no evidence of landslides. However, the possibility of small-scale degradation is large.

It is necessary to pay attention to the protection of traffic from degraded soil and rocks by taking such countermeasures as making the inclination of slopes as gentle as possible and enlarging the width of road shoulders enough by means of side-gutters.

(4) Safety measures

Although the dangers of accidents are large, which will be caused by heavy fatigue from driving in the highland for a long time, presently, no safety measures are taken, such as guard-rails.

If the road is to be used as a transport route in the future, the installation of guard-rails along dangerous places and the improvement of road shoulders are essential. Moreover, as for the one-lane section in the tentative plan, the construction of turnouts at appropriate intervals is necessary.

4-2-4 Estimation of Construction Cost of Road

The calculation of the road's construction cost is the estimation based on the map with its scale of 1=100,000 for both routes. Consequently, it is impossible to calculate the definite amount of works such as earth works, bridges and other structure.

Therefore, the following method is adopted based on the classification of sections by the relative difficulty of improvement works mainly in terms of topography and geology. We estimate the unit cost of construction for each section from the actual results of similar works to the present.

The unit costs of conservation are based on the mean values of actual results of the construction of two-lane road carried out by the government of Peru from 1971– 77. But, as the route is located on unusual highlands and besides is far away from the resistance of construction workers, the unit cost is increased at a premium rate of 10%, considering the working conditions and the conditions for supplying building materials and machines.

As the rate of unit cost rise from 1978 to the end of the period of construction is supposed to be a geometrical ratio of 7% of a year (only for the interest on money) and in regard to both routes,the period of construction is determined on the assumption that the construction is to be completed in 1982. The centroid year of investment is 1981, and so the construction cost includes the unit cost rise to this year.

The mean unit costs, based on the actual results of the past in Peru, are shown in Table 5-18, and from this data, the standard unit drawn as shown in Table 5-19.

Table 5 - 18 Construction Cost of Two-Lane Road (1)

(Unit: M. Soles/km)

Classification	Topography	Unit Cost	Remarks
New Construction	Obstructive Area	15.63	including the case that there is a
	Normal Area	13.34	road less than 1.8 m in width
Widening	Obstructive Area	3.92	the case of altering an improved
	Normal Area	3.33	road into a gravel road
Improving	Obstructive Area	3.09	ditto
	Normal Area	2.67	

Note: 1) Cost in highlands (altitude more than 1,500 m)
2) Construction cost of gravel road
3) Price in 1976

Source: ORDESO

Construction Cost of Two-Lane Road (2)

(Unit: M. Soles/km)

Topography	Material – 1	Material – 2	Remarks
Flat Area	15	20	
Hilly Area	30	28	including pavement
Obstructive Area	40	35	cost at 20 ~ 25%

Note: 1) Price in 1978
2) Cost in new construction

Source: Ministerio de Transportes y Communicaciones

Table 5-19 Standard Unit Cost of Road Construction (Gravel Road)

(Unit: M. Soles/km)

Classification	Topography	Price in 1982	Price in 1978	Basis of Calculation
New Construction	Obstructive Area	39.2	32.0	$\frac{40 + 35}{2} \times 0.775\ (\times 1.07^3) \times 1.1$
	Hilly Area	30.4	24.8	$\frac{30 + 28}{2} \times$ "
	Flat Area	18.3	14.9	$\frac{15 + 20}{2} \times$ "
Widening	Obstructive Area	9.4	7.7	$3.92 \times \frac{\left(\frac{29.1}{15.63} + \frac{22.5}{13.34}\right)}{2}\ (\times 1.07^3) \times 1.1$
	Hilly Area	8.0	6.5	$3.33 \times$ "
	Flat Area	4.9	4.0	$3.33 \times \frac{13.5}{22.5} \times$ "
Improving	Obstructive Area	7.5	6.1	$3.09 \times \frac{\left(\frac{29.1}{15.63} + \frac{22.5}{13.34}\right)}{2}\ (\times 1.07^3) \times 1.1$
	Hilly Area	6.4	5.2	$2.67 \times$ "
	Flat Area	3.8	3.1	$2.67 \times \frac{13.5}{22.5} \times$ "

From this standard unit cost, the construction cost for both Routes (a) and (b) are calculated as follows according to the conditions of existing roads and topography.

(A) Construction cost of Route (a)

1) Sections to be newly constructed:

(Obstructive area)	5 km x 39.2 million soles/km = 1,960 million soles/km
(Hilly area)	15 km x 30.4 = 456.0

2) Sections to be widened and improved.

(Obstructive area)	68 x 16.9 = 1,149.2
(Hilly area)	28 x 14.4 = 403.2
(Flat area)	84 x 8.7 = 730.8

3) Sections to be improved

(Flat area)	83 x 3.8 = 315.4

Total 3,250.6 million soles/km (18,059 thousand dollars)

(B) Construction cost of Route (b)

1) Sections to be newly constructed

(Hilly area)	2 km x 30.4 million soles/km = 60.8 million soles/km

2) Sections to be widened and improved

(Obstructive area)	8 x 16.9 = 135.2
(Hilly area)	23 x 14.4 = 331.2
(Flat area)	25 x 8.7 = 217.5

3) Sections to be improved

(Flat area)	37 x 3.8 = 140.6

Total 885.3 million soles/km (4,918 thousand dollars)

(Note) Conversion rate (US$1 = 180 soles: rate in 1978)

4-2-5 Travel Cost on Road

As the basic data for the calculation of travel cost on the road, the results of research and analysis (Table 5-20) completed by the government of Peru in 1976 are used. But the compensation values for inclination were not available, so the alternative values are taken from the results of similar research made in Japan. The travel cost per vehicle on both Routes (a) and (b) after the completion of construction is calculated as shown in Table 5-21.

5. Transport Cost on Road and its Allotment Between Public and Private Sectors

5-1 Transport Cost on Road

In case of comprehensively evaluating the economical efficiency of the mines development, it is necessary to take the transport cost into account, which includes the construction cost of road, the maintenance cost and the travel cost of vehicles.

The calculated results of the transport cost required until the mine's operation ends are arranged in Table 5-22, in terms of the converted cost in 1978.

5-2 Allotment of Construction Cost of Road between Public and Private Sectors

The allotment of the construction cost of road and the maintenance cost between public and private sectors should be determined while considering the road's impacts on the region because both routes are a large factor for regional development. But at the present stage no definite plan for regional development is formed, so it is difficult to determine the impact.

Table 5-20 Unit Travel Cost of Automobile (Soles/km)

Items		Standard Truck	Large Truck
Travel Cost	Fuel Cost	8.208	3869
	Oil Cost	0.342	0.422
	Tires & Tubes Cost	2.929	4.574
	Maintenance Cost	3.869	5.397
	Depreciation	2.661	7.490
	Sub Total	18.002	21.752
Fixed Cost	Personnel Expense	2.769	3.000
	Tax	2.075	5.842
	Insurance Bill	1.252	2.733
	Inspection Charge	0.072	0.129
	General Administrative Expenses	1.150	1.246
	Sub Total	7.318	12.950
Total		25.320	34.702

Note: 1) Surveyed in 1976.
2) In regard to gravel road.
3) Concerning a bus the same value as a standard truck is adopted.
4) Correction by Inclination.

0 ~ 2%	1.00
2 ~ 4%	1.20
4 ~ 6%	1.30
6 ~ 8%	1.40

Source: Ministerio de Transportes y Comunicaciones.

Table 5・21 Calculation Table of Travel Cost Relevant to the Mines

Year	Discount Rate 7%/year (α)	Operation Period	Ⓐ Route (between the mine and Arequipa) Standard Trucks (x_1)	Large Trucks (x_2)	$\alpha \times (x_1 \times 136.5 + x_2 \times 187.1)$	Ⓑ Route Standard Trucks (y_1)	Large Trucks (y_2)	$\alpha \times (y_1 \times 44.0 + y_2 \times 60.2)$
1978	1.000							
79	0.935							
80	0.873							
81	0.816							
82	0.762		Vehicle/day	Vehicle/day		Vehicle/day	Vehicle/day	
83	0.712	Period of Depreciation (20 years); Atalaya; Tintaya	8	60	8,771	8	60	2,822
84	0.666		8	60	8,204	8	60	2,640
85	0.623		8		7,674	8		2,470
86	0.582	Corocohuayco	28		8,759	28		2,819
87	0.544		22		7,741	22		2,492
88	0.508	Quechua	22	60	7,228	22	60	2,326
89	0.475		14	96	9,440	14	96	3,038
90	0.444		14	96	8,823	14	96	2,839
91	0.415		14	96	8,247	14		2,654
92	0.388				7,710			2,481
93	0.362				7,194			2,315
94	0.339				6,736			2,168
95	0.317				6,300			2,027
96	0.296			96	5,883		96	1,893
97	0.277			96	5,504		96	1,771
98	0.258		14	36	2,231	14	36	718
99	0.242		14	36	2,092	14	36	674
2000	0.226		14	36	1,954	14	36	629
01	0.211		—	36	1,421	—	36	457
02	0.197		—	36	1,327	—	36	427
Travel Cost Relevant to the Mines (price in 1978)			$\Sigma\{(x_1 \times 136.5 + x_2 \times 187.1) \times \alpha\} \times 365$ days $\times 0.7$ = 122,239 × 365 × 0.7 = US$31,488,000			$\Sigma\{(y_1 \times 44.0 + y_2 \times 60.2) \times \alpha\} \times 365$ days $\times 0.7$ = 39,660 × 365 × 0.7 = US$10,133,000		

Table 5 - 22 Transport Cost Relevant to the Mine (Converted in to the Cost in 1978)

(Unit: 1,000 US$)

Items of Transport Cost	Ⓐ Route (Mine ~ Matarani)		Ⓑ Route (Mine ~ Matarani)	
Construction Cost	Expense by the Mine	5,774	Expense by the Mine	2,820
	Public Expense	8,968	Public Expense	1,195
	Sub Total	14,742	Sub Total	4,015
Maintenance Cost	Expense by the Mine	1,270	Expense by the Mine	426
	Public Expense	1,271	Public Expense	427
	Sub Total	2,541	Sub Total	853
Travel Cost	(Mine ~ Arequipa)	31,488		10,133
	(Arequipa ~ Matarani)	7,907		
Total		56,678		15,001

Notes:
1) The value of transport cost stands from 1983 to 2002, assuming that the life period of road is twenty years.
2) The periods of operation of mines are as follows:
   Tintaya (1983 – 97)
   Coroccohuayco (1986 – 2000)
   Quechua (1989 – 2006)
   Atalaya (1978 – 1986)
3) The construction of the road is assumed to be completed in 1982.
4) The maintenance cost is 2 million soles/year · km (Unit cost in 1978)
5) The discount rate of conversion into present cost is 7% per year.
6) The conversion rate into US dollars in 1978 is US$1 = 180 soles.
7) Travel cost is converted to US dollars as of 1976, and its rise is not considered.

Therefore, the following idea is adopted: the mine is to bear all the expense in regard to the sections where there is little necessity for road traffic at present except what is needed to develop the mine mainly. These sections are as follows: from the mine to Yauri and Angostura on Route (a); from the mine to Hector Tejada and Halli Nuevo on Route (b).

In respect to the maintenance cost, the mine should bear half the expense for all the sections, because the heavy vehicles from the mine will account for a large portion.

In case the above-mentioned idea is adopted, the public share of the construction cost will be as shown in Table 5-22, in terms of cost in 1978.

6. Recommendations for Further Detailed Studies

In this report research is made only about the road as a part of the infrastructure of the mine.

In case of investigating the problem of transport from the mine, of course, it is impossible to evaluate it only in terms of the road. In this region,, it is necessary to determine the transport route on the basis of a comprehensive evaluation of investigations including the railroad and the harbor.

Consequently, it will be necessary to execute research on the railroad and the harbor immediately and to review comprehensively the road plan from a new point of view in reference to them.

Concerning the problem of the road alone, as the present research has been carried out in a limited period, many subjects are left to be investigated further. The main subjects are enumerated hereinafter.

(1) The largest defect of roads in this region, not only of the proposed transport routes, is the observation of traffic in the rainy season (from December to April). As the research of this time was carried out in the dry season, it was impossible to investigate the situation in the rainy season.

In order to facilitate definite planning in the future, it is necessary at any cost to make detailed investigation into the rainy season situation.

(2) In regard to Route (a) which is a single route plan for a road, a large portion will be put into common use with the Majes project in some way.

With improvement and maintenance in the future, it is necessary to strive for the close adjustment of the plan, taking this point into account. The improvement of the road for the construction of the Angostura dam especially requires adjustment.

(3) Concerning the section through the Apurimac valley on Route (a), the construction cost is expensive, and there is the large possibility of obstructing the traffic in future, so the deliberate study, based on the detailed plan is necessary after the state in the rainy season is accurately understood. It is advisable to consider the following procedure in adopting the tentative construction and then successively improving it until completion.

(4) In respect to the construction cost and so on, because the unusual inflation in Peru, at present makes it impossible to estimate the future cost, the revision of the cost is by all means necessary at the time of studying the definite plan.

(5) As both Route (a) and (b) will produce large effects on the future development of this region, the government should make a scheme to orientate the future development and growth of this region, presupposing that these will enable the projected road to produce further effects.

CHAPTER 6

HOUSING

CHAPTER 6 HOUSING

Firstly, in the development plans for the mining towns, taking the three mines of Tintaya, Coroccohuayco and Quechua as a single group, to obtain the most suitable solutions to both mining operations and the effects of regional development, the location, scale and facilities were considered.

1. Present Conditions of the Area

1-1 General Conditions

Peru can be generally divided into four main sections: North, Central, East and South. However, the areas discussed in this study are located nearly in the center of the southern section, which is about 850 kilometers southeast of the capital, Lima. The area is mountainous terrain of about 4,000 meter elevation above sea level, and climatic conditions indicate average annual below 10°C, and annual rainfall of 800 to 1,000 mm (concentrated during the rainy season from December to April).

The Southern region is composed of seven departments, with the nation's second largest city, Arequipa, (pop. 305,000) making up the center of the region, plus the other core cities of Cuzco and Puno.

The area under consideration lies in the southernmost tip of Espinar Province, Cuzco Department, 180 kilometers southeast of Cuzco city. (Road mileage is about 260 kilometers.) Administration is by the central government, carried out in an administrative district (Zona de Administracion) composed of the three Departments of Cuzco, Madre de Dios and Apurimac. Cuzco city is the seat of the various central government administrative agencies, presently including ORDESO (Organismo Regional del Desarrollo del Sur Oriente), which controls the development of these three southeastern provinces.

This southeast area is not blessed with a transport system having access to the sea, and for this reason modern industry is in an undeveloped state; the situation is similar for development of resources. On the other hand, it can be said that agricultural and mining resources have great potential.

Firstly, on the subject of the mountainous areas such as Espinar Province and others, where primitive methods of livestock herding is the principal industry, these products are sent out in the direction of Arequipa, and consumer goods are brought in from Arequipa; therefore in this regard we may consider the area to be in the economic sphere of Arequipa. Fig. 6-1 shows the location of this survey.

1-2 Population, Industry

Table 6-1 shows the population distribution of Department of Cuzco. The population of the department showed a negligible increase of from 705,000 in 1961 to 715,000 in 1972. According to ORDESO information, the population had increased to 850,000 by 1978.

Referring to the 10-year period from 1961 onward, the national annual birthrate was 41-42 per 1,000 (1970), and the mortality rate 15 per 1,000 (1961), and judging from the 2.6 ~ 2.7 per cent rate of population increase it can be said that there was a major shift in population from departmental rural areas to large urban areas.

The only significant population increases in the department was in Cuzco Province, and in the mountainous provinces such as Espinar and Canchis, a decrease in population has become apparent, indicating a noticeable trend toward outward migration. Espinar Province has an area of 4,418 square kilometers, and according to the national census of 1972, the population is below 41,000. The population density is 9.4 people per hectare, sparse even when compared with neighboring provinces. The continuous population decrease is shown by the 1977 population figure of only 40,253. More than 85 per cent of the inhabitants reside in isolated hamlets and the urban population is extremely small. (See Table 6-2.) The nationwide age distribution, according to

Fig. 6 - 1 Location Map of Project Area

Table 6 - 1 Population Distribution and Trends by Province in Cuzco Department (1961 – 72)

Province	1961 Population	1972 Population	Change (%)	Area (km²)	Population Density (Man/km²)
CUZCO	118,789	143,343	20.7	523	27.4
ACCOMAYO	33,049	29,980	–9.3	934	32.1
ANTA	50,163	46,330	–7.6	1,858	24.9
CALCA	43,999	46,191	5.0	3,148	14.7
CANAS	30,970	31,546	1.9	1,604	19.7
CANCHIS	76,856	75,616	–1.6	4,178	18.1
CHUMBIVILCAS	56,358	58,312	3.5	5,239	11.1
ESPINAR	41,586	41,461	–0.3	4,418	9.4
LA CONVENCION	81,138	84,161	3.7	36,974	2.3
PARURO	34,644	31,536	–9.0	1,929	16.3
PAUCARTAMBO	30,405	29,983	–1.4	6,448	4.6
QUISPICANCHIS	69,080	62,155	–10.0	7,138	8.7
URBAMBA	35,663	34,623	–2.9	1,833	18.9
Cuzco Department Total	702,700	715,237	1.8	76,225	9.4
National Total	7,906,746	13,558,208	71.5	1,285,216	10.5

Source: CENSOS NACIONALES, 1961, 1972 and ATRAS HISTORICO GEOGRAFICO Y DE PAISAJES PERUANOS (I.N.P.)

Table 6 - 2 Distribution of Urban and Rural Population (1972)

	Urban Population	(%)	Rural Population	(%)	Total
CUZCO	131,386	91.7	11,957	8.3	143,343
ACCOMAYO	13,829	46.1	16,151	53.9	29,980
ANTA	11,751	25.4	34,579	74.6	46,330
CALCA	10,193	22.1	35,998	77.9	46,191
CANAS	3,644	11.6	27,902	88.4	31,546
CANCHIS	23,718	31.3	51,898	68.7	75,616
CHUMBIVILCAS	5,739	9.8	52,573	90.2	58,312
ESPINAR	5,845	14.1	35,616	85.9	41,461
LA CONVENCION	14,093	16.7	70,068	83.3	84,161
PARURO	11,077	35.1	20,459	64.9	31,536
PAUCARTAMBO	3,674	12.3	26,309	87.7	29,983
QUISPICANCHIS	16,178	26.0	45,977	74.0	62,155
URBAMBA	11,695	33.8	22,928	66.2	34,623
Cuzco Department Total	262,822	36.7	452,415	63.3	715,237

Source: CENSOS NACIONALES, 1972

Table 6-3, shows a pyramidal shape; however, the high number of people aged 65 years and older is noticeably out of proportion. On the hand, in the working age population figures, shown in Tables 6-4 and 5, 30 per cent of the total population belongs to the working age group, and in Cuzco Department over 60 per cent of the working population is employed by agriculture and the raising of livestock. In Espinar Province, in spite of its mountainous terrain, only 30 per cent of the population is engaged in agriculture, and a significantly high percentage of the population is engaged in manufacturing and commerce. As discussed previously, agriculture is based on primitive grazing methods, and since productivity is low, 10 to 20 per cent of the agricultural workers migrate to work as seasonal laborers in the Arequipa area during the rainy season. For this reason, the regional development in the form of increased agricultural productivity and creation of new job opportunities is the principal objective.

1-3 Present Status of Urban Development in the Area

Next, let us examine the current status of the urbanization and town facilities in Espinar Province, including the three mines now under study. Espinar Province is divided into six administrative districts (DISTRITO), which include the three mines of Coroccohuayco, Quechua and Tintaya. Population distribution of each district is shown in Table 6-6, but Yauri (population 4,000), the main town of Espinar Province, (CAPITAL DE PROVINCIA) and Hector Tejada (population 900), the main town of Pallpata District, are the only urban areas. All others are small-scale congregations of inhabitants. If we examine Table 6-7 regarding the scale of concentration in Espinar District, we see that only Yauri and the Atalaya mines are composed of 100 families or more, and 3/4 of the population resides in hamlets of 100 families or less. And, 40 per cent of these are in hamlets consisting of 20 houses or less. Because the number of people in the area fluctuates according to seasonal migrations for labor and other reasons, many people maintain residence in both urban and rural areas, dividing their time between one and the other according to necessity, so the urban population is not constant.

Examinig housing conditions, most residents own their own homes, with only 20 per cent of the total consisting of two sleeping rooms or more. Further, over 60 per cent of the population live in shacks, which lack most facilities. Even compared with other areas, the standards of housing conditions are low. (Refer to Tables 6-8 and 9)

The present condition of the main urban facilities is as follows: Firstly, as for transportation facilities, the outline of the transport system is shown in Fig. 6-3. Presently, a railroad from Matarani on the coast to Cuzco via Arequipa and Juliaca is operating, and serves as the main means of transporting goods and materials into the area. Route 3 and 21 (Ruta Nacional) which connect Cuzco and Arequipa comprise the backbone of the road network. Espinar Province lies at an important location on the junction of the highway routes. As for means of railway transport to the area, there are two routes, from Ayavili which uses Provincial road 104 (Ruta Departamental), and from Sicuani which uses National route 21. However, since the former is inoperable during the rainy season, the Sicuani route is employed for the most part. At present, the Katanga and Atalaya mines and other existing mines nearby depend on this route for transport of concentrates. Also, this railroad plays an important part in the total economic activity of the main town of Sicuani, which is the central town of Canchis Province (population: Province 36,000; Urban 13,000), and the expansion and maintenance of this road network is a current problem. (Refer to Chapter 5 for particulars of the road conditions in the area.)

Next, looking at the educational facilities, due to the efforts of the government, compulsory educational facilities have been made available even in remote hamlets; as shown in Fig. 6-4, one school is available on the basis of each 500 people. An extremely high level of children are enrolled in elementary education (Education Basica 1 & 2 CICLO), with a total of 81.8 per cent of children between the ages of 6 and 14 enrolled by 1974, and 93.9 per cent by 1977. However, from 1972 the educational system was revised, and revision is still continuing. But many elementary schools are operating on the old 5-year system. Junior high schools (3 CICLO) that include the 9-year system, are available only in the main towns of Yauri and Hector Tejada, and the province operates only one high school (ESEP) in Cuzco, which was introduced for the first time by the new system. In the Ministry of Education, the targeted enrollment of ESEP (1981) will reach 40 per cent in the future.

Medical facilities: This area maintains at present only 2 hospitals, at Yauri and the Atalaya mines, and serious cases must be sent all the way to Sicuani. As shown in Table 6-10, the number of doctors and hospitals beds is at an extremely low level. In addition, Table 6-11 summarizes the present conditions of facilities in the towns of Yauri and Hector Tejada, which are close to the mines. The basic utilities, such as water supply and electricity, are a major problem and even in Yauri there are problems with the quality of the drinking water

Table 6 - 3 Age Distribution (1972)

	Nationwide	(%)	Cuzco Department	(%)	Espinar Province	(%)
0 – 4	2,201,014	16.2	117,666	16.4	7,682	18.5
5 – 9	2,022,740	14.9	106,888	14.9	6,324	15.3
10 – 14	1,713,510	12.7	84,718	11.8	4,652	11.2
15 – 19	1,410,312	10.4	64,867	9.1	3,292	7.9
20 – 24	1,150,589	8.5	52,371	7.3	2,795	6.8
25 – 29	929,550	6.9	46,854	6.5	2,651	6.4
30 – 34	771,727	5.7	42,084	5.9	2,517	6.1
35 – 39	729,091	5.4	41,893	5.9	2,621	6.3
40 – 44	606,999	4.5	34,841	4.9	2,170	5.2
45 – 49	487,965	3.6	28,665	4.0	1,499	3.6
50 – 54	388,618	2.9	22,179	3.1	1,212	2.9
55 – 59	299,975	2.2	16,117	2.3	928	2.2
60 – 64	274,570	2.0	16,826	2.4	889	2.2
Over 65	522,485	3.9	37,881	5.3	2,190	5.3
Unknown	28,063	0.2	1,387	0.2	39	0.1
Total	13,558,208	100.0	715,237	100.0	41,461	100.0

Source: CENSOS NATIONALES, 1972

Table 6 - 4 Distribution of Labour Force -- Age 6 and Over (1972)

	CUZCO Department	(%)	ESPINAR Province	(%)
Agriculture & Forestry	133,451	61.6	3,665	28.8
Fishing	42	0.0	2	0.0
Mining	913	0.4	468	3.7
Manufacturing	19,814	9.2	3,887	30.7
Utilities	165	0.1	3	0.0
Construction	5,348	2.5	245	1.9
Commerce	15,526	7.2	1,480	11.7
Transport	3,510	1.6	87	0.7
Finance	969	0.4	17	0.1
Services	22,800	10.5	464	3.7
Other	14,038	6.5	2,371	18.7
Total	216,576	100.0	12,689	100.0

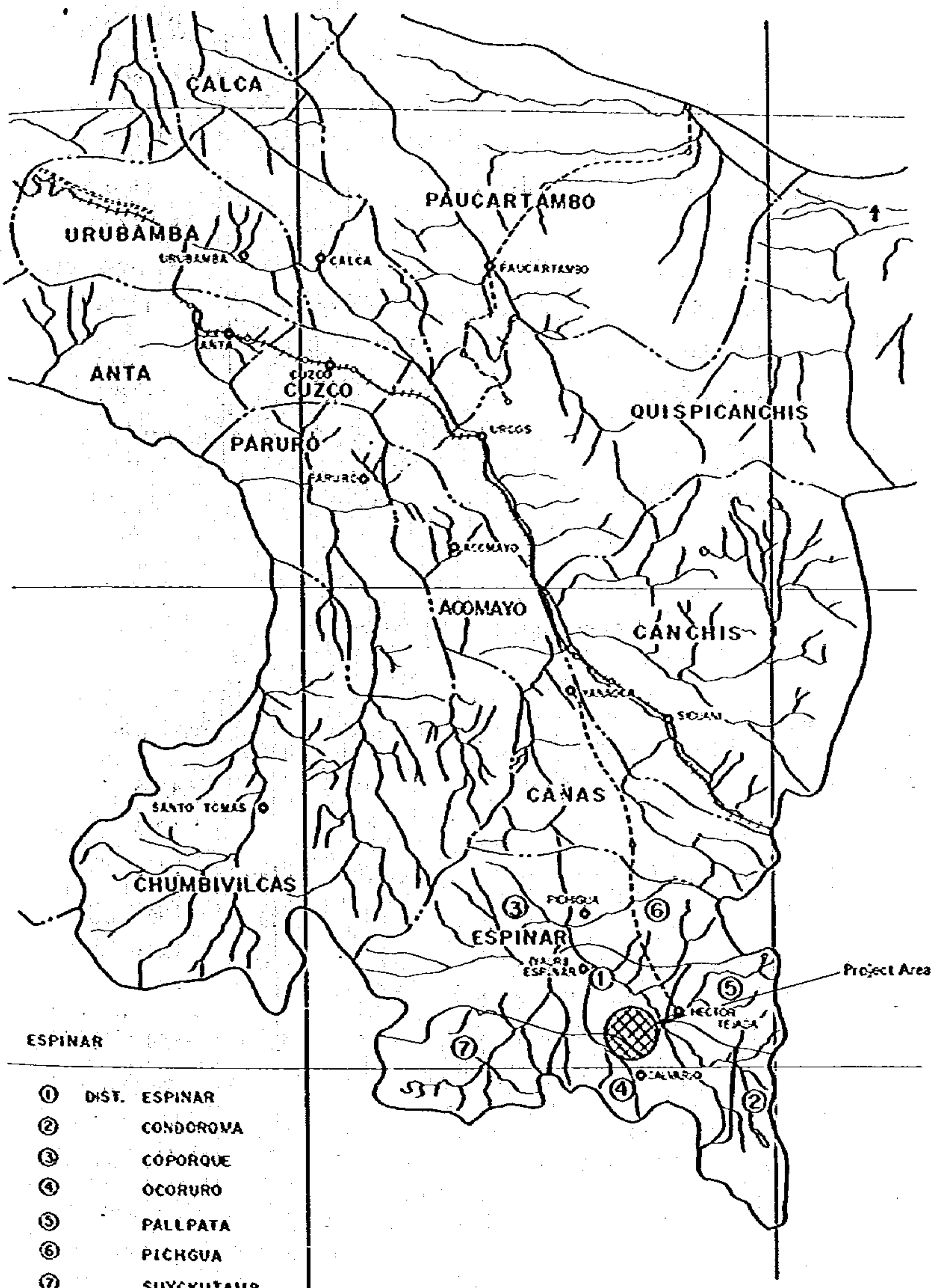
Source: CENSOS NACIONALES, 1972

Table 6 - 5 Population Employed in Occupations -- Age 15 and Over (1972)

	CUZCO Department	(%)	ESPINAR Province	(%)
Specialists	9,087	4.3	230	1.8
Skilled Labour	237	0.1	9	0.1
Management	3,901	1.9	62	0.5
Commercial & Sales	13,144	6.3	1,416	11.3
Services	11,976	5.7	281	2.2
Agriculture & Forestry	128,665	61.4	3,544	28.4
Labour other than Agriculture	30,835	14.7	4,635	37.1
Other	11,761	5.6	2,318	18.6
Total	209,609	100.0	12,495	100.0

Source: CENSOS NACIONALES, 1972

Fig. 6 - 2 Map of South, Cuzco Department



① DIST. ESPINAR
② CONDOROMA
③ COPORQUE
④ OCORURO
⑤ PALLPATA
⑥ PICHGUA
⑦ SUYCKUTAMB

Table 6 - 6 District Population Distribution in Espinar Province (1972)

(Unit: Persons)

	Urban Areas	Rural Areas	Total
YAURI (DIST. ESPNAR)	3,972	11,969	15,941
DIST. CONDOROMA	211	839	1,050
COPORQUE	326	10,643	10,969
OCORURO	212	1,381	1,593
PALLPATA	915	3,463	4,378
PICHGUA	202	5,348	5,550
SUYCKTAMB	7	1,973	1,980
Total	5,845	35,616	41,46

Source: CENSO NACIONAL, 1972

Table 6 - 7 Concentration Distribution in Yauri

Scale of Concentration	Number of Concentrations	Number of Houses	Populations
1 – 5 Houses	505	974	4,808
6 – 10	47	398	1,723
11 – 20	33	406	2,172
21 – 50	14	405	1,785
51 – 100	4	271	1,211
Over 100 1)	2	1,061	4,242
	605	3,515	15,941 2)

Notes: 1) Atalaya Mine Population: 270 (104 Houses)
Yauri Town Population: 3,972 (957 Houses)
2) Average People per Household: 4.54

Source: CENSOS NACIONALES, 1972

Table 6 - 8 Number of Houses by Type

(Unit: Houses)

	Cuzco Department			Espinar Province		
	URBANO	RURAL	TOTAL	URBANO	RURAL	TOTAL
Single Unit Houses	34,924	58,172	93,096	1,248	1,822	3,070
Apartments	952	–	952	3	–	3
Boarding Houses	477	–	477	–	–	–
Rental Rooms	19,248	504	19,752	97	9	106
Unclassified	157	388	545	2	27	29
Shacks	2,238	41,457	43,695	25	5,755	5,780
Non-Residential	264	222	486	17	24	41
Other	14	34	48	–	1	1
Total	58,274	100,777	159,051	1,392	7,638	9,030

Source: CENSOS NACIONALES, 1972

Table 6 - 9 Listing of Houses by Number of Bedrooms

(Unit: Houses)

	Cuzco Department			Espinar Province		
	URBANO	RURAL	TOTAL	URBANO	RURAL	TOTAL
0 Bedrooms	25,655	41,108	66,763	342	2,086	2,428
1	18,456	43,453	61,909	776	4,099	4,875
2	7,633	8,403	16,036	195	780	975
3	3,025	1,112	4,137	30	165	195
4	990	264	1,254	5	34	39
Over 5	390	127	517	2	6	8
Uncertain	2,115	6,310	8,425	42	468	510
Total	58,274	100,777	159,051	1,392	7,638	9,030

Source: CENSOS NACIONALES, 1972

Fig. 6 - 3 Transportation Network

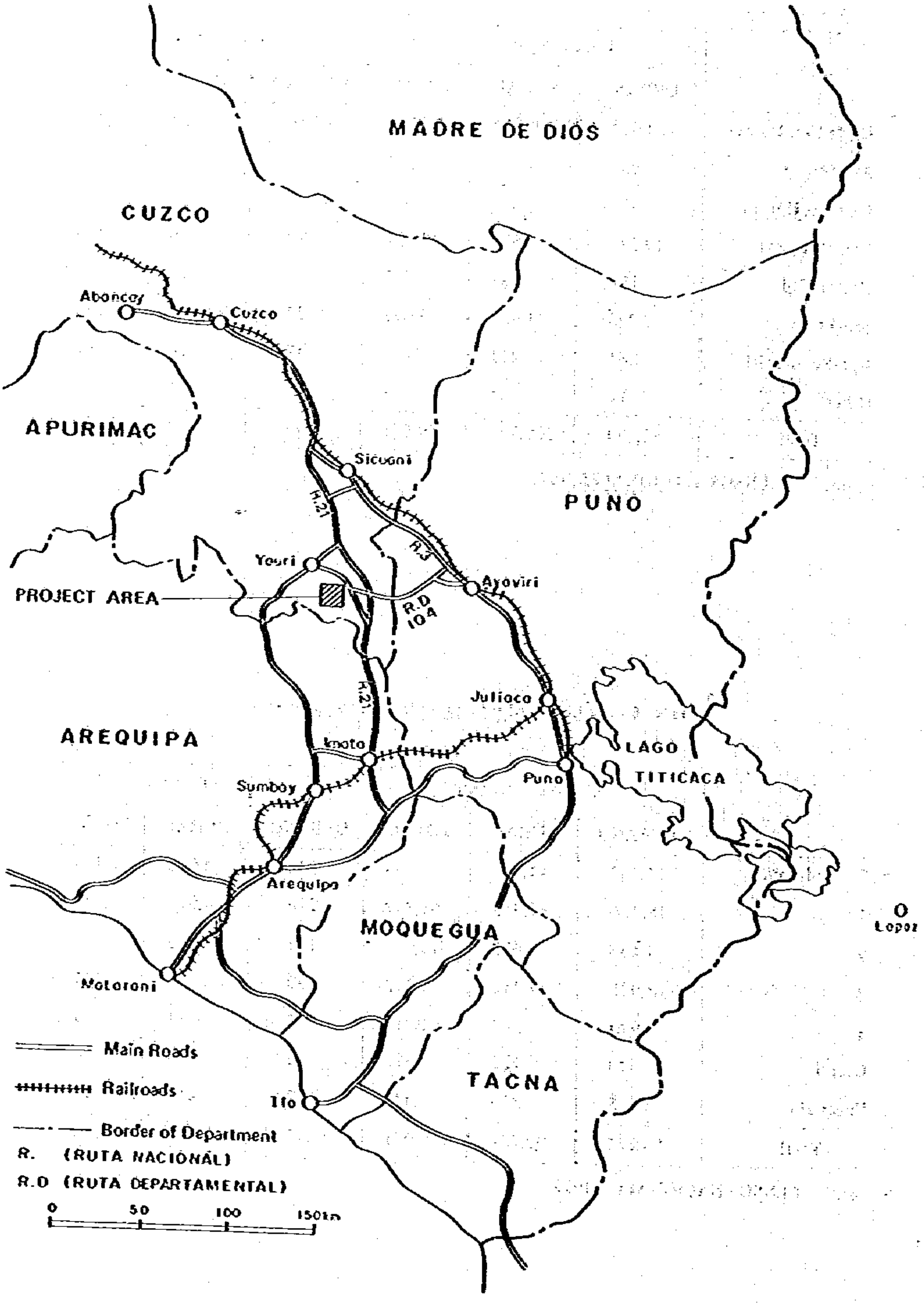
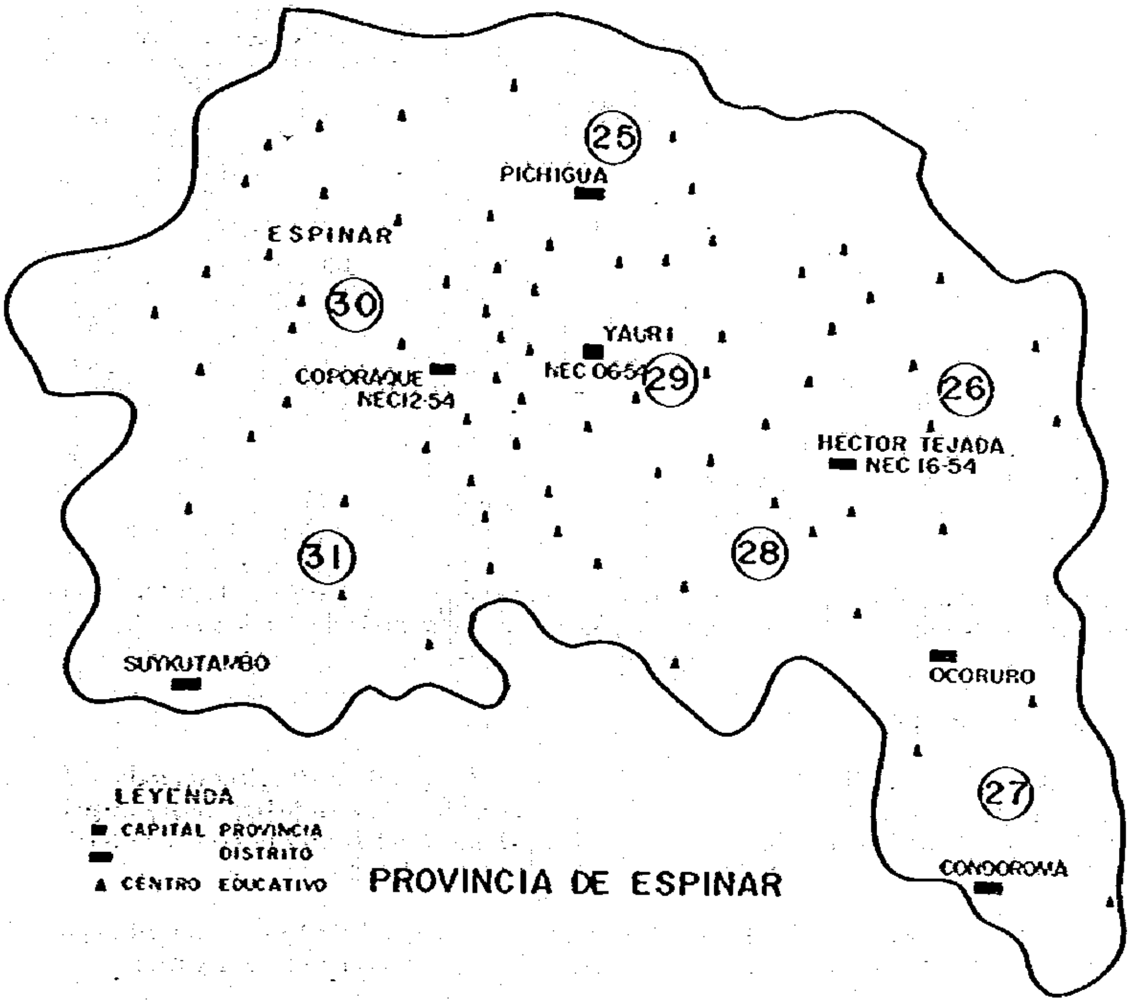


Fig. 6 - 4 Present Condition of Educational Facilities in Espinar Province (Oct. 1978)



School District	No. Schools	No. Students	No. Teachers
06-54 Espinar	39	4,915	122
12-54 Coporaque	28	2,577	52
16-54 Hector Tejada	25	2,473	53
Espinar Province Total	92	9,965	227

Source: Ministerio de Educación

Table 6 - 10 Present Condition of Medical Facilities and Number of Doctors

	Population	Number of Doctors	Number of Hospital Beds	Number Doctors per 10,000 People	Number Beds per 10,000 People
Nationwide[1] (1969)		6,870	30,596	5.2	23.2
Southeast Region[2] (1978)					
Cuzco	850,220	110	858	1.3	10.1
Madre de Dios	25,615	7	58	2.9	23.0
Apurimac	280,302	9	185	0.3	6.5

Note: 1) Plan del Peru, 1971～75
2) Information Compiled by ORDESO

supply. Electric capacity is insufficient and improvement will require much attention. Together with maintenance of the mine development infrastructure, we must expect improvements in these points as well.

1-4 Future Plans for the Area

At present in the Republic of Peru, two regional agencies are working with plans for regional development. These are the National Development Long-term Plan – 1990 (Plan Nacional de Desarrollo a Largo Plazo – 1990 – Instituto Nacional de Planificacion) and the Urban Development Long-term Plan (Plan Nacional de Desarrollo Urbano – Ministerio de Vivienda).

The former concentrates on the social and economic aspects, and the latter on the urban plans. To clarify the long term plan of area development in any case, the study proceeds in the following steps:

First Stage: Research level
Second Stage: Guideline of policy
Third Stage: Making of National Planning
Fourth Stage: Formation of plans for each region

At present, (Autumn, 1978), the seond stage has been completed, and within the next one or two years the fourth stage is expected to be complete.

In the long-range urban development plan, one target of the southern region's development is to disperse the urban functions now presently clustered in Arequipa to the two cities of Puno and Cuzco, to produce a multi-nucleus regional structure. In connection with this, the transport network facilities linking the various towns can be considered a major problem. Also, in these plans, 1990 has been set as the target year to establish the standard urban system (Sistema Urbano Nacional Normatiyo), and city classification of grades 1 through 8 has been established together with other classifications. Yauri ranks in the 6th class as a small city (Centro Principal de Area Nucleada Urbana). The particulars of the urban development plans will be decided in the future (according to the Ministry of Vivienda, Yauri's development plans will be fixed by Mid-1979), but in connection with the plans of the mining towns, it will be necessary to make sufficient consideration for joint adjustment of these plans.

Table 6 - 11 Outline of Yauri and Hector Tejada[1]

		YAURI (DIST. ESPINAR)	HÉCTOR TEJADA (DIST. PALLPATA)
Population (1972 Census)	URBANO	3,972	915
	RURAL	11,969	3,463
	TOTAL	15,941	4,378
Housing Units (1972 Census)	URBANO	957	250
	RURAL	2,558	738
	TOTAL	3,515	988
Administrative Facilities		Espinar Province Office Yauri Town Hall Post Office	
Educational Facilities		Kindergarten Normal School (9 Year System) Technical School (Old System) (SEGUNDARIA TECNICA)	Kindergarten Normal School (9 Year System)
Medical Facilities		National Hospital[2] (12 beds, 1 doctor, 1 dentist 2 male nurses, 1 hygienist)	Clinic (Doctor and dentist make rounds from Sicuani. Resident male nurse and intern)
Religious Facilities		Church	Church (Pastor makes rounds from Yauri)
Commercial Facilities		70 Regular Shops Market (Open every Sunday)	25 Regular Shops Market (Open every Thursday)
Other		Inn 2 Cinema 1	
Basic Town Facilities		Water Main Electric Power Facilities (Hydroelectric 12 KW, Diesel 24 KW)	

Note: 1) Above items were collected by hearing.
2) Atalaya mine maintains a 10 bed hospital with 1 doctor.

2. Considering Conditions of Development and Placement of the Mining Towns

In connection with the construction of the mining towns, the General Mining Law and other related statutes are sufficient, and a plan by which each mine can achieve effective operations is being sought. However, at the same time in this case a place for the yet-to-be-developed mines of Tintaya, Coroccohuayco and Quechua, and also the Atalaya mines, already in operation, should be considered, and the merits of this integration must be explored to its greatest limits and a development structure should be sought, beginning with improvement of existing regional society's living standards in Yauri and others.

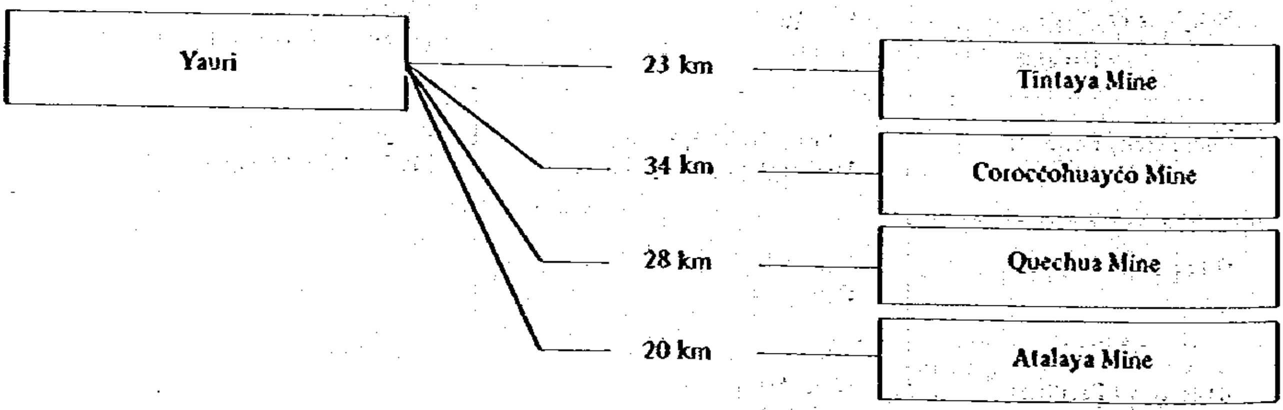
Here, with the understanding of the location conditions and existing towns of each of the mines, the possibilities connected with the development of the mining towns is analyzed, as well as their size and locations.

2-1 Conditions for Locating the Mines and Existing Plans

Fig. 6-5 shows the mines and their existing streets and layout plans. The entire area is at an altitude of 3,900 to 4,000 meters, and is a plain at a gradual slope or a riverbank. The area over 4,000 meters elevation shows the pattern of mountainous terrain. The towns of Yauri and Hector Tejada area, in any case, on level land below 4,000 meters elevation.

The area is spacious; it is divided from the southeast to the northwest by the flow of the Salado River and its tributary, the Canipia River. Both the Atalaya and Quechua mines are located along the Canipia River, and the Tintaya and Coroccohuayco mines situated in valleys proximate to the Salado River. The two areas divide at the 4,700 meters altitude (Cerro Ccalun Ccoime), preventing any easy connection between them. A connecting road exists between the Coroccohuayco and Quechua mines, but its elevation varies by about 300 meters along the route. To meet this problem, there is Departmental road 104 (Ruta Departamental) along the Salado River, and connecting this with local road 565 (Ruta Vecinal), linking the Tintaya and Coroccohuayco mines, is relatively easy.

The layout of Yauri and the road distances of the four mines is as follows:



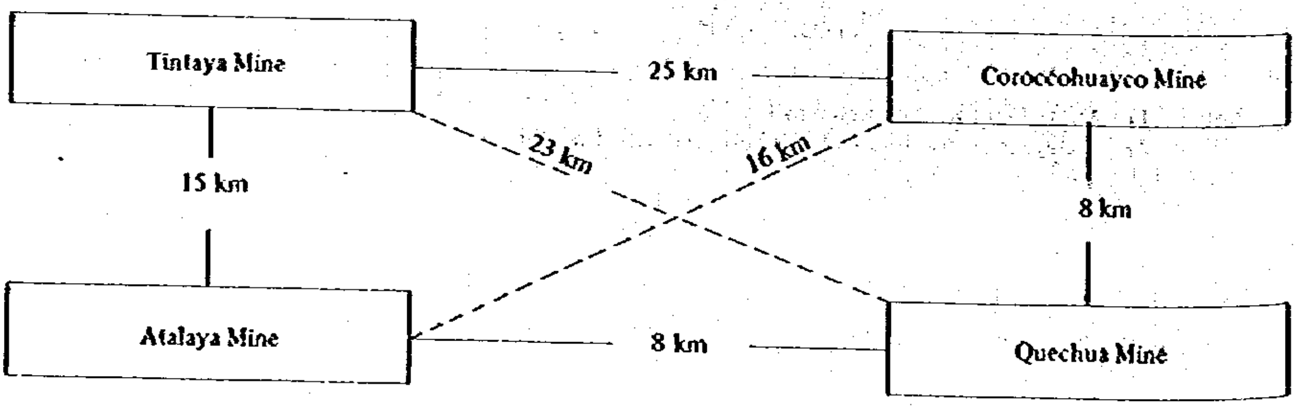
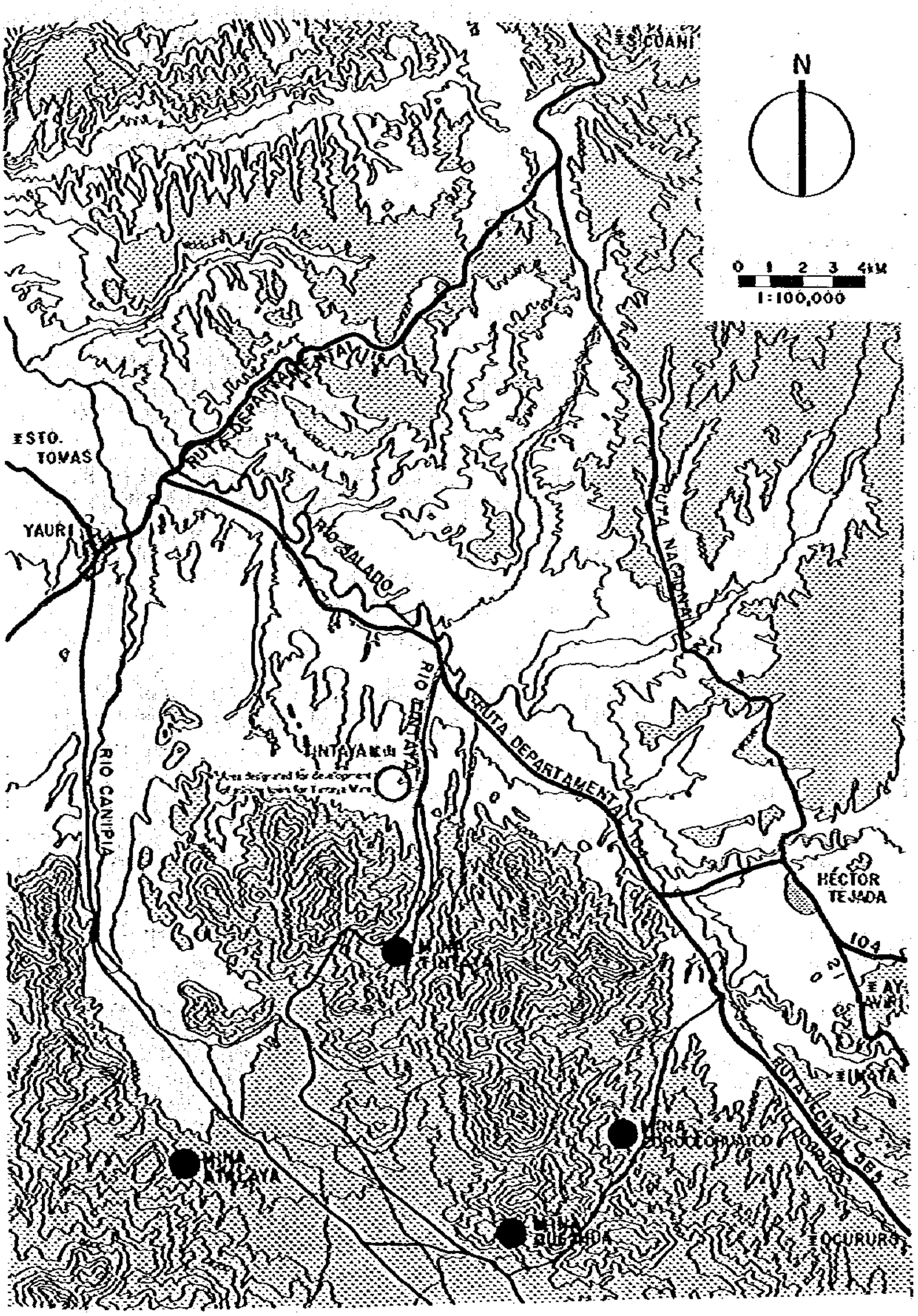


Fig. 6 - 5 Area Designated for Development of Mining Town



Next, Table 6-12 shows the details of operation of each mine, which was comprised from the study made from mine sources under the premise of mining town plans.

Table 6 - 12 Assumption for Infrastructure Development Plans for Each Mine

	Tintaya	Corocсohuayco	Quechua	Atalaya
Operation tons/day	8,000	1,000	8,000	450
Concentrate Production tons/year	152,000	20,000	92,000	9,600
Number of Workers	900	600	650	262
Estimated Period of Construction	1980 ~ 82	1983 ~ 85	1986 ~ 88	–
Mine Life	15	15	15	8

Comparing the details of the four mines, the scale of output, number of workers, etc., from every angle, it can be said that the Tintaya mine will become the central point for these mines. Further, geographically, the Tintaya mine is at the point where the future regional population will be distributed most heavily, and the planning study of each of the mines must be made keeping this point in mind.

Figs. 6-6, 7 and 8 show the present conditions of operation at the Atalaya mine and the general status of the mining town plans which are being put into effect at the Tintaya mine, which has already advanced to the basic engineering level. As can be seen in the figures, the housing sites for the Atalaya mine are part of the mine, and the housing site for the Tintaya mine is planned to be located 5 kilometers north of the left bank of the Tintaya River.

2-2 Development Style of the Mining Town

When developing a mining town, there are two basic ways to attain objectives of contributing to raise the living standards of the already existing community by taking advantage of a concentration of mines, which are shown as follows:

(1) Develop more than two residential sites simultaneously,

(2) Construct in an easily accessible location such substructures for mines and the surrounding community, i.e., hospitals, junior high school (CICLO III), senior high school (ESEP), hotels, recreation centers, etc.

Either of the two will help the mining town to decrease its construction costs, maintenance and management costs on one hand, and it is an effective method for mines and existing communities to sustain the facilities of a standard model with features that are otherwise impossible to retain alone.

In considering the possibility of jointly developing the residential sites of several mines, as discussed before, the Tintaya mine should become the core from the viewpoints of size of working population, location conditions, as well as priority of project commencement and life of mine. Geological conditions hinder both Tintaya–Quechua and Corоccohuayco–Quechua mines with steep mountains, while Coroccohuayco–Tintaya lie in comparatively easily accessible locations along Department road 104. Accordingly, the joint development of residential sites for the Tintaya and Coroccohuayco mines is the most likely alternative. The two mines belong to a common water route and they are under the most favorable conditions of sharing a single water supply facility system. There would be many difficulties to construct residential sites of the three mines jointly.

The location of the core facilities is aimed at each mine and existing communities; in the first place, the residential site of the Tintaya mine is considered for the same reason mentioned previously. The other candidate is Yauri, the central town of Espinal Province. Three alternatives are mentioned here for considering the development style of the mining towns:

(1) Construct residential sites at each mine near the foot and raise the area's core facilities at Yauri.

(2) Construct residential sites near the foot of the mountain and establish the area core facilities at the Tintaya mine.

(3) Construct on one lot the residential sites for both the Tintaya and Coroccohuayco mines along with other core facilities.

The relative displacement of mining towns of each development style is shown in Figs. 6-9, 10 and 11. Table 6-13 describes the evaluations made on these alternatives with regard to costs of construction of the towns, convenience of using the core area facilities, and commuting conditions from the mining towns.

In the case of 1, comparing to establishing core city facilities in the mining town, facilities are to be used for longer periods free from the limitations of mine demands, but costs and trip time will be greater for surrounding cities.

Case 2 : Location of core city facilities will be closer to the future center of population distribution, and will be easier to use from mining towns and existing towns, and at the same time it will become possbile to maintain the sites for facilities together with the infrastructure of the residential site of the Tintaya mine.

Case 3 : It is desirable to construct residential sites for both the Tintaya and Coroccohuayco mines at the midway point of the two mines, and it becomes necessary to review the plans of the mining towns in the overall mine development project. Although, in this case, the commuting distance for employees of the two mines and the distance to the core city facilities from the residential areas of the Atalaya and Quechua mines will be greater than in case 2, the economic merits of jointly constructing an infrastructure of residential and public welfare facilities are evident. When a common residential site is constructed at the mid-point of the two mines, the commuting distance is 12 kilometers. The development style of the mining towns should reflect the intention and development schedule of the management of each mine; however, at this stage alternatives 2 or 3 should be selected.

In order to materialize the construction of joint facilities or construction of the two mining towns jointly, it is necessary for the managerial body of every mine to have a system that operates and maintains facilities cooperatively. In the future it will be necessary for the related organizations to handle cooperatively these studied agendas of town management.

2-3 Size of Mining Towns and Land Utilization

2-3-1 Population of Mining Towns

Based on assumptions for infrastructure development related to the three mines of Tintaya, Coroccohuayco and Quechua, if we seek the population of the town which will be formed as each mine proceeds in its development, we will have the following: (Table 6-14)

First, it is assumed that ten per cent of mine employees (commuting population that owns homes) will be local residents and that housing in the mining town will be provided to the other 90 per cent. The ratio of bachelors to married employees is assumed to be 25 to 75, and the population related to mining is determined by counting the average size of a family as four (excluding the worker).

[Note: According to examples of already existing mines, the percentage of bachelors in the Atalaya mine is 31 and in the Huanzala mine (MINERA SANTA LUISA: medium scale mine with 730 employees located in North Peru) is 23; the percentage is generally low in mines that are close to towns and high in mines that are in the mountains or in remote places. The family size at the Atalaya mine is 5 and in Huanzala 3.7; it is said that families are smaller in mountain communities.]

Consequently, it is estimated that 7,740 people will settle as the mine-related population in the three mines. This is equal to twice the town population of Yauri. It is necessary to expect further settlement of service-related personnel, and it is estimated here that the ratio will be 50 per cent of the mine-related personnel.

Fig. 6 - 6 Outline of Atalaya Mine (1978)

Crude Ore Production Concentrate Production	450 tons/day 9,600 tons/year
Period of Operation	1970 ~ 1985
Working Population	Employees 24, Workers 233, Instructors 5, Total 262 Among workers, 73 bachelors, 160 married
Main Facilities	Housing (Employees housing, 2 wings. Workers housing, 24 wings.) School (5-year, 280 children) Hotel (1 wing) Hospital (10 beds, 1 doctor, 1 X-ray technician) Supply and general shops (6 – 7 shops) Bakery Dining hall and clubhouse Workers' union hall, Electric Generator (Diesel type, Max. Capacity 1,100 kW/hr)

Source: MINERA ATALAYA S.A.

Disposition of Main Facilities

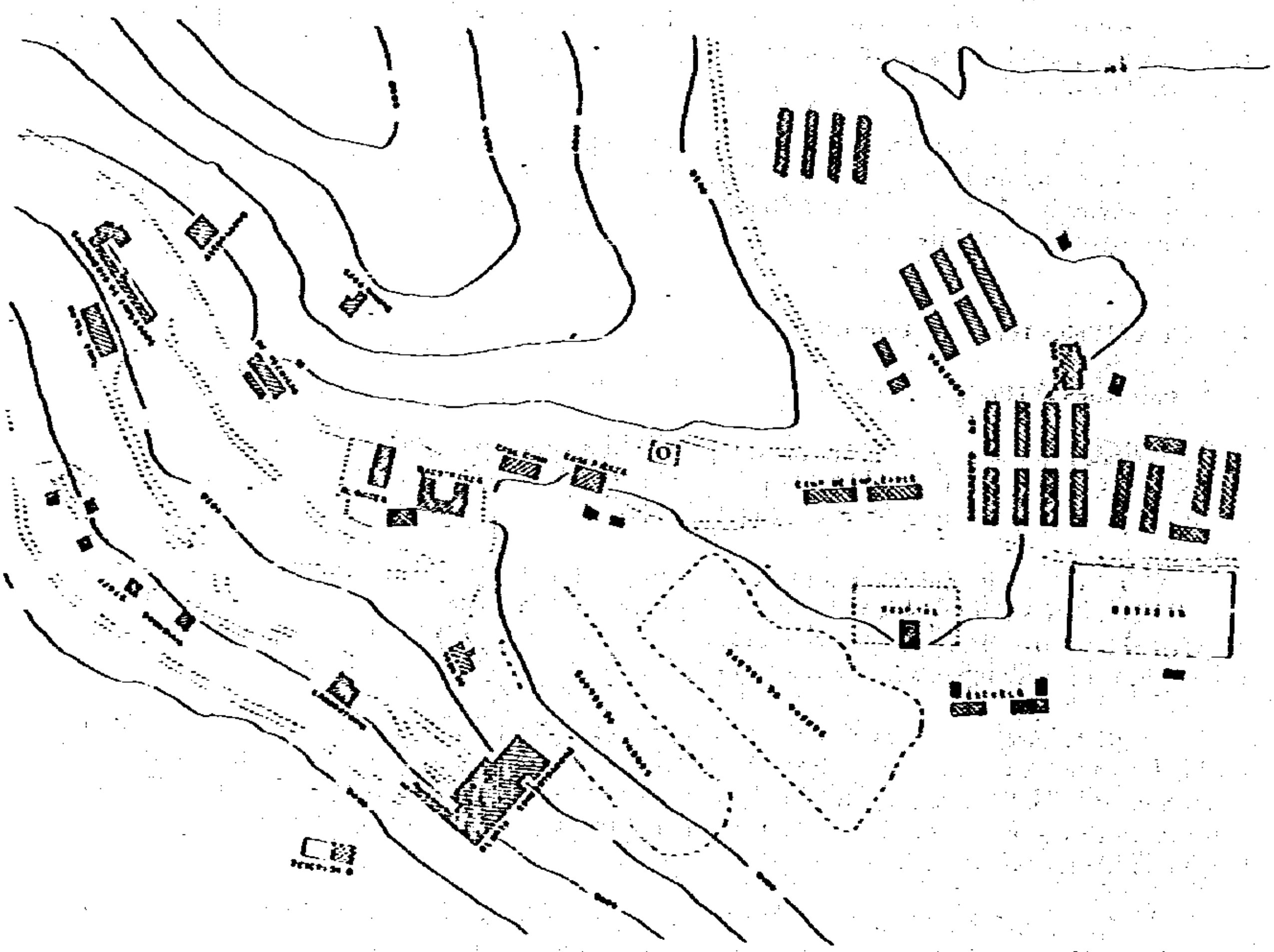


Fig. 6 - 7 Outline of Tintaya Mine Development Plan

Crude Ore Production Concentrate Production	8,000 tons/day 152,000 tons/year
Working Population	Bachelors 180 Married 720 Total 900
Main Town Population	3,780
Main Town Facilities	Housing Educational facilities (Kindergarten, Normal school, Technical school) Medical facilities (Hospital) Social services (Nursery) Community center (Meeting hall, Reading room, etc.) Recreation center Commercial facilities (Market, General shops, Bank, Restaurant, Petrol stand) Church Administrative facilities (Post office, Cable telephone, Fire department, Police) Workers' Union Office, Power facilities (Diesel generator 15,000 kW capacity)

Source: Tintaya Project F/R and Minero Peru

Disposition Plans of Main Facilities

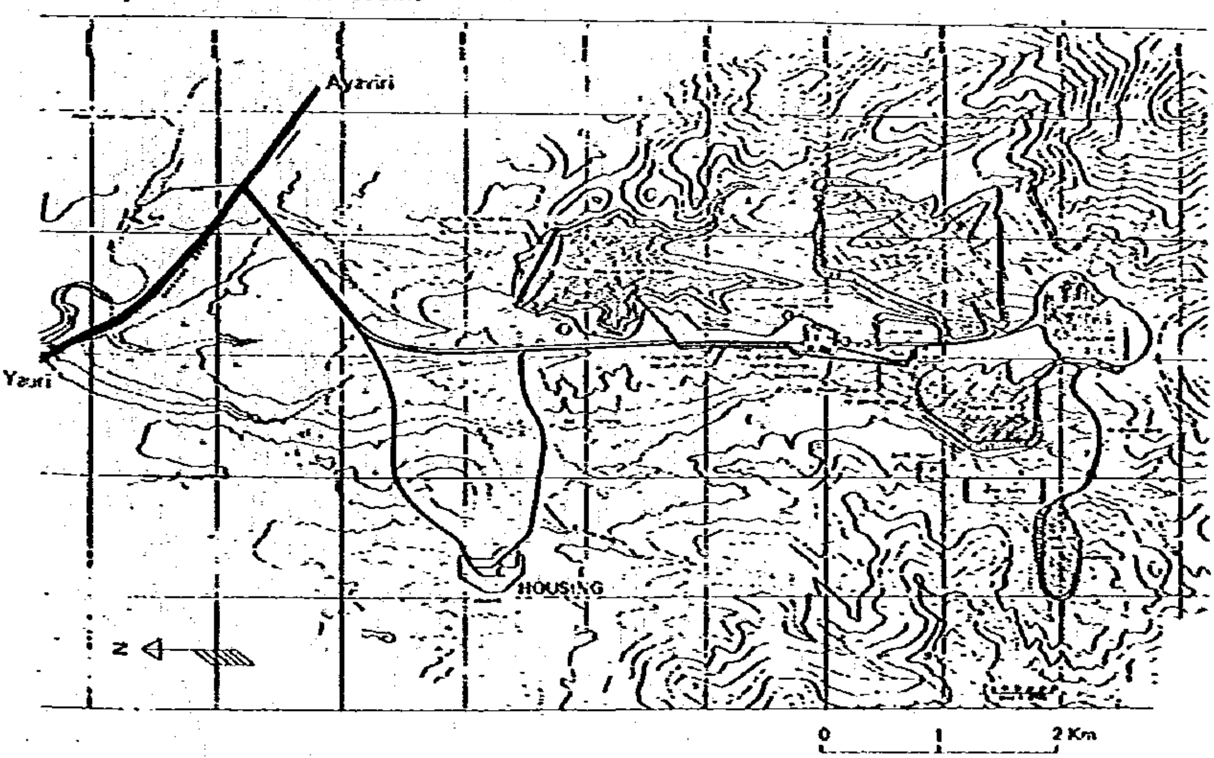
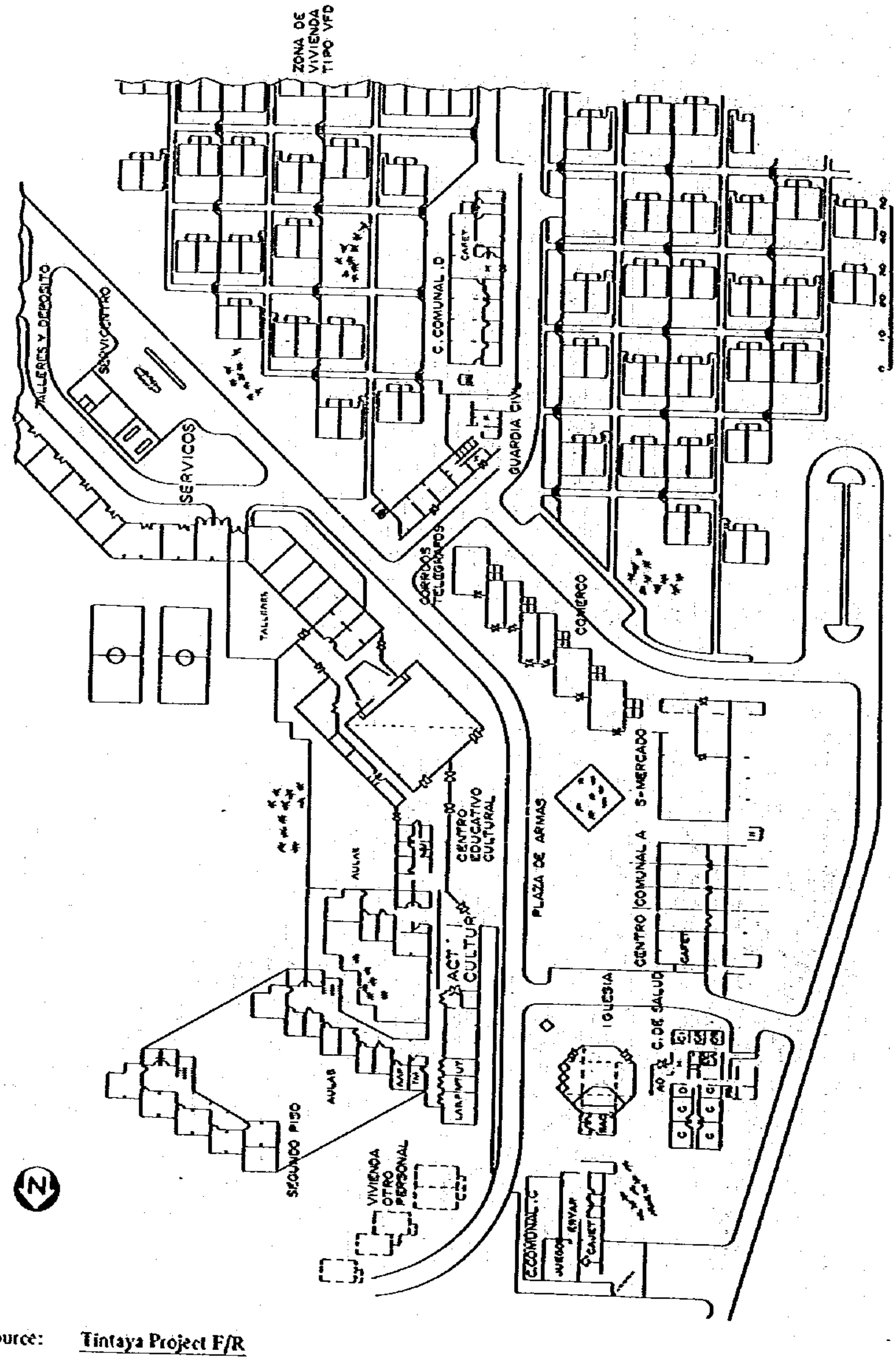
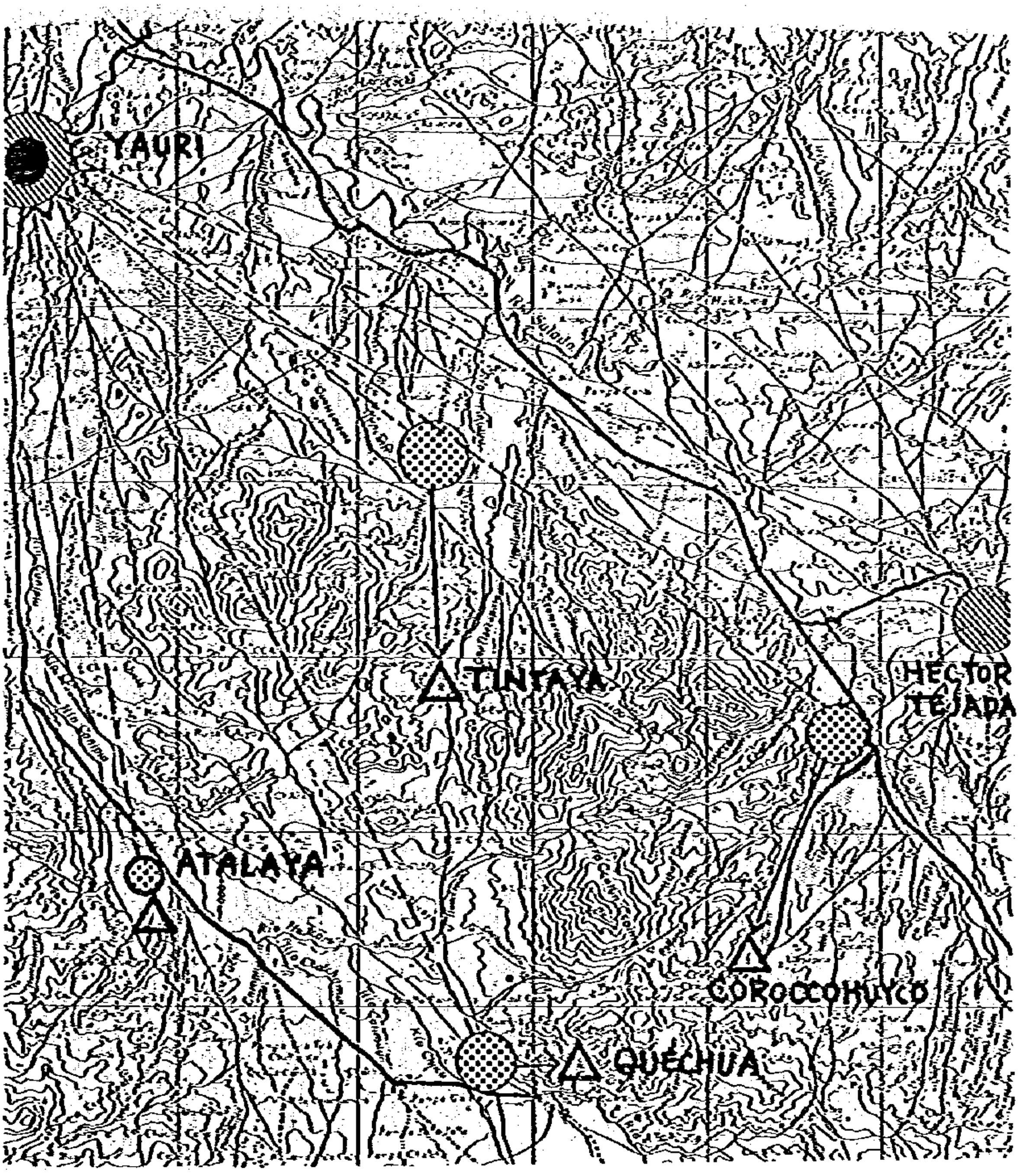


Fig. 6 - 8 Disposition Plan of Facilities



Source: Tintaya Project F/R

Fig. 6 - 9 Alternatives of Mining Town Development Types ①



Existing Towns

Residential Sites

Local Facilities

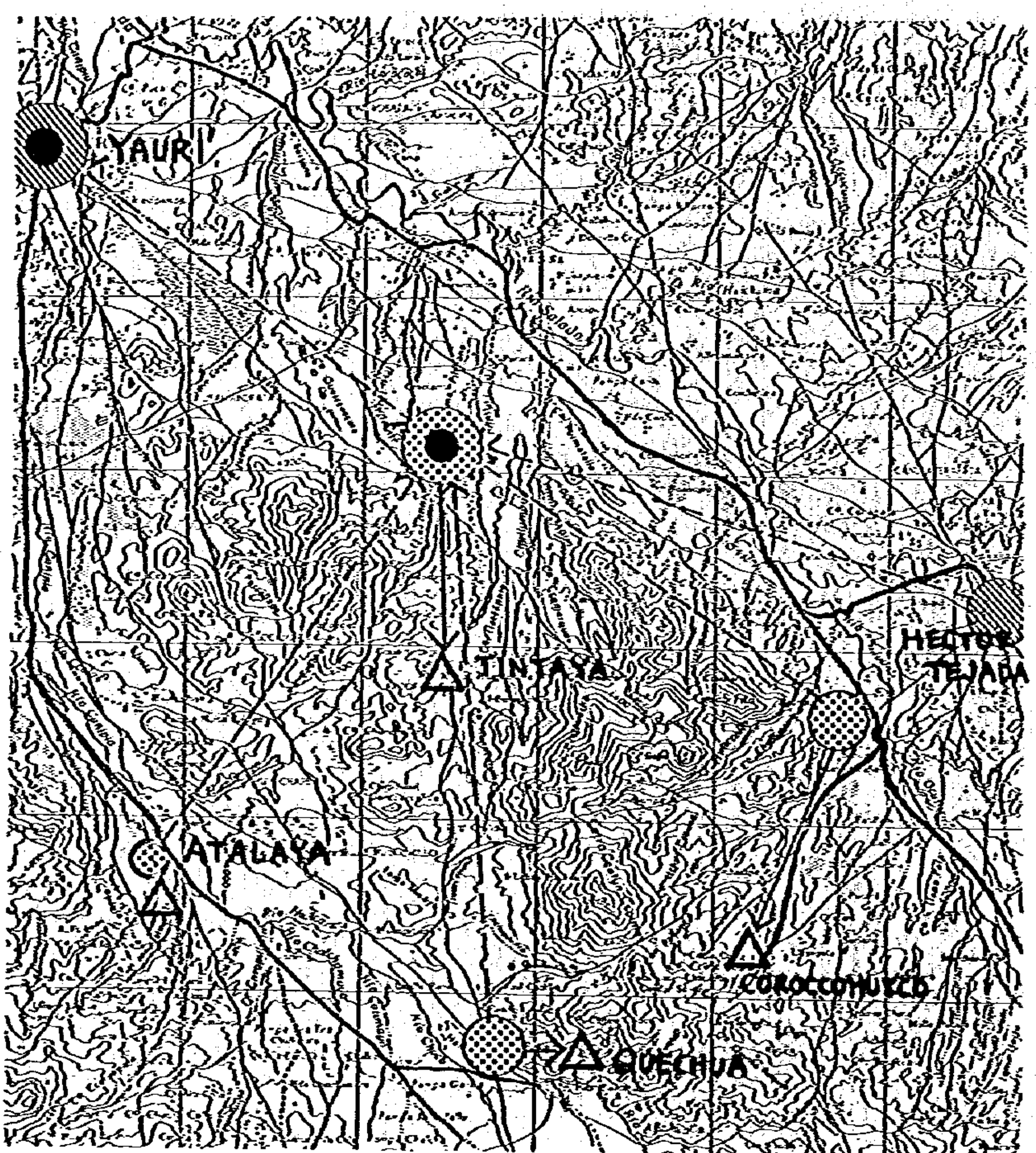
Mine Site

Commuting of Mine Workers

Use of Local Facilities

5 4 3 2 1 0 5 km

Fig. 6 - 10 Alternatives of Mining Town Development Types ②



Existing Towns

Residential Sites

Local Facilities

Mine Site

Commuting of Mine Workers

Use of Local Facilities

5 4 3 2 1 0 5 km

Fig. 6 - 11 Alternatives of Mining Town Development Types ③

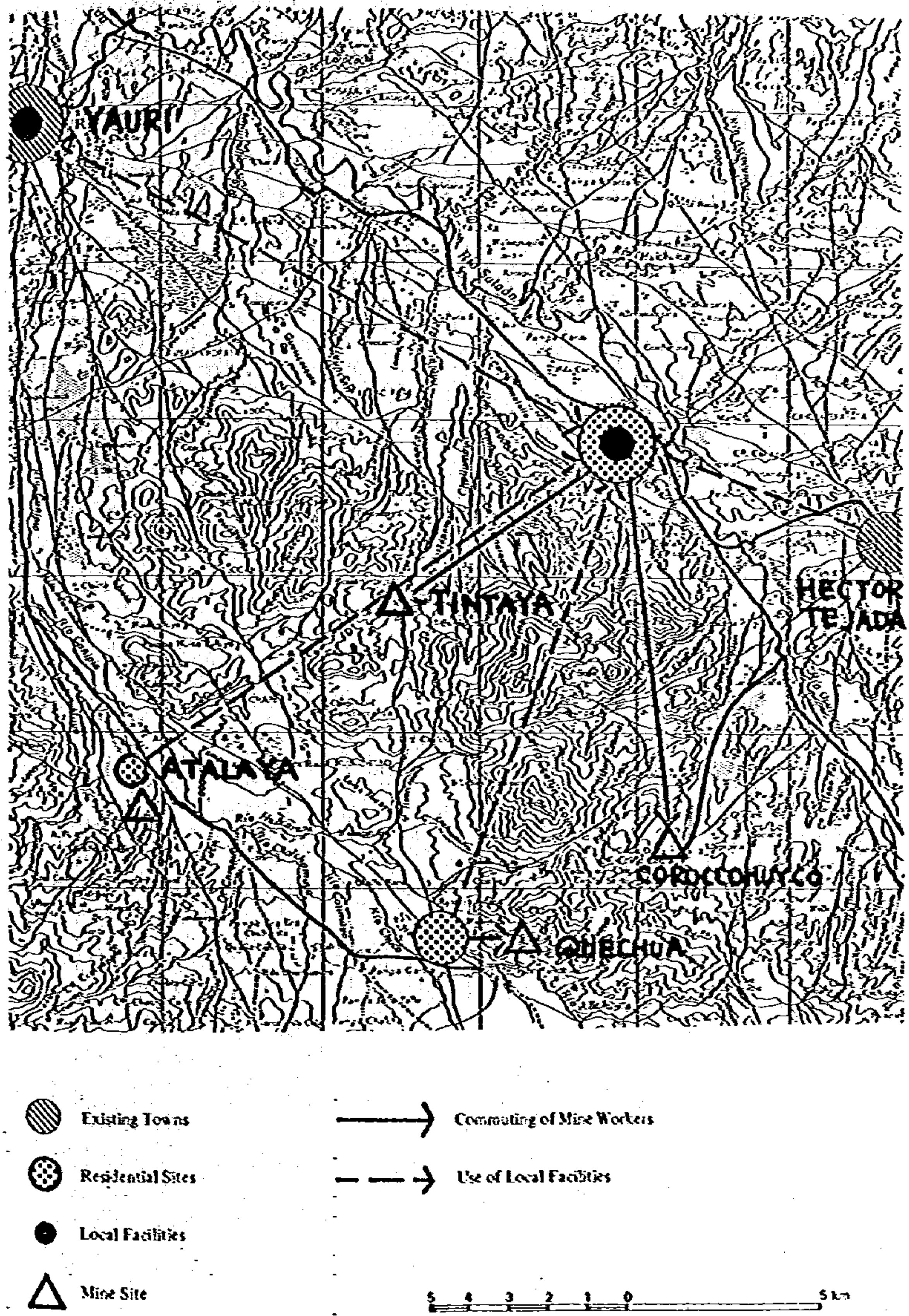


Table 6 - 13 Evaluation of Alternatives of Mining Town Development Types

Item Evaluated	Mining Town Construction Cost	Convenience of Local Facilities	Commuting Conditions of Each Mine	Period of Possible Use of Local Facilities
Alternative ①	△	△	◎	◎
" ②	○	◎	◎	○
" ③	◎	◎	○	○

Note: ◎ ; Very good
○ ; Good
△ ; Not necessarily good

Table 6 - 14 Size of Population of the Mining Towns

	Tintaya	Coroccohuayco	Quechua	Total
Workers	900	600	650	2,150
Bachoelors	203	135	146	484
Married	607	405	439	1,451
Total	810	540	585	1,935
Family Population	2,430	1,620	1,755	5,805
Mine-related Employment	3,240	2,160	2,340	7,740
Service-related Employment	1,620	1,080	1,170	3,870
Total Popultion of Mining Town	4,860	3,240	3,510	11,610

[Note: In the aforementioned example of the Huanzala mine, the percentage of service-related employment such as one-day part timers, in shops and restaurants, etc. is approximately 40 per cent of the equivalent of the mine-related employment.]

It is necessary for the mining town to have ample space for future expansion, including for the settlement of this service-related personnel. The population of service-related industries increases as the years pass after starting mine operation, and the final population of the mining town is expected to reach approximately 11,600, including the service population.

2-3-2 Area and Land Utilization of Mining Town

It is necessary for the mine plans to include land space not only for employee housing but also for parks, recreation, open land and roads as well as for educational, cultural, medical and social service facilities; the space for residence must be secured intentionally, not only for the mine-related population, but also for the service-related population.

Table 6-15 shows the two cases considered to determine the extent of expansion in compliance with development style; such as Case A – to construct the mining town of Coroccohuayco alone; and Case B – to construct both mine cities of Tintaya and Coroccohuayco.

Talbe 6 - 15 Determination of Expansion of Mining Town

		A Single Town for Only Coroccohuayco Mine		B Combined Town for Coroccohuayco and Tintaya Mines	
Mining Town Population	Mine Worker Population	2,160		5,400	
	Service Related Population	1,080		2,700	
	Total	3,240		8,100	
Number of Houses Housing Space	Bachelors	135	1.4 ha	338	3.4 ha
	Married	405	8.1 ha	1,012	20.2 ha
	Total	540	9.5 ha	1,350	23.6 ha
Parks, Open Space Recreational Land		9.5 ha		23.6 ha	
Roads Land for Public Facilities		9.5 ha		23.6 ha	
Town Expansion for Mine Worker Population		28.5 ha		70.8 ha	
Town Expansion for Service Population		14.3 ha		35.4 ha	
Total Area of Mining Town		42.8 ha		106.2 ha	

Firstly, housing area was determined by assuming the area of a house for the related mine-employed personnel as being:

Bacheolor house	100 m² per person
Family house	200 m² per person

Next, the extent of the town for the employment-related population is determined by a land utilization ratio of:

1/3	housing
1/3	parks, open space, recreational area
1/3	roads, public and welfare facilities

In addition, housing areas for the service-related population is estimated to be 50 per cent of the above, and thus the final extent of the mining town is determined. As a result, the total area of the mine town is 43 hectares in Case A and 106 hectares in Case B. In either case, the population density for the town will be 76 per hectare.

2-4 Selection of the Mining Town Location

Regarding the location of the mining towns, the following basic conditions must be fulfilled:

① They must be close to the mine and accessible to the workers

② They should have good geological and base conditions; the topographical development should be easy

③ Supplies of drinking water should be secure

④ The environment should be adequate for residential use

⑤ It should not interfere with the other uses of the land (i.e., agricultural use)

In connection with ①, the terms of the General Mining Law require that it be located within 20 kilometers or within 30 minutes commuting distance from the mine; so that workers may go to work on foot, it is required that the residential area be located at the foot of the mountain, but it is desirable from the view of preserving the living environment to separate the working area a reasonable distance from the residence. In particular, care must be taken to assure that the town is located in a place which avoids the effects of runoff of water or dust from the waste piles, or effects connected with the transport of ore and fuel.

In the case of the Coroccohuayco mine, the elevated table over the north riverbank is wide and sufficient possibilities exist for it to satisfy the above-listed conditions for development. This area is close to local road 565, offers convenient connections to Yauri and Hector Tejada, and can easily obtain its drinking water from the Salado River.

Here, considering the relation of the development form of the mining town already mentioned, the following prospective areas for development in each district are shown. (Refer to Fig. 6-12 and Photo 6-1, 2 and 3)

A. If a single mining town is built at the Coroccohuayco mine:

In this case, a location convenient for commuting to the site will be given precedence, but the following two sites will be given consideration:

A-1 Hilltop on the east side of Coroccohuayco Valley

This is close to the mine site and can be reached by walking, but if a residential site is contemplated for the Tintaya mine, it becomes somewhat inconvenient.

Fig. 6 - 12 Map of Prospective Mine Twon Development Sites

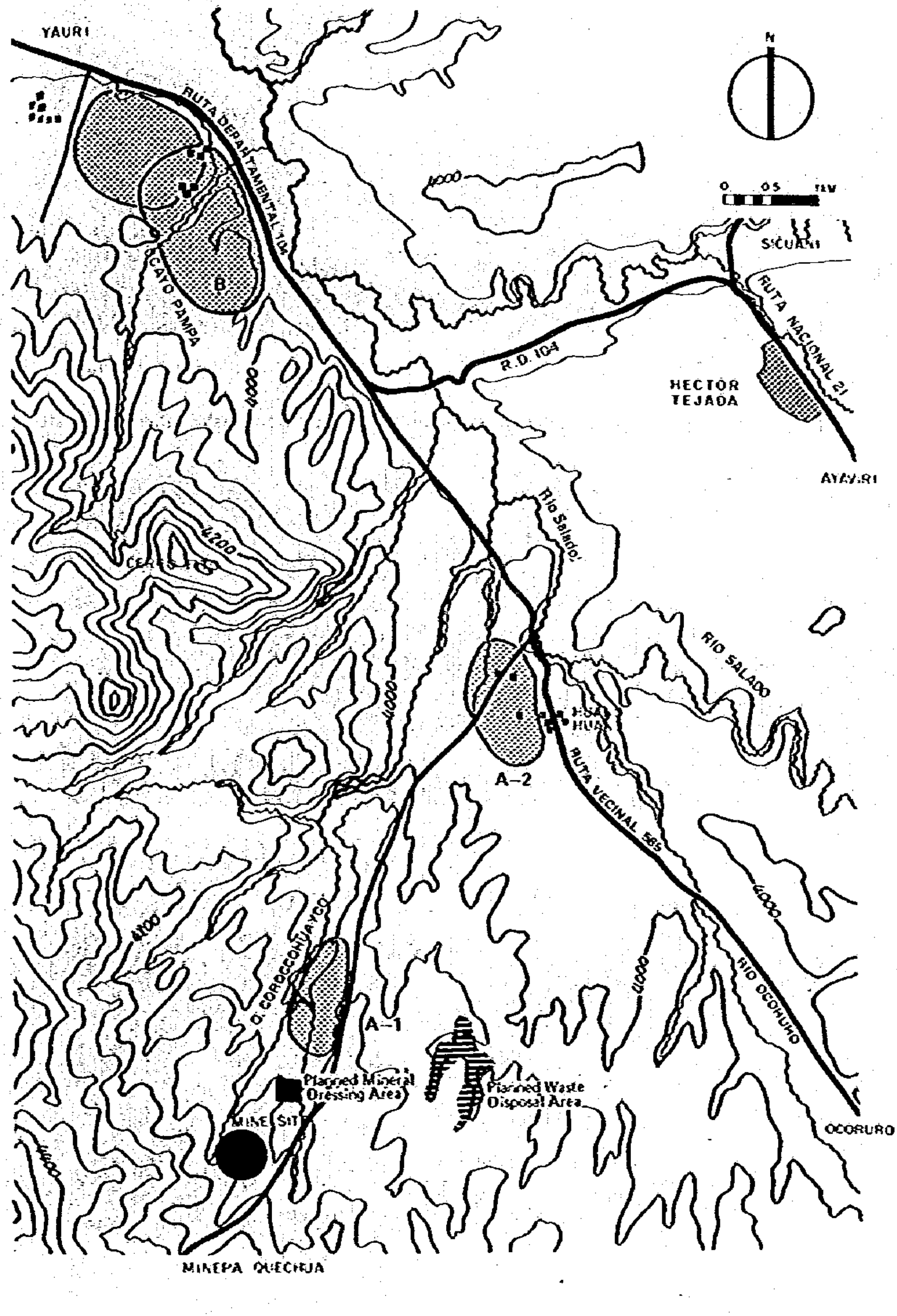


Photo 6 - 1 A - 1 East Part of Coroccohuayco Valley (from Mine Site)

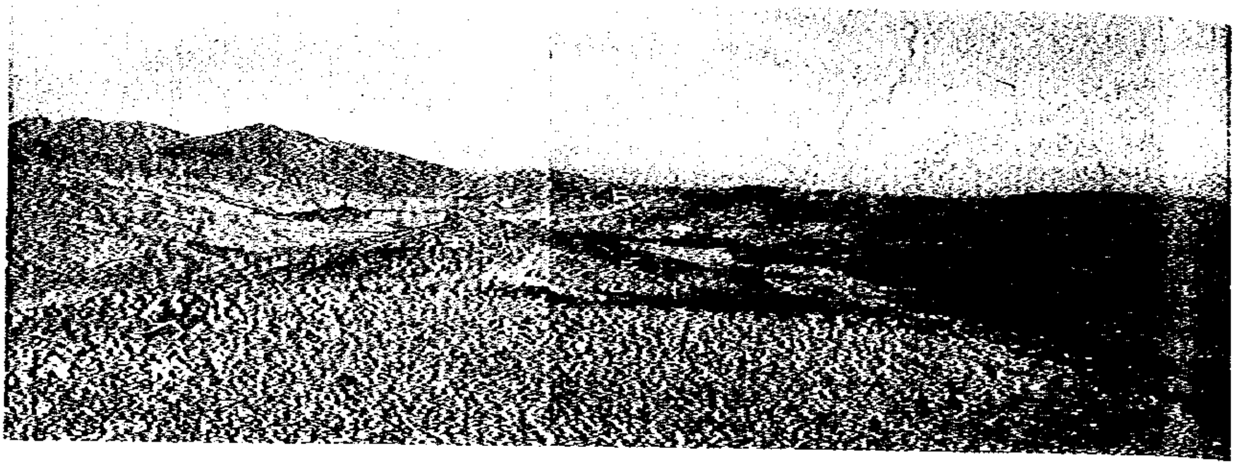


Photo 6 - 2 A - 2 Hills on North Side of Huano Huano (from the North, Salado River on the left)

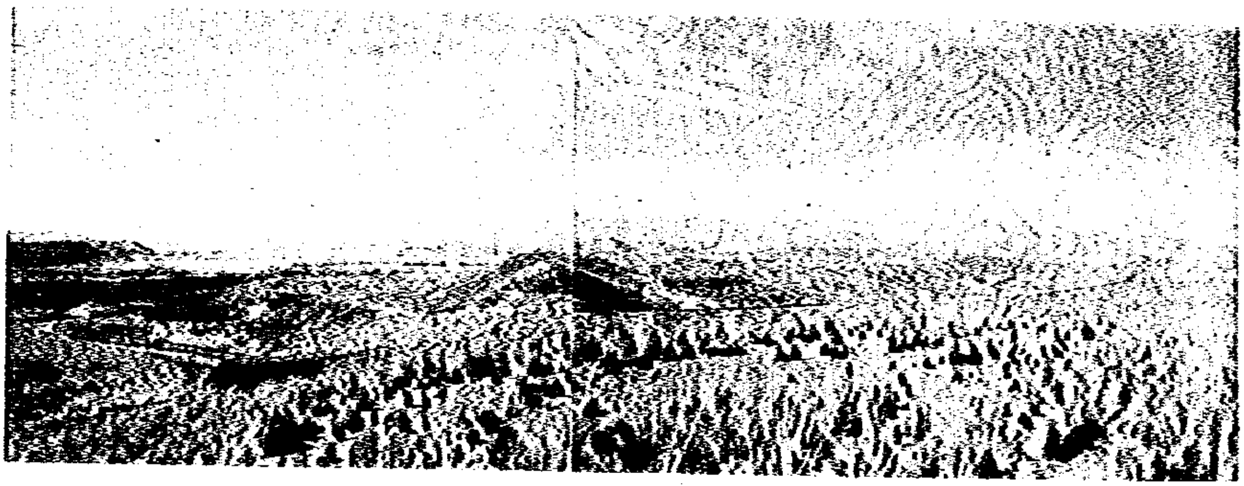


Photo 6 - 3 B Ccayo Pampa (from the East)

A-2 HUANO HUANO

This is approximately 5 kilometers distance from the mine site, but is proximate to local road 565, and offers convenient connections to the Tintaya mine housing site and Yauri.

B. If a single town is built to serve both the Tintaya and Coroccohuayco mines:

In this case, the flat area (Ccayo Pampa) located on the left bank of the Salado River, which is midway between the mine sites, can be considered the most appropriate area. Distance from here to each of the mines is about 12 kilometers, and the location is easily accessible to both Department road 104 and Local road 565.

3. Plan of Town Facilities

3-1 Premises of Facility Plans

Before the facility plans of mining towns can be made, the related statutes must be ogranized as a prerequisite to the plans.

Some of the main laws related to the development of mining towns in the Republic of Peru include the following:

(1) General Mining Law (DECRETO LEY No. 18880, LEY GENERAL DE MINERA, 1971)

(2) Corporate Mining Regulation (DECRETO SUPREMO No. 025-72-EM-DS, REGLAMENTO DE LA COMUNIDAD MINERA, 1972)

(3) Article 326 relative to the General Mining Law (DECRETO SUPREMO No. 025-73-EM-DS, REGLAMENTO DEL ARTICURO 326 DE LA LEY GENERAL DE MINERIA, RELATIVO A VIVIENDA, 1973)

(4) Mine Safety and Benefit Regulation (DS-034-73, REGLAMENTO DE BIENESTAR Y SEGRIDAD MINERIA, 1973)

(5) Mine Corporation Housing Construction Law (DECRETO LEY No. 20007, SEBRE VIVIENDA E INSTALACIONES Y SERVICIOS DE BIENESTAR, 1973)

(6) National Construction Law (DS-039-70-VI and S.D. 063-70-VI, REGLAMENTO NACIONAL DE CONSTRUCCIONES, 1970)

Within the various statutes, the planning of mining towns is particularly affected by the following important items:

(1) Responsibility of facilities construction by mine industries

In Article 326 of the general Mining Law, if the mine is located in isolated territory, the mining corporation is responsible for the maintenance, support and management of the following:

① Worker's housing (VIVIENDAS ADECUADAS)
② School construction and support (ESCUELAS Y SU FUNCIONAMIENTO)
③ Recreational facilities (INSTALACIONES ADECUADAS PARA LA RECREACION)
④ Social service facilities (SERVICIOS DE ASISTENCIA SOCIAL)
⑤ Medical services not covered by the social welfare program (ASISTENCIA MEDICA Y HOSPITALARIA GRATUITA EN LA MEDIDA QUE ESTAS PRESTACIONES NO SEAN CUBIERTAS POR LAS ENTIDADES DEL SEGURO SOCIAL)

In Article 326 of the General Mining Law, this so-called isolated territory (Zonas Alejadas) is specified as by over 30 minutes by automobile at safe driving speed from a populated area, or over 20 kilometers; this "populated area" (POBLCION) is defined by Article 326 as being a place which contains facilities, maintains services, with a population at least 10 times the number of workers of the mine and their families. Consequently, in the case of the three mines of Tintaya, Coroccohuayco and Quechua, the above regulations for the construction and maintenance of the above-mentioned facilities is the responsibility of the mines themselves.

According to Article 326 and its amendments, the items required for construction, support and maintenance are understood to be as follows:

① Housing: Worker's homes

② Employees facilities: Bachelors' dining hall

③ Administrative facilities: Administrative Building (City Hall, etc.), Post Office

④ Medical facilities: Hospital

⑤ Educational, cultural facilities: Schools (Kindergarten, Primary school), Church

⑥ Commercial facilities: Market

⑦ Recreational facilities: Cinema, Club house, Sports ground

⑧ Town facilities: Water supply, Sewage, Rainwater drainage, Electric power, Waste disposal

Further, regarding the planning of the mining town, a joint committee (COMPERMI: Comisión Permanente Mixta de Vivienda y Energía y Minas) made up of members of the Mining Ministry, Housing Ministry, and Power Ministry advise the mine companies concerning the Mine Company Housing Construction Law, and approval is required from them. Plans and blueprints must be drawn up by architects and town planners registered with the Peru Technological Association and Architects Association.

(2) Regulations connected with housing design

In regards to company housing for employees, the mining companies can allocate, in the beginning period of operation, temporary housing units used during construction, but must provide the employees with permanent housing to those who require such within 3 to 5 years from start of operations. The following is required under the Mining Company Housing Construction Law and Article 326 of the General Mining Law concerning designs of the permanent housing:

Bachelor Housing:

① One bedroom must be able to contain one or three beds (two beds not acceptable).

② The maximum units per wing is 24.

③ For each four workers, such hygienic facilities as warm and cold showers, toilet, and washbowl (BAÑOS Y SERVICIOS HIGENS) must be made available.

④ Cooking is prohibited in sleeping rooms.

Family Housing:

① The building must be a collective type independent structure lower than 3 stories, with the first floor having less than 12 units.

② All housing units must at least make available the following:
1 living/dining room
1 bedroom
1 bath (shower, toilet, washbowl) "Baño"
1 kitchen

③ The number of bedrooms must be increased by one room for every 3 residents over the age of 5 years

④ A laundry room must be included for each four housing units, or for each unit

⑤ Each unit must have drinking water and sewage facilities. Also, in housing located above the 3,000 meter elevation, heating facilities must be included.

The floorspace and dimensions of each room are determined by national construction regulations, but their main provisions are as follows:

① Bedroom: More than 10 m^2, with no side less than 2.8 m

② Living/dining room: More than 16 m^2, with no side less than 3.0 m

③ Ceiling height: 2.3 m

④ Steps: Effective width 1.0 m, minimum step surface 0.25 m

⑤ Yard or garden: More than 30 per cent of the lot

⑥ Percentage of lot allotted to structures: 60 per cent or less

According to Article 139 of the General Mining Law, mines in Peru are classified as small, medium or large mines in accordance to their scale of production (crude ore, annual sales or mine area), and enforcement standards of facilities for housing and maintenance vary according to each category.

In granting approval to the mining town plans and housing designs of the previously mentioned COPERMI, these are considered. However, because the approval standards have not been clearly specified, it will be necessary to take particular caution regarding the scale of housing, etc., in the future.

Large mines are those which produce 5,000 tons of crude ore and over per day. According to this standard, the Tintaya mine will be a large-sized mine and the Coroccohuayco mine medium-sized. As indicated in the plans shown previously, in the case of joint development of the Tintaya and Coroccohuayco mines there will be a problem as to how to make adjustments between the two.

3-2 Study of the Contents of Facilities

Facing the plan of the facilities, compliance to the development form of the mining town is considered, and as for the housing which will be the direct subject of study of the Coroccohuayco mine, other facilities which will benefit the general public are:

(1) In the case a single mining town is built for the Coroccohuayco mine, and all of the necessary facilities are built within the district.

(2) In the case a joint mining town is developed for both the Coroccohuayco and Tintaya mines, with combined facilities built.

3-2-1 Housing

Based on the population as shown in item 2-3 of the scale study of the mining towns, the number of company houses to be supplied at the Coroccohuayco mine is shown in Table 6-16.

Table 6 - 16 Number of Housing Units

	Composition of Workers		Composition of Household		Total
	Staff 1)	Worker 2)	Bachelor	Married	
Working Population	90	510	150	450	600
Required Housing Units	90	450	135	405	540

Notes: 1) STUFF EMPLEAD
2) OBRERO

In this, it is estimated that 10 per cent of the total mine workers are commuting from their own homes (locally hired workers), with the remaining 90 per cent being provided with housing. For the percentage of locally hired workers, it was estimated until now that this would comprise 25 per cent for the Tintaya Feasibility Report, and in the development plans for Coroccohuayco and Quechua mines even 20 to 30 per cent, but if the three mines are operated simultaneously, we must take into consideration that the ratio of locally hired workers will fall, or that a trend toward many locals wishing to reside in company housing due to the difference in standards between the company housing and local homes will arise. From these points, the number of locally hired workers at the three mines must be held to 10 per cent of the number of workers (2,150), or about 220 men.

The composition of the different housing types is determined according to the family type of the residents or the number of family members. The company housing resident census of the Huanzala mine (MINERA SANT LUISA S.A.) is available as information on the composition of residents in an existing mine. (Table 6-17) Here, in Table 6-18, the basic data on this is used to show the types of residents.

As for each type of house scale, the following have been built so as to fulfill the framework of the standards for the housing plans listed above:

Bachelor housing	25 m^2 floorspace per person
Family housing	
1 bedroom type	60 m^2
2 " "	72 m^2
3 " "	85 m^2
4 " "	100 m^2

In Fig. 6-13 and Table 6-19, the models considered for construction of the housing scale are shown as the standard housing for the Tintaya mine development plans and floorspace. These examples are applicable to large-scale mine housing plans, and compared with the above-listed standards they are given extra space. They are considered adequate for the medium-scale mine being studied at this time, but future studies on the development of a common mining town for the Tintaya and Coroccohuayco mines will be adjusted to more concrete needs.

Further, the average floorspace per unit of family housing according to the above will be approximately 76 m^2.

3-2-2 Public Facilities

According to the provisions of Article 326 of the General Mining Law and prevailing conditions at mining towns in Peru, the essential public facilities and scale are shown in Table 6-20. Here, the mining town's scale is divided into two possible cases, and the scale of facilities needed for each outlined.

Case A: If a single mining town is built for the Coroccohuayco mine (planned population 3,420).

Case B: If a common mining town is constructed for the mines of Tintaya and Coroccohuayco (planned population 8,100).

In connection with the area of the facilities and others, many figures are estimates, and it will be necessary in the future to study them in more detail according to conditions at the site. Further, this is also the case for facilities which will be used other than at the mining town.

The concept of the plans for the main facilities is as follows:

(1) Educational facilities

As shown in Fig. 6-14, the educational system in the Republic of Peru is composed of a 9-year compulsory school system of 4-2-3.

Table 6 - 17 - 1 Family Composition of Residents at Hoanzala Mine Company Housing (1973 Survey)

Family Type \ Dependents	0	1	2	3	4	5	6	7	8	9	Total (%)
Worker Only (Bachelor)	169	–	–	–	–	–	–	–	–	–	169 (23.2)
Worker & Father, Mother	–	6	2	1	–	–	–	–	–	–	9 (1.2)
Worker & Children	–	1	1	1	–	–	–	–	–	–	3 (0.4)
Married Couple	–	49	–	–	–	–	–	–	–	–	49 (6.7)
Couple & 1 Child (Under 5 yrs.)	–	–	31	94	13	15	4	2	–	–	159 (21.8)
Couple & 1 Child (Over 5 yrs.)	–	–	86	20	63	77	47	27	11	5	336 (46.2)
Couple & Parents & Child (Under 5 yrs.)	–	–	–	–	–	1	–	–	–	–	1 (0.1)
Couple & Parents & Child (Over 5 yrs.)	–	–	–	–	1	–	–	–	1	–	2 (0.3)
Total (%)	169 (23.2)	56 (7.7)	120 (16.5)	116 (15.9)	77 (10.6)	93 (12.7)	51 (7.0)	29 (4.0)	12 (1.6)	5 (0.7)	728 (100.0)

Source: PROGRAMA DE VIVIENDA Y BIENESTAR COMPAÑIA MINERA SANTA LUISA S.A.

Table 6 - 17 - 2 No. of Required Housing Units by Type According to Composition of Family

Housing Type	Bachelor Housing	1 BR House	2 BR House	3 BR House	4 BR House	Total
Required Units	169	90	371	93	5	728
%	23.2	12.4	51.0	12.8	0.7	100.0

Source: PROGRAMA DE VIVIENDA Y BIENESTAR COMAÑIA MINERA SANTA LUISA S.A.

Table 6 - 18 Number of Houses Constructed by Type

(Unit: Houses)

	Bachelors[1] Housing	Family Housing					Total
		1 BR	2 BR	3 BR	4 BR	Sub Total	
Staff Housing	23 (25)[2]	– (0)	40 (45)	27 (30)	– (0)	67 (75)	90 (100)
Workers Housing	112 (25)	32 (7)	202 (45)	90 (20)	14 (3)	338 (75)	450 (100)
Total	135 (25)	32 (6)	242 (45)	117 (22)	14 (3)	405 (75)	540 (100)

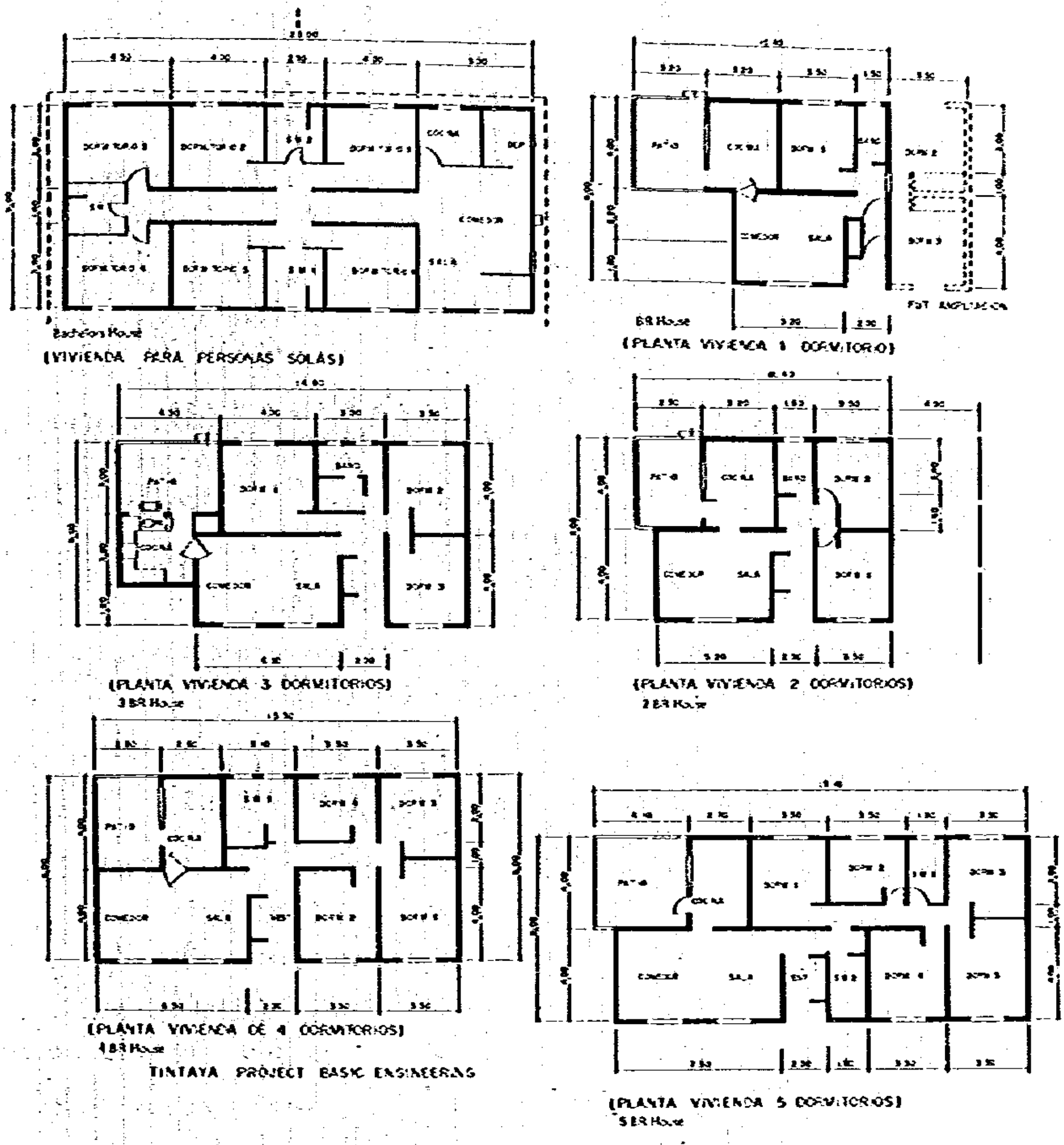
Notes: 1) Bachelors housing is given as single rooms.
2) Amount in parentheses shows per cent.
3) BR: Bed Room

Table 6 - 19 Style of House, Tintaya Mine Company Housing

(Unit: m^2)

Contents \ House Type	1 BR	2 BR	3 BR	4 BR	5 BR	Variation
Entrance Vestibule	3	3.6	2.9	3.1	5	3.2
Livingroom Diningroom	18	19	23	23.6	27	28 11.8
Principal Bedroom	12	10	11.4	11.2	9.6	10.6
Bedroom N° 2	–	10	10	9.6	6.9	11.6
Bedroom N° 3	–	–	10	8.3	8.9	8.9
Bedroom N° 4	–	–	–	6.7	9.9	6.9
Bedroom N° 5	–	–	–	–	11.5	–
Toilet	3	4	7.8	7.8	9	9
Kitchen	11	11	9	8.9	9.3	9.5
Maid's Bedroom, Toilet	–	–	–	–	–	9.6
Circulation, Walls and Closets	15	19.4	24.9	33.8	35.9	49.5
Garage	–	–	–	–	–	18
Total	62	77	99	113	133	177

Fig. 6 - 13 Layout of Tintaya Mine Housing

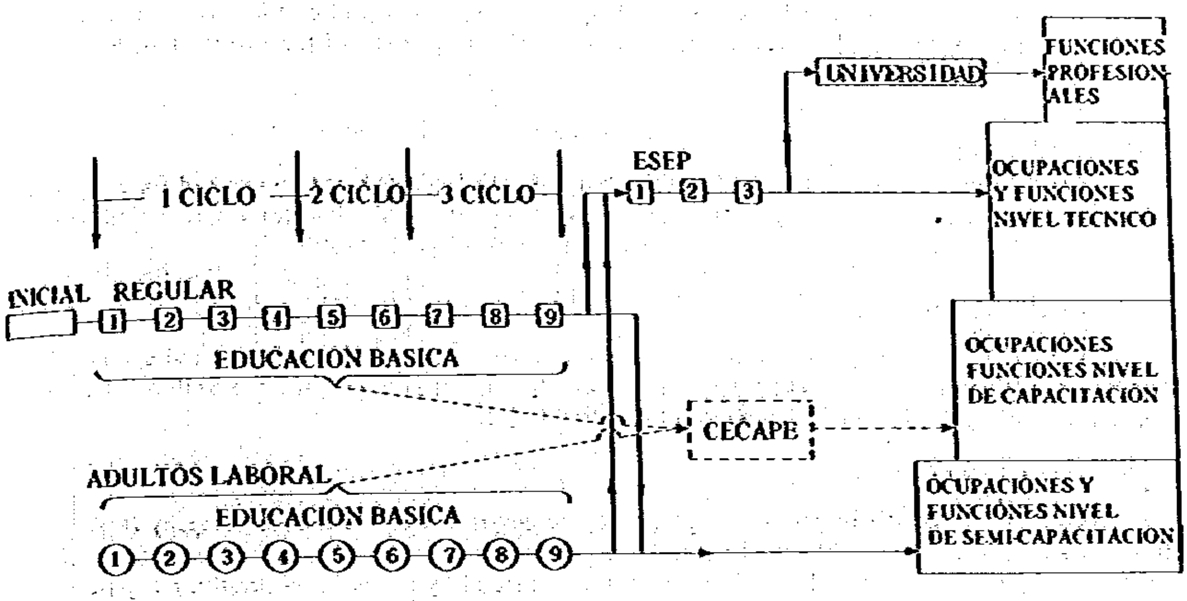


Source: Tintaya Project Basic Engineering

Table 6-20 Table of Public Facilities Plan

Item		Facilities required by law	Case A (Pop. 3,240) Size of facility	Case A Floorspace m²	Case A Lot area m²	Case B (Pop. 8,100)	Case B m²	Case B m²	Specification
Educational facilities	Kindergarten	O	5 Classes	550	2,500	5 Classes I 7 Classes I	550 690	2,500 3,000	200 m² + 70 m² x Classrooms
	Normal school	O	C.E.B (I,II,III) 15 Classes	2,600	20,000	C.E.B (I,II) 15 cl C.E.B (I,II,III) 22 cl	2,600 3,500	20,000 30,000	1,200 m² + 90 m² x Classrooms
	Workers school			-	-		-	-	Using normal school facilities
Cultural, religious facilities	Church, central Plaza	O		200	2,000		400	3,000	
	Community center (library, meeting hall, workers union office, etc.)			300	1,000		600	2,000	
Public health, social service facilities	Public health center (hospital)	O	22 Beds	1,160	4,000	54 Beds	2,120	7,000	500 m² + 30 m² x Number of beds
	Nursery			150	500		250	1,000	
Parks & recreation facilities	Neighborhood park		1 Location	-	20,000	2 Locations	-	40,000	
	Children's playground		2 Locations	-	5,000	5 Locations	-	12,500	
	Athletic field	O	1 Location	-	20,000	2 Locations	-	20,000	
	Gymnasium, clubhouse	O	1 Location	500	1,500	2 Locations	1,000	3,000	
	Recreation center (including cinema)	O		500	1,500		800	2,500	Other than cinema, meeting room, game room, concert hall, bar, etc.
Commercial service facilities	Bank		1 Shop	60	200	2 Shops	120	400	
	Supply	O		300	1,000		500	2,000	
	Market, shopping area			300	1,000		500	2,000	
	General stores, restaurants		10 Shops	1,200	2,500	20 Shops	2,400	5,000	(120 m²) per shop with living quarters
	Service maintenance shops		5 Shops	600	1,300	10 Shops	1,200	2,500	"
	Employees dining hall	O		150	500		300	1,000	
	Hotel		10 Rooms	800	2,500	20 Rooms	1,100	3,500	500 m² + 30 m² x Number of rooms
Administrative, management facilities	Town hall	O		100			150		
	Post and cable office	O		150	1,500		200	2,500	
	Police station, fire house			150			200		
	Management office		1 Shop	100		2 Shops	100 100		
Basic town facilities	Traffic facilities								
	Water supply	O							
	Sewage	O							
	Rain drainage	O							
	Electric power	O							
	Waste collection	O							

Fig. 6 - 14 Peruvian Educational System



Using the previous population estimates to find the number of school-age children, the figure will be roughly as follows:

		Proportion to Total Population	Number of Students	
			Case A	Case B
Kindergarten		0.06	190 (5 classes)	490 (12 classes)
Normal School	I CICLO	0.08	260	650
	II CICLO	0.04	130	320
	III CICLO	0.06	190	490
Total			580 (15 classes)	1,460 (37 classes)

Note: 40 students per class

Because the service-related population has been included in the mine town figures, the number of school-children at the beginning of operations will be about 2/3 of the above.

The number of classes in the normal school is not particularly fixed, but since a framework of 18 to 27 students classes is considered appropriate, in the event of case B, a basic system of two primary schools (I, II CICLO) centered around the two basic living spheres is desirable. Further, the middle school (III CICLO) can be attached to either of the primary schools and be used to service the entire town.

According to the educational level of the workers, a workers' school (ADULTOS LABORAL EDUCACION BASICA) is necessary, but it can make use of the ordinary school facilities. Also, in the future, facilities for a technical training school and high school, etc., should be studied.

(2) Cultural, religious facilities

According to law, besides the required church, building of a community center with a library, meeting hall, recreation room, workers' union office, etc. is specified. In the event of case B, a community center for each of the two neighborhoods will be built, and it is desirable to give one of the two the function of the facilities for the entire city.

(3) Public health, social service facilities

For the future town population, plans for a hospital with facilities based on one bed for every 150 residents is made. The hospital will be given the functions of a regular consultation area, emergency treatment center, and a public health center including consultation for medical and public health.

(4) Parks, recreational facilities

The residents' main forms of recreation are cinema and soccer games; a theatre and sports field-clubhouse facilities will be required. The theatre can be used for various purposes, and the addition of a game room, bar, restaurant, etc., is desirable, thus making it a recreation center.

(5) Commercial service facilities

Facilities for the sale of goods are operated by or contracted to the mining company (there are cases of the mining company and the workers' union cooperating to procure such necessities as foodstuffs, etc., subsidized by the company), and there will be a market operated by a general cooperative group (regular market or open air market) and general individually-run shops.

A bakery, auto repair, petrol stand, and maintenance service shops for construction, etc. will be required.

Finally, for guest facilities, construction of a hotel is being considered.

4. Costs of Mining Town Development

In recent years in Peru rapid inflation has continued. Looking at changes in home building costs for example, Fig. 6-15 shows that within the last two years (May, 1975 ~ March, 1977), construction costs have risen approximately 2.4 times. However, because the currency has been periodically devaluated, these rapid increases have no bearing on US Dollar or Japanese Yen calculations.

Based on the scale of mining town development and construction plans outlined previously, the cost of mining town development is shown on Table 6-21. Here, 1978 US dollar values are used for construction unit costs, and calculation of construction at that time is based on an estimated annual price rise of 7 per cent for the infrastructure and community facilities, which will be completed by 1984, and for the company housing, which will be completed by 1987.

In the cost of development, similar to the study of town facilities, the construction cost of housing is considered only for the Coroccohuayco mine company housing alone, and other cases are divided into two possibilities:

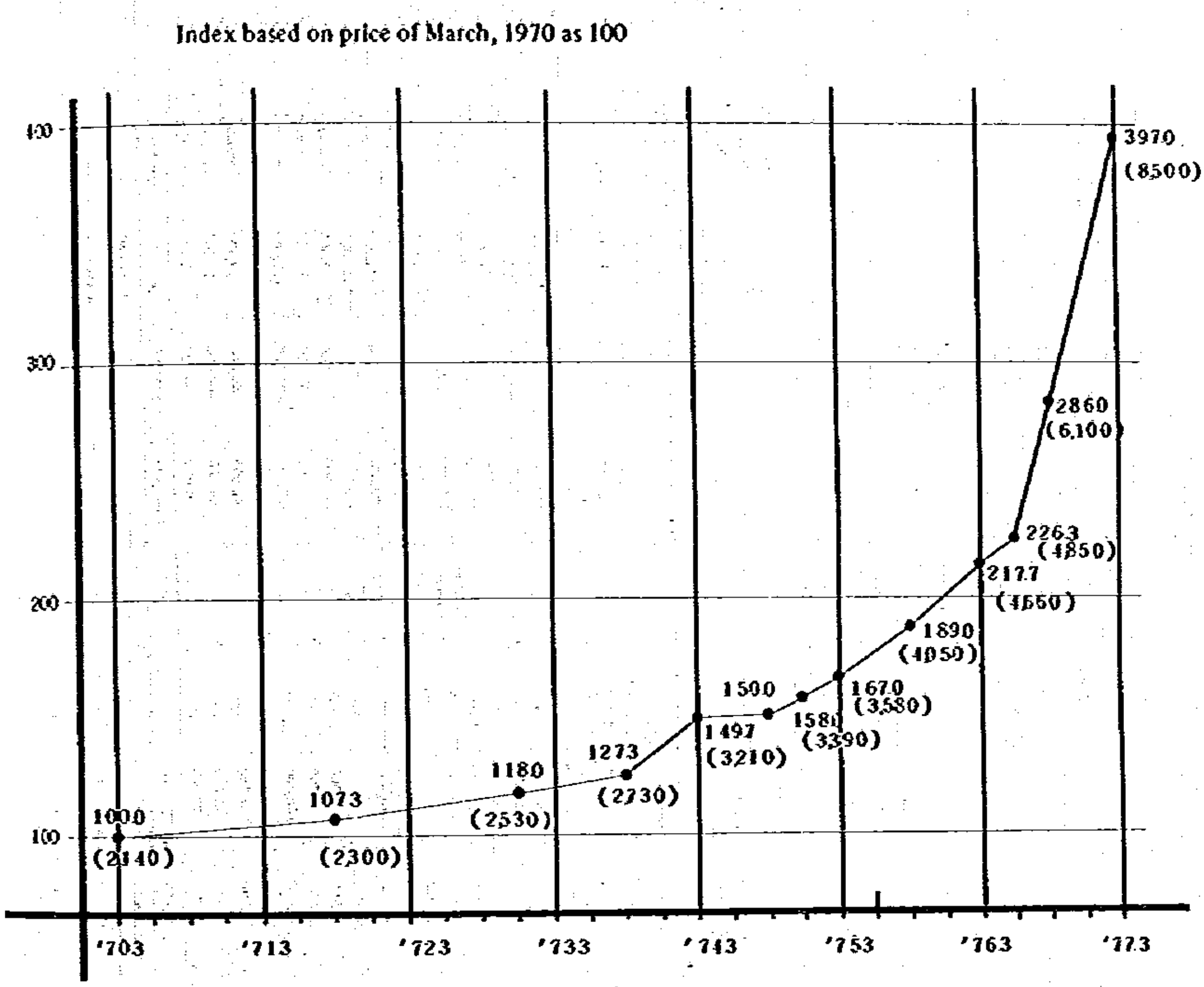
Case A: Construction of only a single town for the Coroccohuayco mine

Case B: Construction of a joint mining town for the Coroccohuayco and Tintaya mines

In the case B, the related costs of the Coroccohuayco mine are estimated to be 40 per cent of the total costs, based upon the ratio of employee population of both mines.

The development costs of this town do not include such infrastructure as roads, water supply, electric power, etc., as well as construction costs outside the town development area. (Example: water reservoirs and conduits, power generator and cables)

Fig. 6 - 15 Annual Changes in Housing Construction Costs in Peru



Note: ( ) indicates direct construction cost per square meter in soles.

Table 6 - 21 Chart of Mining Town Development Costs

		Facilities required at the start of operations	Case A Amount	Case A 1978 Unit price	Case A Amount 1978	Case A Amount Medium year
Land Acquisition Cost		O	ha 42.8	US$ 80	US$ 3,420	US$ 5,130
Mine infrastructure construction costs	Civil engineering (rough works)	O	42.8 ha	3,800	162,640	243,960
	Road construction	O	6.4 ha	46,000	294,400	441,600
	Parks	O	12.8 ha	19,000	243,200	364,800
	Drinking water & sewage	O	3,240	185.0	599,400	899,100
	Electric power	O	3,240	220.0	712,800	1,069,200
	Subtotal				2,012,400	3,018,660
Construction costs	Workers housing					
	Bachelors housing	O	3,375 m²	150	506,250	930,690
	1 Br quarters	O	1,920	190	364,800	670,650
	2 〃	O	17,424	190	3,310,560	6,086,130
	3 〃	O	9,945	190	1,889,550	3,473,750
	4 〃	O	1,400	190	266,000	489,010
	Subtotal				6,337,160	11,650,230
	Kindergarten	O	550 m²	180	99,000	148,500
	Normal school	O	2,150	180	387,000	580,500
	Normal school		450	180	81,000	-
	Church	O	200	320	64,000	96,000
	Community center		300	190	57,000	-
	Hospital, public health center	O	1,160	450	522,000	783,000
	Nursery		150	150	22,500	-
	Gymnasium, clubhouse	O	500	150	75,000	112,500
	Recreation center	O	500	270	135,000	202,500
	Bank		60	230	13,800	-
	Supply	O	300	120	36,000	54,000
	Market	O	300	120	36,000	54,000
	General stores, restaurants		1,200	150	180,000	-
	Service maintenance shops	O	600	150	90,000	135,000
	Employees dining hall	O	150	150	22,500	33,750
	Hotel	O	800	300	240,000	360,000
	Town hall	O	100	230	23,000	34,500
	Post and cable office	O	150	230	34,500	51,750
	Police station, fire house	O	150	230	34,500	51,750
	Management office	O	100	180	18,000	27,000
	Subtotal				2,170,800	2,724,750
	Total				10,523,820	
Development Costs of Start-of Operations					10,169,520	17,398,770

		Case B Amount	Case B 1978 Unit price	Case B Amount 1978	Case B Amount Medium year	Costs related to Corocoohuayco mine 1978	Costs related to Corocoohuayco mine Medium year	Remarks
Land Acquisition Cost		ha 106.2	US$ 80	US$ 8,500	US$ 12,750	US$ 3,420	US$ 5,130	Obtained from local interviews
Mine infrastructure construction costs	Civil engineering (rough works)	106.2 ha	3,800	403,560	605,340	162,640	243,960	• The road area is 15%
	Road construction	15.9 ha	46,000	731,400	1,097,100	294,400	441,600	• Including rainwater drainage
	Parks	31.9 ha	19,000	606,100	909,150	243,200	364,800	• The parks will be 30% including sportsground and plaza
	Drinking water & sewage	8,100	150.0	1,215,000	1,822,500	486,000	729,000	• In case B, the unit cost is 80% of case A
	Electric power	8,100	180.0	1,458,000	2,187,000	583,200	874,800	• Electric construction includes telephone system
	Subtotal			4,414,060	6,621,090	1,769,440	2,654,160	
Construction costs	Workers housing							All construction costs include furniture
	Bachelors housing					506,250	930,690	25 m²/person x 135 people
	1 Br quarters					364,800	670,650	60 m²/unit x 32 unit
	2 〃					3,310,560	6,086,130	72 m²/unit x 242 〃
	3 〃					1,889,550	3,473,750	85 m²/unit x 117 〃
	4 〃					266,000	489,010	100 m²/unit x 14 〃
	Subtotal					6,337,160	11,650,230	
	Kindergarten	1,240 m²		223,200	334,800	99,000	148,500	
	Normal school	5,020		903,600	1,355,400	361,440	542,160	
	Normal school	1,080		194,400	-	77,760	-	Amounts for service-related population included
	Church	400		128,000	192,000	51,200	76,800	
	Community center	600		114,000	-	45,600	-	
	Hospital, public health center	2,120		954,000	1,431,000	381,600	572,400	
	Nursery	250		37,500	-	15,000	-	
	Gymnasium, clubhouse	1,000	Same as Case A	150,000	225,000	60,000	90,000	
	Recreation center	800		216,000	324,000	86,400	129,600	
	Bank	120		27,600	-	11,040	-	
	Supply	500		60,000	90,000	24,000	36,000	
	Market	500		60,000	90,000	24,000	36,000	
	General stores, restaurants	2,400		360,000	-	144,000	-	
	Service maintenance shops	1,200		180,000	270,000	72,000	108,000	
	Employees dining hall	300		45,000	67,500	18,000	27,000	
	Hotel	1,100		330,000	495,000	132,000	198,000	
	Town hall	150		34,500	51,750	13,800	20,700	
	Post and cable office	200		46,000	69,000	18,400	27,600	
	Police station, fire house	200		46,000	69,000	18,400	27,600	
	Management office	200		36,000	54,000	18,000	27,000	
	Subtotal			4,145,800	5,118,450	1,671,640	2,067,360	
	Total					9,781,660		
Development Costs of Start-of Operations						9,488,260	16,376,880	

Note: For the medium year of operations, the basic maintenance costs and facility maintenance costs will be 1984, and for housing construction costs, 1987. In any case, the table shows costs at the start of operations.

Also, construction costs are divided into those that are necessary at the initiation of mine operations (within a three to five year period from the beginning of operations) and those which will be necessary to build thereafter, respectively.

The cost of town development related to the Coroccohuayco mine can be seen in Table 6-22.

The development cost of the Coroccohuayco mine town (at the time operations begin) will be 17,400,000 US dollars for case A, and 16,380,000 US dollars for case B, based on costs at the median of the operating period, and housing construction costs occupy 67 to 70 per cent of development. Also, case B is expected to lower the basic maintenance and facility construction costs by 20 per cent under those of case A. It goes without saying that by combining the development of the two mining towns, other economical results will be obtained in the construction costs of the areas not shown here, and in costs of support operation of facilities.

Table 6 - 22 Summary Chart of Development Costs

(Unit: 1,000US$, ( ): %)

Item	Case A		Case B	
	1978 Prices 1)	Cost at the Median 2) Year of Operation	1978 Prices 1)	Cost at the Median 2) Year of Operation
Cost of Land	3 (0.0)	5 (0.0)	3 (0.0)	5 (0.0)
Mine Infrastructure	2,012 (19.1)	3,019 (17.3)	1,769 (18.1)	2,654 (16.2)
Company Housing	6,337 (60.2)	11,650 (67.0)	6,337 (64.8)	11,650 (71.1)
Facility Construction	2,171 (20.6)	2,725 (15.7)	1,672 (17.1)	2,067 (12.6)
Total	10,524 (100.0)	17,399 (100.0)	9,782 (100.0)	16,377 (100.0)

Notes: 1) Total development cost
2) Development cost at the time of beginning of operations only

5. Recommendations for Further Detailed Studies

This study of planning shows the possibilities of joint construction of a mining town and town facilities; the joint development of the three mines of Coroccohuayco, Tintaya and Quechua, taking advantage of the merits of their integration, can develop a mining town that will contribute to the area's development. However, including the premises of these plans, in the process of moving onward to concrete, detailed plans there remain a number of problems which must be studied. We will itemize these points and make our proposition for the next detailed plan.

(1) Regarding the form of mining town development

In dealing with the joint development of the 3 mines, construction of mining towns, and town facilities, the merits of integration depend on agreement among the main operators, and on whether or not a system for town construction and support operations can be established. Also, it is important for each mine to be developed according to a suitable schedule in order to materialize. Especially, the development plans for the Tintaya mine have already entered the basic engineering stage, and if the other two mines lag behind, it is feared that adjustment will be difficult. It will be necessary, therefore, to study their related authority in the future.

(2) Regarding the enforcement of laws and regulations related to mining town development

As discussed previously, mines in Peru are classifed into three categories; large, medium and small, and the enforcement of laws and regulations concerning the plans for company housing and welfare facilities differ by category; but currently these standards are not strictly interpreted. Because in the future COPERMI is expected to establish more concrete standards, it will be necessary to proceed with caution. Also, as with the case outlined herein, it will be necessary to continue to study about various adjustments for the joint development of a mining town for a large- and medium-sized mine.

(3) Adjustment with regional planning

Presently the Republic of Peru is proceeding with a policy of long-term urban develop planning which will become the basis of regional development planning, and will soon enter the stage of drawing up concrete area planning. In compliance with this plan, the development plans for the town of Yauri will be decided, and must be coordinated with the mining town development plans.

(4) Regarding topographical and geographical surveys

This time the survey was based on a scale of 25,000:1, but by the time the next detailed plans are produced, a more detailed topographical survey and geographical survey will be required about the projected area of the mining town.

(5) Regarding development costs

As shown in the report, Peru is currently undergoing rapid inflation, and care must be given to this trend. Also, because in high mountain areas, costs of transportation of materials carry a large proportion of overall construction costs, sufficient study is necessary with regard to this point.

CHAPTER 7

GEOTHERMAL ENERGY DEVELOPMENT

CHAPTER 7 GEOTHERMAL ENERGY DEVELOPMENT

1. Outline of Geothermal Development in Peru

1-1 Geothermal Regions in Peru

The part of the circum-pan-Pacific earthquake belt in Peru has gained attention as a rich area of geothermal resources (Fig. 7-1). At present, there are famous active volcanoes including the Ubinus volcano and geothermal development has already gotten underway in El Tatio in northern Chile which is a geological continuation of the southern part of Peru. Geothermal surveys are also being conducted in Puchuldiza near Peru. This has raised interest in geothermal development in Peru as a source of energy, and local research including collection of basic materials by organizations such as Ingeomin is now being undertaken.

The results of nation-wide surveys and studies on hot springs and other types of springs have resulted in the classification of six geothermal areas in Peru as shown in Fig. 7-2. There are many potential geothermal sites in areas V and VI in this figure.

Fig. 7 - 1 Main Geothermal Regions of the World

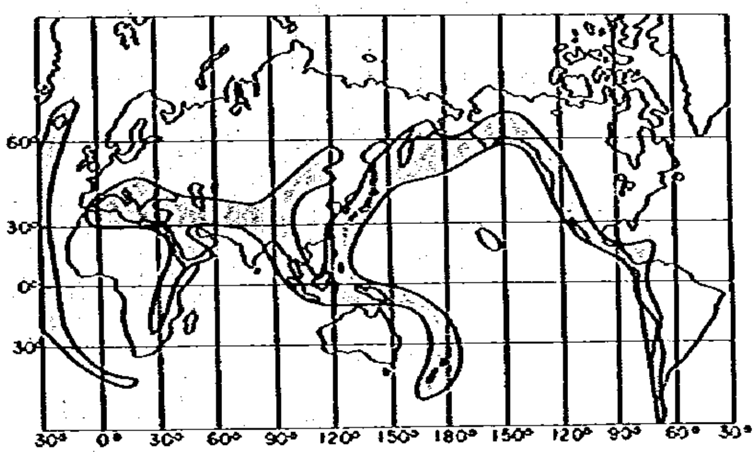
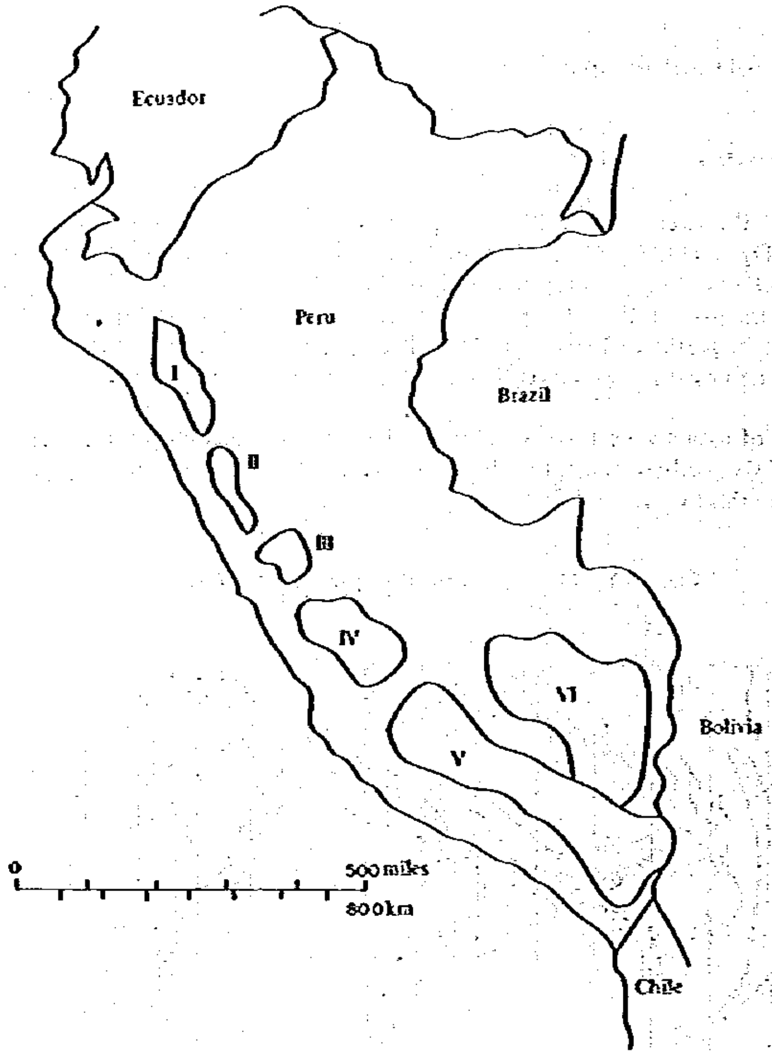


Fig. 7 - 2 Geothermal Regions in Peru



1-2 Geothermal Areas Surveyed

The five areas shown in Fig. 7-3 were found to be potential geothermal sites in the vicinity of the project areas in the southern part of Cuzco Department. A general survey of these areas was carried out by the Geothermal Technical Development Co., Ltd. of Japan in 1976 and comparisons among the various areas were reported.

According to this survey, the Quisicollo and La Raya regions show the greatest potential for geothermal development. The spring temperatures in the San Pedro and Uyurmiri regions are low and they show no geological potential. In a comparison of the Quisicollo and La Raya regions, estimates of the underground temperature in the La Raya region by means of chemical thermometers were excellent, and the Quisicollo region was shown to be very good with respect to the quantity of radiant heat and the location conditions. There were also records of eruption of hot water and alteration in the Macarara and Rio Jarma regions which adjoin the Quisicollo region and it appeared that these regions should also be surveyed. Based on these results, the most recent surveys were centeled on the Macarara and Rio Jarma regions.

1-3 Geothermal Development System in Peru

The Peruvian Government has still not established any particular system for geothermal development. However, considerable interest is being shown in local energy resources and Ingeomin has started a nation-wide survey of such resources. Electro Perú and Minero Perú are also studying geothermal development based on their respective viewpoints.

Although they have not participated in the surveys mentioned above, the technology of such organization as Petro Peru will be necessary in future work including surveys and borings.

2. Prospects for Geothermal Utilization in the Power Generation and Other Fields

2-1 Geothermal Power Generation

Italy started using geothermal steam for power generation in the Larderello region in 1906 and before the Second World War, Italy was already generating 135 MW by such means. After the war, technical exchanges increased and progress was made in survey methods. Various countries undertook and planned geothermal power generation to meet increasing energy demands. As shown in Table 7-1, the capacity of geothermal power facilities had reached 1,500 MW as of 1976 and was tending to increase as of 1976.

Fig. 7-3 Index Map of the Project Areas

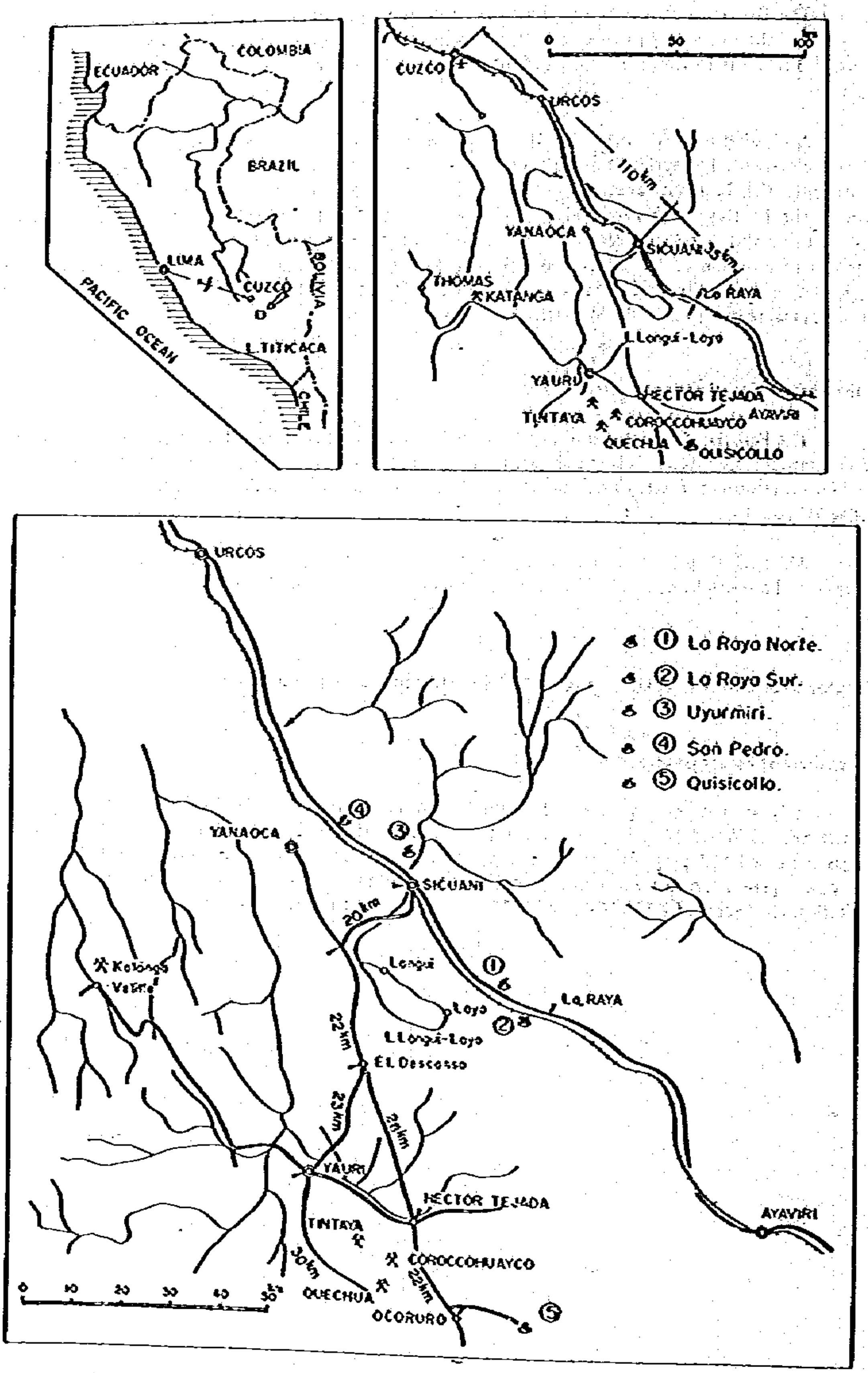


Table 7 - 1 List of Geothermal Power Plants throughout the World

As of June, 1976

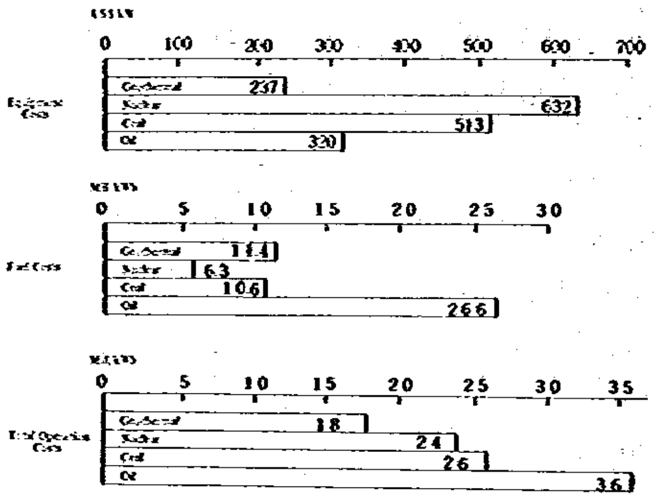
Country	Site	Existing Output (1,000 kw)	Under construction or planned (1,000 kw)	
Italy	Larderello	380.6		
	Monte Amiata	22.0		
	Others	15.0		
	Total	417.6		
Japan	Matsukawa	22.0 (Figures in parentheses show output for partial operation)	Kakkonda	50.0
	Otake	11.0 (7.5)	Hachoboru	50.0
	Onuma	10.0	Mori	50.0
	Onikubi	25.0 (12.5)		
	Total	68.0		150.0
New Zealand	Wairakei	192.6	Broadlands	200.0
	Karewa	10.0	Waiotab	564.0
	Total	202.6		764.0
Mexico	Para	82.0	Mexicali	295.0
	Cerro Prieto	75.0		
	Total	157.0		295.0
U.S.A.	Geyser	522.6	Geyser	406.0
			Imperial Valley	65.0
			Battle Mountain	10.0
	Total	522.6		481.0
Iceland	Namafjel	3.0	Namafjel	3.0
	Hengil	17.0	Kulafula	60.0
	Total	20.0		63.0
France			Guadaloupe (Island in the Caribbean Sea)	30.0
Kenya			Nairobi	15.0
U.S.S.R.	Pauzhetsk	5.0	Pauzhetsk	95.0
	Paratunka	0.7	Kunashiri	6.0
			Abatimskaya	30.0
	Total	5.7		131.0
Taiwan			Matseo	10.0
India			Lie	50.0
Indonesia			Kamodjang	30.0
			Dieng	5.0
			Total	35.0
Philippines			Trai	220.0
			Los Baños	220.0
			Total	440.0
Nicaragua			Momotambo Others	175.0
El Salvador	Ahuachapan	60.0	Ahuachapan	60.0
Chile			El Tatio	20.0
Total		1453.5		2119.0

Note: In addition, detailed surveys are being conducted in Greece, Ecuador, Algeria, Yugoslavia, China, Peru, Guatamala, Costa Rica and Colombia.
Source: Ministry of International Trade and Industry of Japan, etc.

The total geothermal power generation capacity still only accounts for 0.1% of the total. According to D.E. White, at least 530,000 MW of power can be supplied over a 50-year period just by geothermal fluid resources at 3 km or less in depth. Geothermal areas in various countries are becoming highly interesting as available energy resources.

The costs of geothermal power generation are not excessive when compared with other types of energy, and sufficient profit can be obtained from a comparatively small capacity generating plant of 10 ~ 30 MW. Comparative costs of power generation are shown in Table 7-2.

Table 7 - 2 Comparison of Power Generation Costs



In all cases, the power generation systems [Fig. 7-4 (a), (b) and (c)] utilize steam obtained from hot water or underground dry steam. Research is underway on new systems such as the multi-flush system [Fig. 7-4 (c)] and a steam power generating system utilizing media with low boiling points [Fig. 7-4 (d)]. Such systems have been partially put into operation and are resulting in a decrease in the power generation costs.

The accuracy of surveys is being improved by means of the accumulation of data obtained from geothermal surveys performed in various countries. This will also lower the cost of power generation.

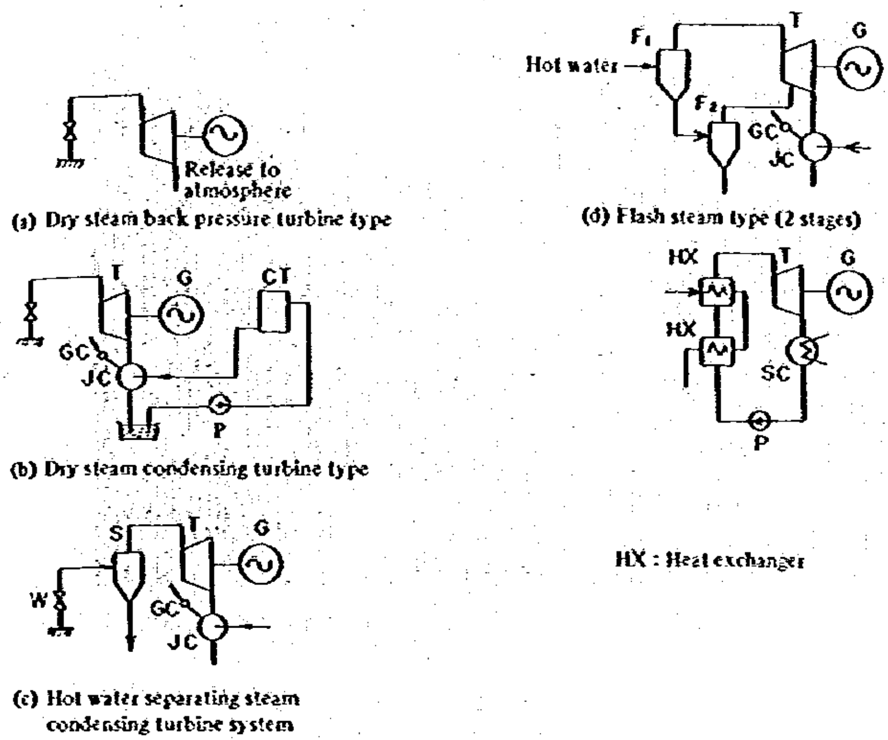
2-2 Agricultural Utilization

There are many examples of geothermal utilization in agriculture, especially in the cold country of Iceland, in Hungary with its continental climate and in the Soviet Union. In Japan, there are also large numbers of agricultural research facilities, plant farms, etc. utilizing hot springs, but they are all on a small scale.

In Hungary there are no volcanoes and the land is flat, but in the southeastern part of the country, there is a high heat glow and there is widespread hot water at a temperature of 50 ~ 90°C 2,000 m underground. From 1963, the Hungarian Government recommended that this heat be put to use in agriculture and as a result, hot water was being used in cultivation in 550,000 m² of glass and 1,200,000 m² of vinyl greenhouses by 1972. This heat was also being used for pig and chicken raising and for refrigeration, and 20,000 tons of hot water per hour are being pumped up from about 500 deep wells. The hot water is utilized in a two-stages system in which low temperature hot water is used to heat the soil in vinyl greenhouses after being used to heat glass greenhouses. As a result of this geothermal utilization, it has become possible to regulate vegetable shipments in Hungary and to export to various countries in northern Europe.

Since the areas which are the objects of this survey are all at a high altitude, there are remarkable differences in temperature and there is a major possibility of geothermal utilization in agriculture.

Fig. 7-4 Generation Systems for Geothermal Power Plants



W : Well T : Turbine JC : Jet Condenser P : Pump F : Flush tank HX : Heat exchanger S : Steam/water separator
G : Generator CT : Cooling tower SC : Steam compressor GC : Surface condenser DG : Degassing equipment

2-3 Utilization for Heating, etc.

Geothermal hot water is also widely used to heat homes. The largest scale example of this is in Reykjavik, the capital of Iceland. Heating is necessary throughout the year and geothermal hot water has been supplied to ordinary houses since 1928. At present, geothermal hot water is used for heating Reykjavik and its suburbs with a population of about 100,000. The people in the city use almost no other types of fossilized fuels.

One example of geothermal utilization in home heating from the standpoint of energy conservation is the heating of 2,500 homes in Melun, a suburb of Paris. In this case, only 90 tons of hot water per hour at a temperature of 70°C can be obtained from a single geothermal well and this covers only about 10% of the heat required at peak periods. Since only geothermal heat is sufficient in summer for hot water supplies, the system is such that one-third of the annual heat requirements can be supplied geothermally (Figs. 7-5 and 6).

Such as system is comparatively easy to establish if conditions are controlled.

Since there are many hot springs in various parts of Peru, such areas should be investigated in the future. The areas currently surveyed could be included in the plan for the mining city development region if a heat source can be obtained, but the economy of the project must be investigated if long distances are involved.

Well-known examples of geothermal utilization in other industries include a pulp factory in New Zealand and a diatomite factory in Iceland. Fig. 7-7 shows various applications for geothermal utilization systems. The applications will be wide ranging if matches can be made with location conditions.

Fig. 7 - 5 Melun Heating System

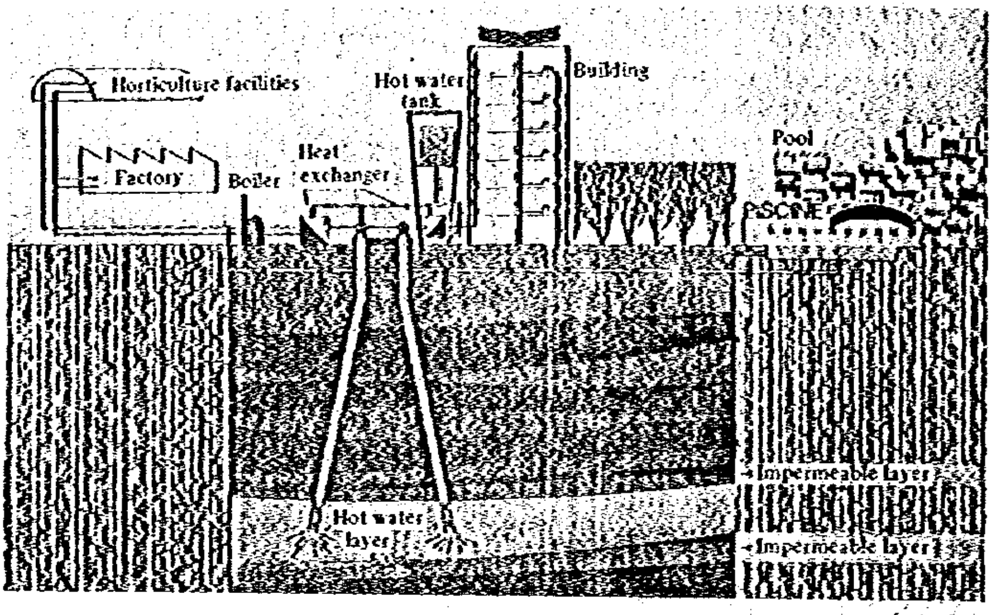


Fig. 7 - 6 Melun Regional Heating Load

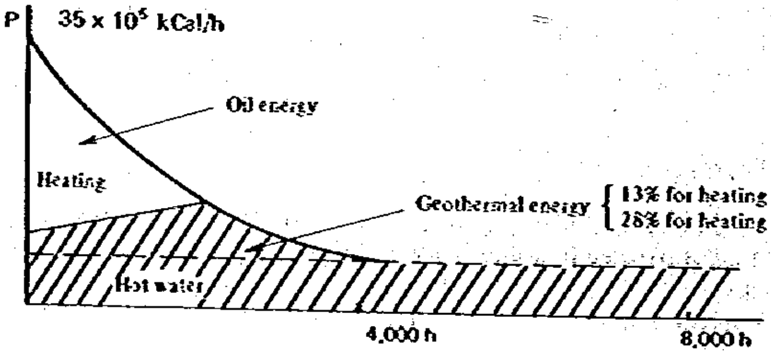
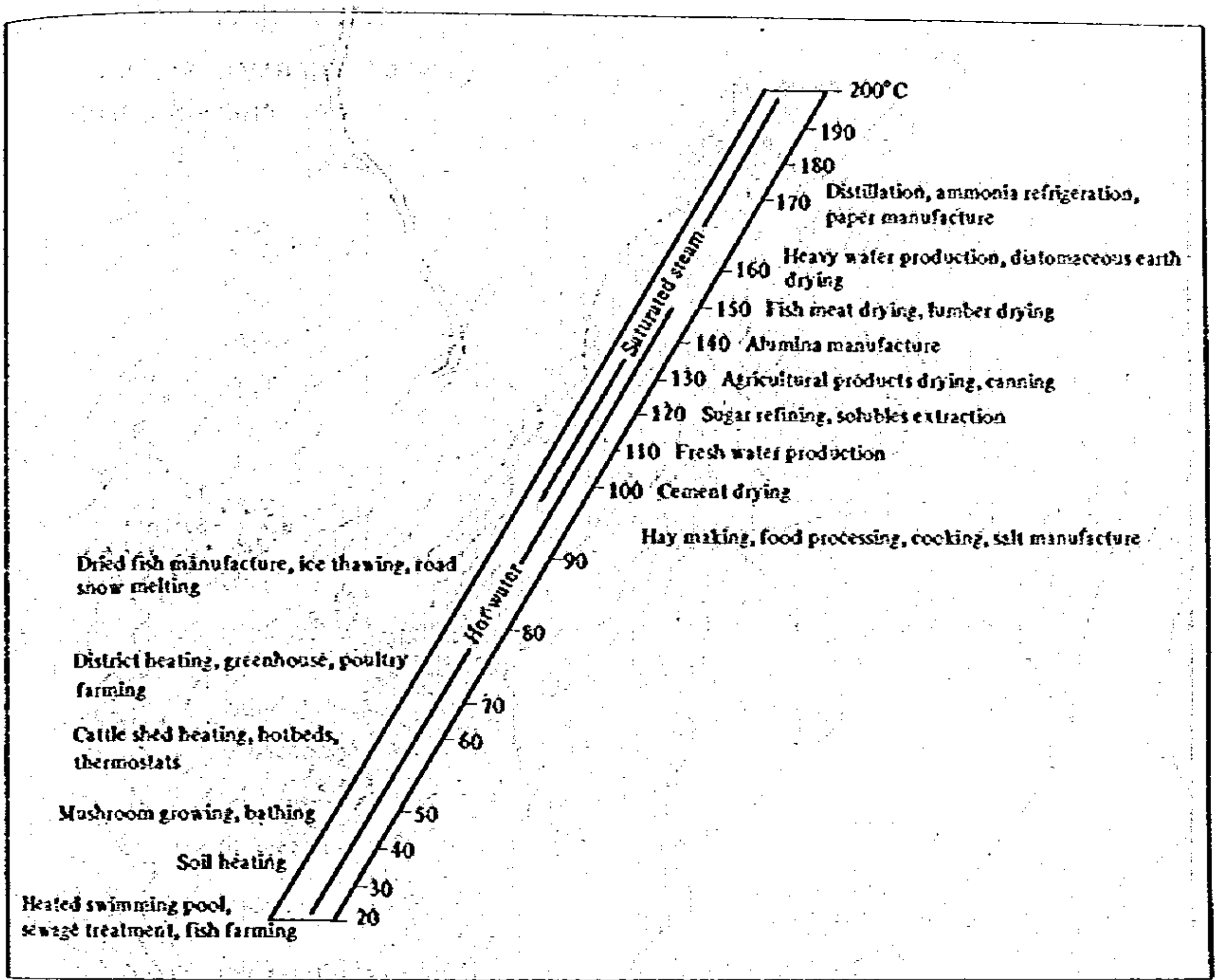


Fig. 7 - 7. Geothermal Fluid Utilization according to Temperature



3. Geothermal Survey of the Potential Area

3-1 Location and Local Conditions

The project area is in the western Andes mountains in the southern part of Peru and belongs to Ocoruro town, Espinar Province, Cuzco Department. The center of the project area is located at 71°02' west longitude and 15°05' south latitude. It consists of grasslands at an altitude of about 4,100 m and an adjacent hilly region at an altitude of 4,400 m.

The area is about 30 km in a straight line from the Coroccohuayco and Quechua mines and about 40 km from the Tintaya mine. The region is almost completely flat with no large obstructions.

The weather is of the cold highland type and there are rainy and dry seasons which are affected by seasonal winds. The annual average temperature is less than 10°C and the precipitation is about 900 mm per year. Table 7-3 shows meteorological data from the La Raya region.

The area is cut by a trunk road from Ocoruro and the town of Qusicollo is located on the plain about 10 km to the east. It is a potential geothermal area with hot springs and areas of metamorphosis. In this report, the areas are referred to as the Rio Jama, Macarara and Qusicollo areas from the north (Fig. 7-8).

Fig. 7 - 8 Location Map of Geothermal Showings, Quisicollo Area, Southern Cuzco, Peru

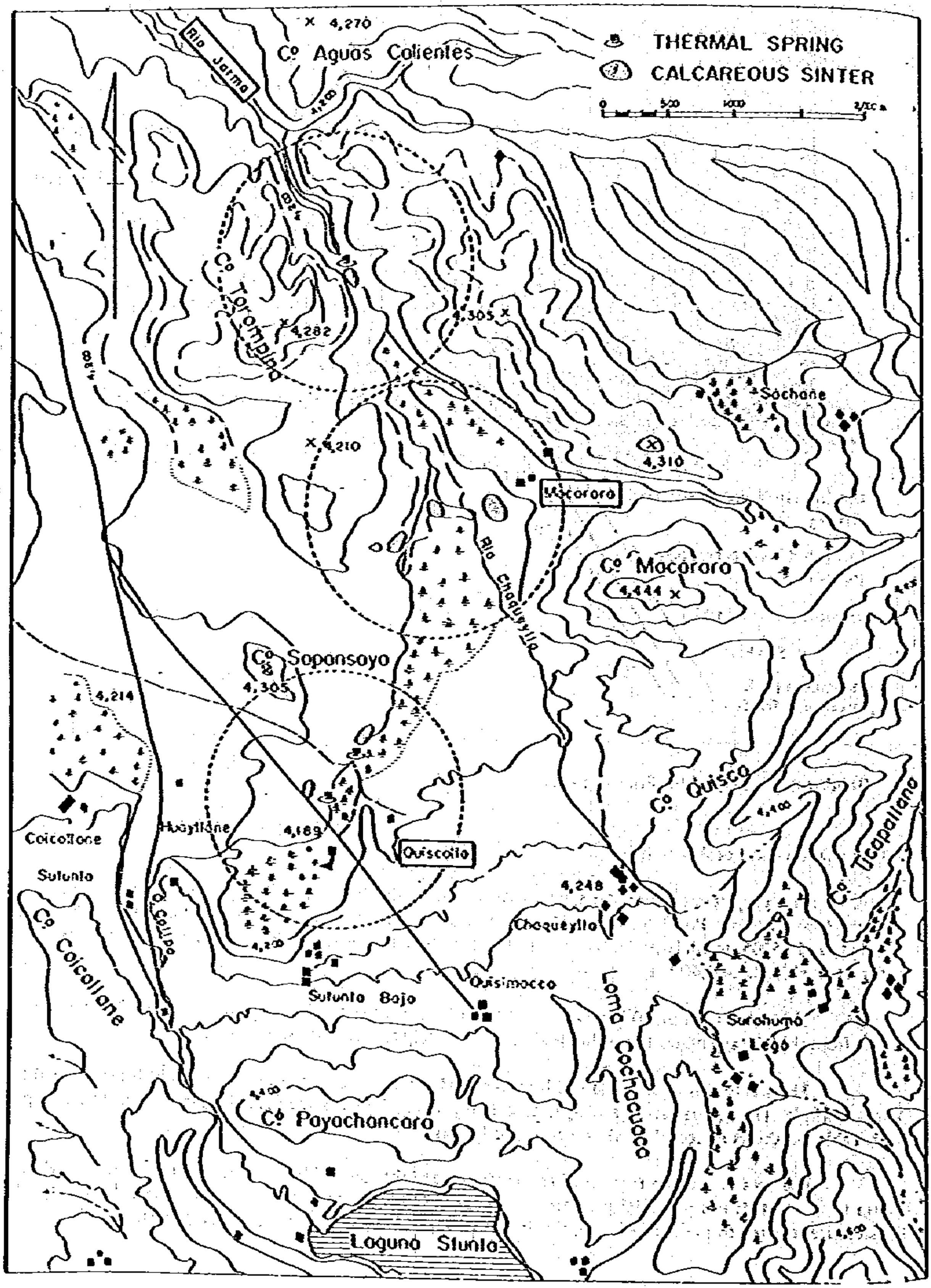


Table 7 - 3 Climate in the Raya Pass Region

(Average values of most recent three year data from Agricultural Research Station)

	Average air temperature (°C)		Precipitation (mm)
	Max.	Min.	
Jan.	12.9	1.3	185.6
Feb.	13.3	2.1	167.2
Mar.	13.9	1.9	167.6
Apr.	13.9	0.1	65.8
May	14.4	–2.9	14.9
June	13.4	–4.9	2.5
July	13.7	–5.5	2.5
Aug.	14.3	–4.4	14.3
Sept.	14.9	–1.7	30.9
Oct.	15.4	–0.8	35.4
Nov.	15.4	–0.4	55.1
Dec.	13.9	1.1	122.2
Annual average	14.0	–1.2	864.0

3-2 Geology and Structure

3-2-1 Geological Characteristics of the Region Near the Project Areas

The large Yauri valley spreads to the northwest including the project areas. Yauri lacustrine deposits are scattered throughout the Yauri valley and there is a straight boundary in the NNW – SSE directions on the eastern and western edges. It is suggested that the Yauri valley was formed by a cave-in due to a fault. This distribution is limited by an almost linear boundary in the WNW – ESE direction also on the southern edge.

The western, southern and southeastern sides of the Yauri valley are all covered with tertiary and quaternary valcanic rock. The northern and northeastern sides have cretaceous Ayabacas limestone strata and tertiary Puno conglomerate, sandstone, rock strata. Near the southwestern ends of the Yauri valley, there is diorite and because of this there are various mines in this area including the Atalaya, Tintaya, Corocсohuayco and Quechua mines.

The project area is located at the southeastern end of the Yauri valley and is in contact with the boundary between the valley and the eastern Laramani mountain pass. The Laramani mountain pass consists mainly of cretaceous Ayabacas limestone strata and tertiary Puno conglomerate, sandstone and rock strata. At the boundary, there is some Tacaza volcanic rock coming out in the tertiary pliocene.

The Yauri lacustrine deposits in the Yauri valley consist mainly of strata of white tuff which developed from thin stratification. The age measured by K/Ar was found to be 5×10^6 years (early pliocene age).

3-2-2 Sedimentary Rock

(1) Moho stratum (Ayabacas limestone stratum)

A mesozoic cretaceous limestone stratum is mainly exposed in the center of the project area. This strata was compared with the Ferrobamba limestone strata on the west side of the Yauri valley, but it was considered to be an Ayabacas limestone strata originating from a reef or the seashore according to the fossils.

This stratum normally consists of lumpy dense limestone, with almost no changes in the rock quality. The limestone is mainly grey, dark grey or bluish grey, but part of it is light grey or white. The limestone consists mainly of recrystallized polymorphic calcite, but there are also minute amounts of dolomite and quartz included throughout. There are often small lumps of chert type coagulated material included and rarely light-grey sandy limestone or black limestone-type hard rock.

In the project area, there are some changes in the surfaces of this stratum in each block, but it shows a sharp incline with a strike of N–S ~ NNW–SSE–W.

(2) Yauri lacustrine deposits (Descanso and Yauri strata)

This stratum is neotertiary pliocene lacustrine stratified rock consisting of an upper layer (Descanso stratum) and lower layer (Yauri stratum).

In the project area, the deposits are located in the grasslands which occupy the western half. The Descanso stratum is along the Laramani mountain pass and the Yauri stratum is in the center of the grasslands.

The Descanso stratum is divided into three layers. The bottom layer consists of alternate layers of sandstone and conglomerate; the middle layer of acidic tuff or tuff-like sandstone; and the upper layer of tuff-like sandstone and tuff-like silty rock in alternate layers. The stratification surface is slanted very slightly at less than 5° and the stratum is 60 ~ 250 mm thick.

The Yauri stratum consists of alternate layers of tuff, tuff-like silty rock, tuff-like sandstone, limestone like silty rock and limestone-like sandstone covering the Descanso strata with parallel unconformity. In part of this stratum, there is base conglomerate interspersed with carbon compounds.

In the project area, very little of this stratum is exposed and it is difficult to separate the Descanso and Yauri strata.

(3) Glacial deposits

These deposits were formed in the pleistocene glacial age. In the project area, they are found on the Laguna Sutunta north shore in the southern part and in the Cerro Agua Caliente – Cerro Susua in the northern part.

These deposits are mainly volcanic conglomerate which strongly reflects the local characteristics of the project area. They also include glacial deposits with limestone conglomerate and quartzite conglomerate, and deposits from melting ice. The deposits from melting ice flowed down and became buried in the base of the glacier and at an altitude of about 4,200 m, small scale out-wash planes have formed.

(4) Alluvial deposits

There are layers of gravel deposited in the riverbed along the Rio Jarma which flows from south to north in the center of the project area and there is sandy mud in the nearby wet area.

In the boundary area between the Yauri valley and the Laramani mountain pass, some fan-shaped terraces of gravel layers are found in places.

3-2-3 Volcanic Rock

The volcanic rock consists of typical types such as early tertiary eocene rough andesite and agglomerate. They are correspond to the middle layers of the Tacaza strata.

In the project area, these rocks are found in almost the entire eastern half. In addition to brownish-purple or greyish-brown rough andesite and agglomerate, there is an interspersion of sandstone and other types of rock mainly of volcanic origin.

Alkaline basalt-type lava from the center layers of the Tacaza strata collected at Cerro Chuspine in the Laramani mountain pass located in the northern extension of the project area was found to be 55×10^6 years old by K/Ar measurements.

On the outer southern side of the project area, there is volcanic rock consisting of quaternary pleistocene andesite, basalt, agglomerate, etc. This volcanic rock has an almost flat stratification surface, while that in the project area changed remarkably from slightly to sharply slanting. The strike also showed big changes in each block.

3-2-4 Geological Structure and Alteration Action

There is a structural line extending in the NNW – SSE direction near the Rio Jarma in the northern part of the project area. There is a protrusion of volcanic rock regulated by this structural line. Part of this structural line is still active after the protrusion of volcanic rock which indicates that there is fault breccia including volcanic rock in the fault along the river to which this structural line belongs.

The fault along the river separates from the Rio Jarma near the Jarma hot spring and turns to the NNE – SSW direction.

In the center of the project area, there is a graben structure opening towards the south. The graben part is a grassland and there are alluvial deposits. A fault in the E–W ~ NE–SW direction which cuts these N–S structural lines develops after about 1 km.

The various geological blocks marked off by the faults in the N–S and E–W directions each have different slopes and there are many cases where the stratification surfaces between the blocks are not continuous.

The area showing geothermal characteristics develops at the site where the faults in the N–S and E–W directions cross. There is a hot spring at the bottom of the Rio Jarma at the point where the NNE-SSW fault which forms a boundary between the Ayabacas limestone stratum and the volcanic rock in the Rio Jarma region and the NNW–SSE fault which extends along the Rio Jarma meet. Nearby, there is calcareous sinter. There are fine veins of clacite in the limestone near the hot spring, but none in the volcanic rock. No other altered minerals which are visible geothermal showings were found.

In the Macarara region, there is wide-ranging calcareous sinter in the place where the N–S ~ NW–SE fault which forms a graben structure and the ENE–WSW fault which intersects the first fault cross.

Calcareous sinter appears to be formed mainly at the points of intersection of faults, and is distributed at three different points in the west, center and south. From an evaluation of the distribution range and scale, there is a possibility that there was predominant geothermal activity from the Quisicollo region in the south in the past.

There are small outcroppings of volcanic rock at various points near the calcareous sinter, but there were no altered ores which could be considered as visible geothermal showings.

In the Quisicollo region which was surveyed in 1976, there were several hot springs with calcareous sinter upstream in the Rio Jarma, but there were no outcroppings in the vicinity and no relation could be found between the geological structure and geothermal showings. However, temperature distribution measurements at a depth of about 1 m showed that there are high temperature regions on an extension of the N–S fault and since it extends in the NE–SW ~ E–W directions, geothermal showings appear to be formed mainly at the intersection point between the N–S fault which forms the graben structure and the NE–SW fault which intersects it.

Materials were sampled from the areas showing geothermal characteristics and the ores were identified by X-ray analysis. The results are shown in Table 7-4. (Refer to Fig. 7-9 for the sampling locations.)

From these results, it is suggested that calcereous sinter is formed in the geothermal regions and there were large numbers of hot springs formed although they can not be found now.

The following sections describe typical rocks and their structures in the project area. The sampling locations are shown in Fig. 7-9. (Appendix)

Figs. 7-10, 11 (Appendix) and 12 are the geological and sectional figures mainly for the Rio Jarma and Macarara areas, but also including the Quisicollo area.

Table 7 - 4 Results of Powder X-ray Analysis of Specimens from Geothermal Showings in the Macarara Region

Sample No. / Ore	X-F 1	X-F 2	X-F 3	X-F 4	X-F 5	X-F 6	X-F 7	X-F 8	X-F 9	X-F 10	X-F 11	Components
Plagioclase	◎			△	×	×				△		$NaAlSi_3O_8 \cdot CaAl_2Si_2O_8$
Orthoclase	◉							○		×		$(K\ Na)Si_3O_8$
Quartz	◎	×		△	×	△	△	○	×	△	×	SiO_2
Calcite		◎	◎	◎	◎	◎	◎		◎	◎	◎	$CaCO_3$
Aragonite										○		$CaCO_3$
Halite		△	△				◎	◎		◉		$NaCl$
Gypsum			○				○	○		○		$CaSO_4 \cdot 2H_2O$
Soda alum								○				$NaAl(SO_4)_2 \cdot 12H_2O$
Kaolinite	△											$Al_2Si_2O_5(OH)_4$
Halloysite								○				$Al_2O_3 \cdot 2SiO_2 \cdot 4H_2O$
Natrojarosite								△				$NaFe(SO_4)_2(OH)_6$
Searlite								△				$NaBSi_2O_6 \cdot H_2O$

◎ .... Very large amounts

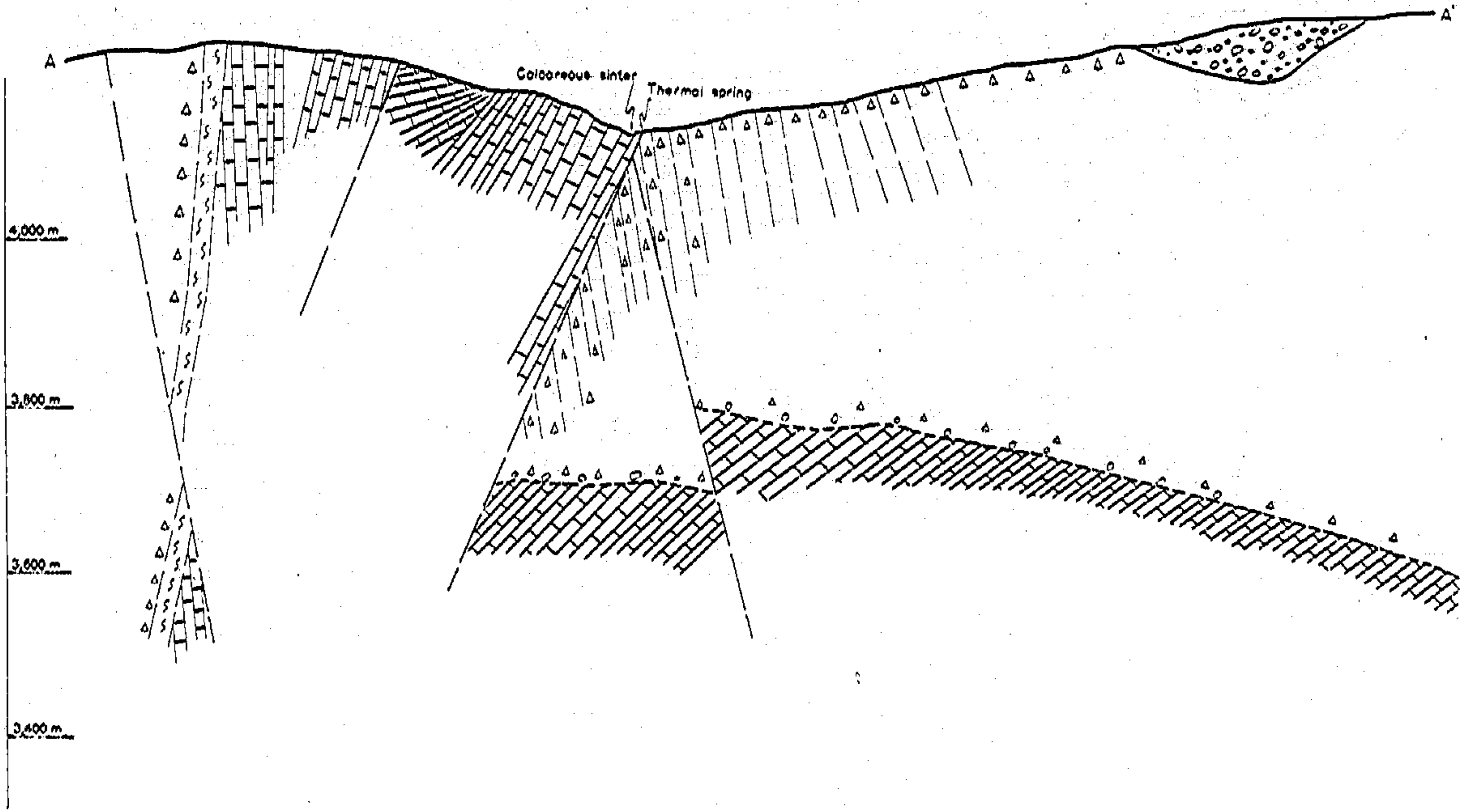
◉ .... Large amounts

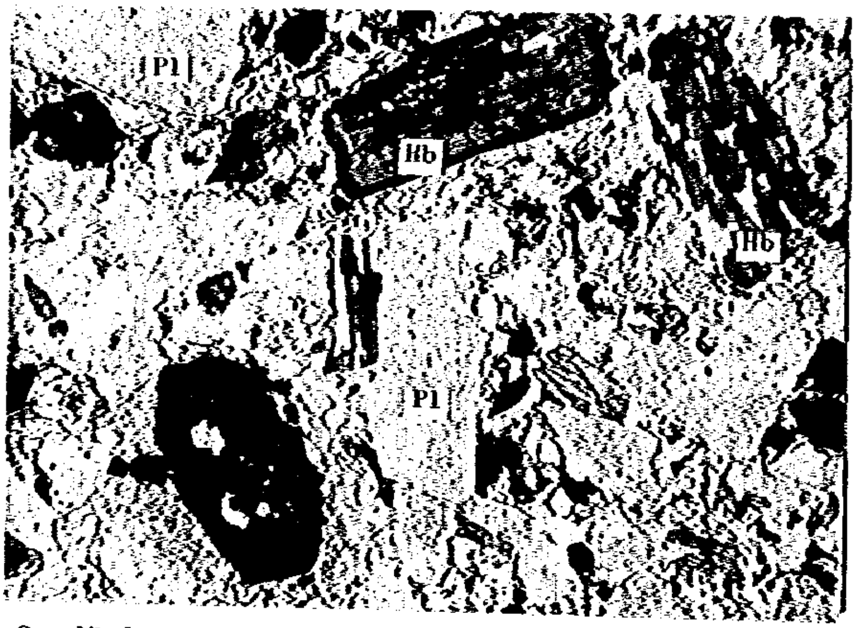
○ .... Usual amounts

△ .... Small amounts

× .... Traces

Fig. 7 • 12 Sectional Map of Geothermal Area





Open Nicol

0 0.5 mm

Lithic-crystalline tuff

Hb : Hornblende
Pl : Plagioclase

Crossed Nicol

0 0.5 mm

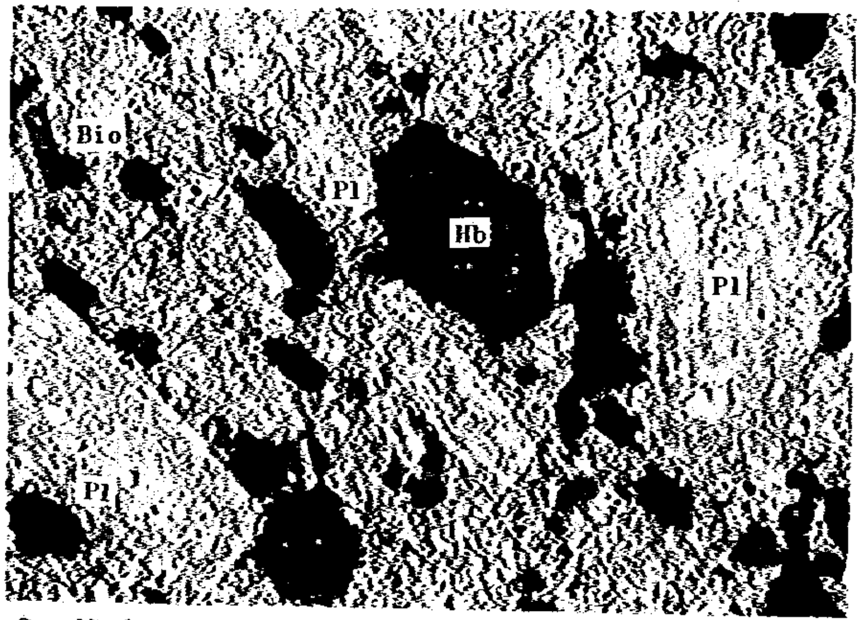
Lithic-crystalline tuff

YF-1 Lithic crystalline tuff

Macroscopically, this is reddish purple andesitic coarse tuff. Microscopically, it contains many fragments of andesitic – porphyritic rock, as well as crystalline tuff.

The main structural minerals are plagioclase, hornblende and quartz. Accessory minerals include microcline, clinopyroxine and calcite. There was almost no volcanic glass and the matrix was imbedded mainly with carbonates, fine quartz and feldspar.

Plagioclase:	1.5 ~ 0.5 mm in size, idiomorphic – hypidiomorphic. Carlsbad twins and albite twins developed. Subjected to sericitization.
Hornblende:	1.0 ~ 0.5 mm in size, idiomorphic – hypidiomorphic. Tabular. Light green to brownish green. Remarkable pleochroism and anistroism, and two-directional cleavage. The crystal margin is replaced by means of ferrous oxide.
Quartz:	0.3 ~ 0.1 mm in size, anhedral. There are many cases of comparative rounding; irregular forms are also seen.
Fragments:	2.0 mm in average size, reaching a maximum of 4.0 mm. The most common rocky fragments are (clinopyroxine) hornblende and andesite. Some of these fragments has a flow structure. There are also a few porphyritic fragments.



Open Nicol

0 0.5 mm

Porphyrite

Bio : Biotite
Hb : Hornblende
Pl : Plagioclase

Crossed Nicol

0 0.5 mm

Porphyrite

YF-2 Porphyrite

Macroscopically, this rock is a grey to light reddish-purple porphyrite or andesite with a weak flow structure. Microscopically, there is plagioclase, hornblende and calcite in the form of phenocrysts with a porphritic texture. The ground mass consists of plagioclase, hornblende, calcite and a fine crystalline substance (quartz).

Phenocrysts

Plagioclase: 2.0 ~ 0.5 mm in size, idiomorphic – hypidiomorphic.
Carlsbad and albite twins and a zonal texture.
Small particles of sericite and calcite are included and contamination with a fine glassy substance is seen in the margin areas.

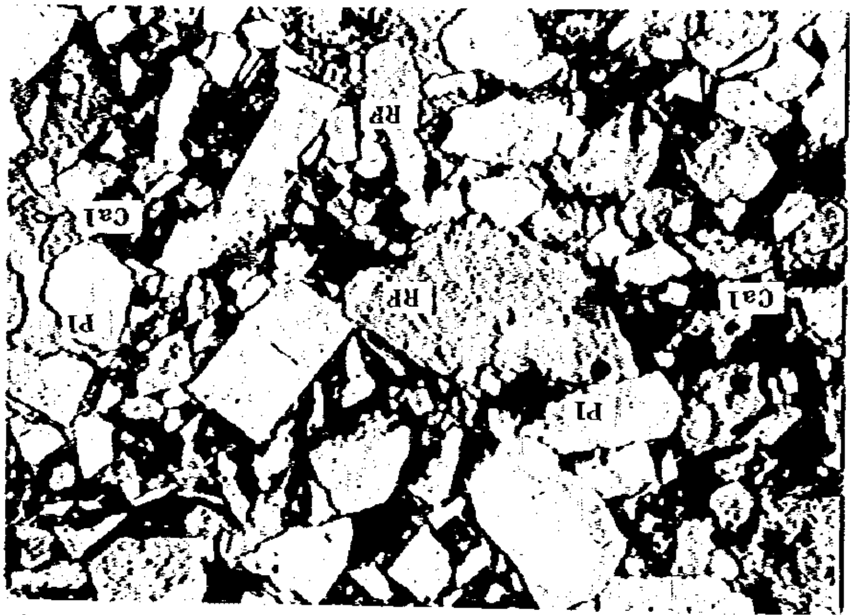
Hornblende: 1.0 ~ 0.5 mm in size, idiomorphic – hypidiomorphic.
Tabular – diamond shaped; liver brown to orange-brown in color. Remarkable pleochroism and anisotroism. Margin replaced by carbonates or ferrous oxides. Opacite margin observed. Complete replacement in side the crystals observed in some cases.

Ground mass

Plagioclase: 0.1 ~ 0.05 mm in size, idiomorphyic – hypidiomorphic.
Albite twins and zonal texture. As in the case of the plagioclase, the inside of the crystals is contaminated with inclusions such as calcite and clay minerals.

Calcite: 0.1 mm in size, anhedral with mafic minerals embedded in the crystal margin area and between the crystals.

YF-4



Open Nicol

0 0.5 mm

Lithic-crystalline tuff breccia

Cal : Calcite
Pl : Plagioclase
RF : Rock Fragment

Crossed Nicol

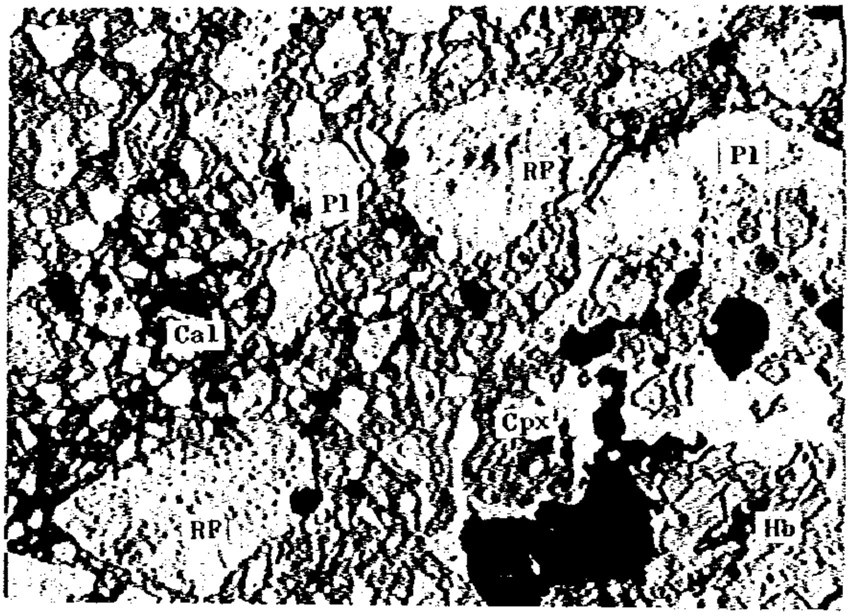
0 0.5 mm

Lithic-crystalline tuff breccia

YF-4 Lithic-crystalline tuffacious breccia

Macroscopically, this is brown – reddish-brown tuffacious breccia. Microscopically, it has a pyroclastic texture with many andesitic fragments included. The structural minerals are plagioclase, quartz, calcite, biotite, clinopyroxine and ferrous oxide.

Plagioclase:	1.5 ~ 0.2 mm in size, idiomorphic – hypidiomorphic. Many are crushed and irregular. Carlsbad and albite twin crystals and zonal texture. Calcite included in crystals.
Quartz:	0.5 ~ 0.2 mm in size, anhedral. Comparatively advanced rounding. Quantitatively much less than the plagioclase.
Biotite:	0.5 ~ 0.3 mm in size, idiomorphic – hypidiomorphic. Tabular or lath-like. Remarkable pleochroism and anisotroism. Some replacement by ferrous oxide.
Calcite:	0.5 ~ 0.2 mm in size, anhedral. Filling seen between matrix and crystal granules.
Rock fragments:	4.0 x 3.0 ~ 0.3 x 0.2 mm in size. Subrounded – breccia in shape, but quantitatively, more subrounded. Most of the rock is andesitic. Also some dioritic rock fragments.

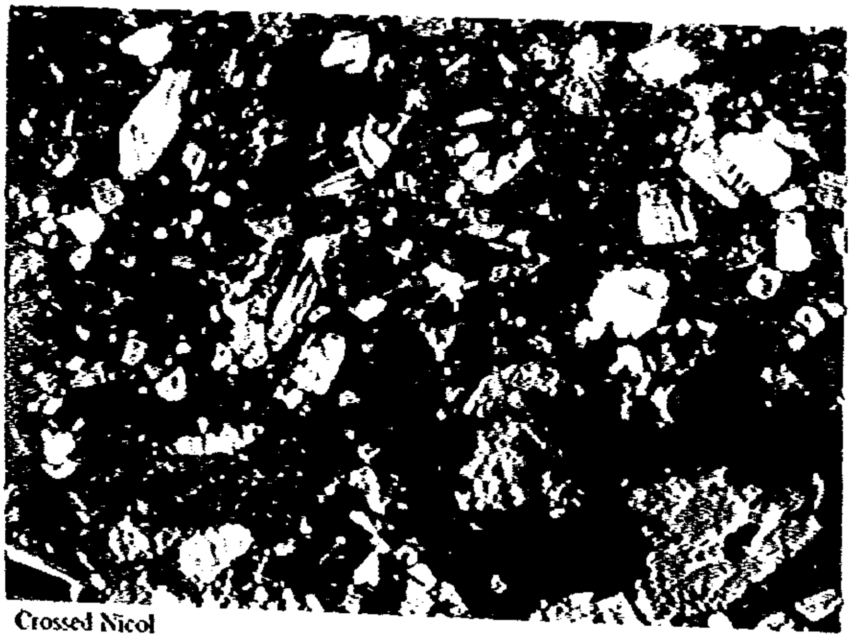


Tuff breccia

Cal : Calcite
Cpx : Clinopyroxene
Hb : Hornblende
Pl : Plagioclase
RF : Rock Fragment

Open Nicol

0 0.5 mm



Tuff breccia

Crossed Nicol

0 0.5 mm

YF-5 Tuff-breccia

Macroscopically, this rock is dark reddish purple tuff breccia including light green andesitic breccia. Microscopically, it is porphyritic andesite with a breccia size of 2.0 x 2.0 mm in large cases and 0.5 x 0.5 mm in small cases. The andesite consists of plagioclase, hornblende, clinopyroxine and calcite as phenocrysts and mainly plagioclase as ground mass. The mafic minerals have been chloritized and carbonatized. In addition to the breccia, there is plagioclase, quartz, hornblende and chlorite. Carbonates are embedded in these. No volcanic glass is seen; it is replaced by carbonates.