CHAPTER 3

DEVELOPMENT OF MINES

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1. Current Situation of the Peruvian Mining Industry

1-1 Topographic Overview

The Republic of Peru is located in the western part of the South American continent. It lies between 0° and 18°21' south latitudes and extends from the Pacific coast in the west to the Amazon Plain in the east. Its total area is 1,285,215 km², equivalent to 3.3 times that of Japan.

The vast and soaring Andes mountain system cuts across the nation from southeast to northwest. On its west lies a narrow coastal belt and on its east an extensive stretch of plains thickly covered by tropical plants.

The Andes mountain system consists of three mountain ranges; namely, the Cordillera Occidental, Cordillera Oriental and the Cordillera Sub-Andina. The Cordillera Occidental and Cordillera Oriental join each other at the Marañon Canyon at the north and the Mantaro Canyon at the center, while there is no point of contact between the Cordillera Oriental and the Sub-Andina.

The Cordillera Occidental, comprised of rocks of the Mesozoic Era and the Tertiary Period, is the highest of the three mountain ranges. Its ridges run approximately parallel to the Pacific coast line and form the watershed of the continent. The highest peak is the Nevado Huascaran that rises 6,768 m above sea level. The west side of the mountain range is severed in many places by rivers which pour into the Pacific Ocean.

The Cordillera Oriental, comprised mostly of rocks of the Palaeozoic Era, runs straight into Peru from Bolivia. After once bending near Abancay, it stretches northwest to the 7° parallel S.L. where it disappears. From there, it passes under the rocks of the Mesozoic Era, then reemerges in Ecuador. Most of the peaks in the southern and central parts of this mountain range exceed 5,000 m above sea level. Rivers in the Amazon lowland flow through deep canyons.

The notable feature of the Andes system is its group of canyons that extend longitudinally; the Marañon in the north, the Mantaro in the center, the Titicaca basin and Vilcanota canyon in the south.

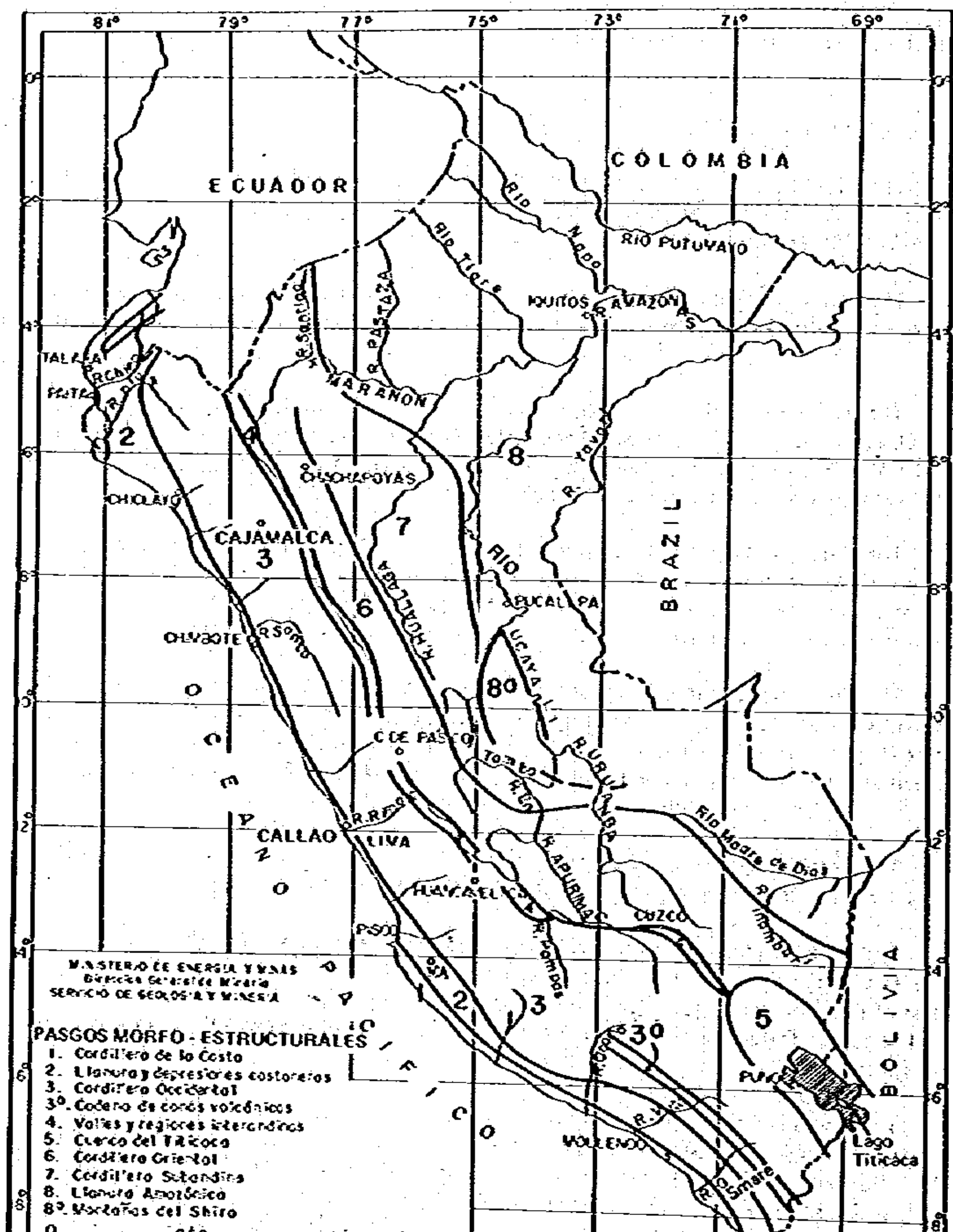
The Cordillera Sub-Andina which is comprised of rocks of the Mesozoic Era and the Tertiary Period, lies to the east of the Cordillera Oriental and stretches northwest from 12° S.L. toward the northern region. To the east of this mountain range which exceeds 3,000 m in height, spreads the gently undulating plains of the Amazon. The salient feature of this range are the hills of Shira, Contamana and Contoya where the branch of the Andes system terminates.

The Andes highlands, particularly the long and narrow range of mountains formed by the Cordilleras Oriental and Occidental, comprises a plateau of more than 4,200 m in elevation, sharply severed by a group of rivers which flow into the Pacific Ocean, Rio Amazonas and Lake Titicaca. On this Altiplano towers mountains and massive rocks, some of which are more than 6,000 m high. The climate in this region is mercurial. In the big canyons the temperature vacillates between intense heat to mild while on the highlands and in places higher above, it drops from cold to freezing temperatures.

The Amazon Plain has a high average temperature and is densely covered by tropical plants.

The coastal region is a softly undulating stretch of land varying in width from 20 km to 100 km at some points and with an elevation ranging between 500 m to 1,500 m above sea level. The region is comprised of coastal terraces, the piedmont alluvial plains and series of low hills. Fig. 3-1 is a map of the Andes System.

Fig. 3 - 1 The Andes Mountain System



1-2 Mineral Resources Endowment

The Republic of Peru is one of the most richly endowed countries of the world in its variety and quantity of available mineral resources. This paragraph will deal mostly with the so-called basic metals such as copper, lead and zinc.

The ore deposit distribution of each metal is as shown in Fig. 3-2.

Broadly speaking, porphyry copper type deposits are mainly found in the northern and southern regions. For instance, the Michiquillay, Cerro Verde, Santa Rosa and Quellaveco Mines operated by Minero Peru (Empresa Minera del Perú) and the Toquepara and Cuajone Mines operated by the Southern Peru Copper Corporation, all have huge deposits of a few hundred million tons each. These deposits generally accompany some molybdenite but contain neither gold nor silver.

In the central region are located mainly the vein type and the contact metasomatic type deposits which generally contain one or more of copper, lead, zinc or silver, and the scale of these deposits usually ranges between several million tons to several tens of million tons each. Examples are the Casapalca, San Cristobal, Morococha, Cerro de Pasco, Yauricocha and Cobriza Mines operated by the Centromin Peru (Empresa Minera del Centro del Perú), the Huanzala Mine of the Santa Luisa S.A. (an affiliate of the Mitsui Metal Mining Co., Ltd.) and the Antamina Mine of Minero Peru, all of which exist 4,000 m or more above sea level.

The project areas covered by this survey, as detailed in Paragraph 2, is located between the central and southern regions which generally abound in skarn deposits. There are such as the Tintaya Mine of Minero Peru, the Atalaya Mine of the Atalaya Mining Company, and the Coroccohuayco currently under joint prospecting by the Overseas Mineral Resources Development Co. and the Minero Peru. The Quechua Mine which is currently being prospected by the Mitsui Metal Mining Co. mainly consists of porphyry copper type deposits but also includes some skarn deposits. These skarn deposits generally contain high grade copper ore and almost invariably accompany some gold and silver.

The existing total ore reserves of deposits currently mined or planned for development in terms of metal contents are claimed to be 25 million tons of copper, 3.5 million tons of lead and 8.5 million tons of zinc. (Refer to Table 3-1.) Gold and iron ore reserves are also well known.

1-3 Production Status of Mineral Resources

The recent production volumes of major metals in Peru are shown in Table 3-2. A sharp increase of copper production up to 377,500 tons recorded in 1977 is attributable to the newly operating Cuajone Mine which produced 175,800 tons of blister copper and the fact that reduced production of the Toquepara Mine was compensated by the stepped-up production at various mines of Centromin Peru as well as by the processing of oxide ores at the Cerro Verde Mine of Minero Peru.

Of the 377,500 ton copper production, 284,200 tons was produced by the Cuajone and Toquepara Mines of the Southern Peru Copper Corporation, 63,100 tons by the Centromin Peru and most of the remainder by the Cerro Verde Mine of Minero Peru. In other words, these three companies accounted for more than 95% of total production.

In regard to lead and zinc, approximately half of the nation's total production is produced by the Centromin Peru alone.

<u>MINERO PERU</u> (Empresa Minera del Perú)

Minero Peru was established on April 14, 1970 under D.L. No. 18225 and is now being operated under the Organization Law D.L. No. 20035 promulgated on May 30, 1973. Its operating budget for Fiscal Year 1978 was 6,214.7 million soles. Topmost among Minero Peru's development programs are such priority projects as stabilizing the operation of oxide ore processing at the Cerro Verde Mine which is already in operation, then that of sulfide ore processing, the expansion of the Ilo refinery and installation of a new zinc refinery, and development of the Tintaya Mine. Also on its waiting list are exploration and development projects of such large deposits at Michiquillay, Quellaveco, Santa Rosa and Antamina, all of which should promise Minero Peru to make spectacular strides soon.

Fig. 3 - 2 Peru's Principal Mining Centers

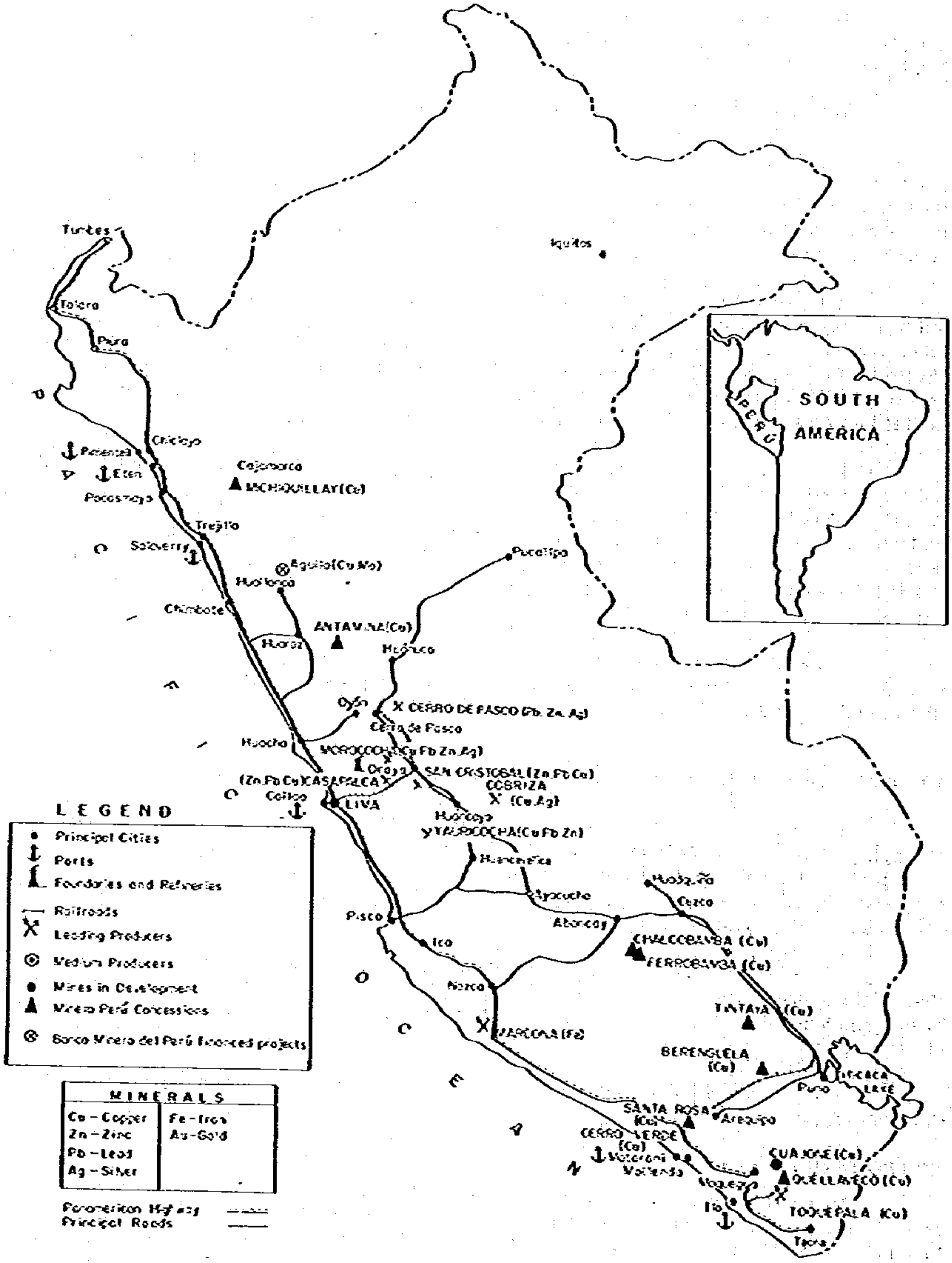


Table 3 - 1 Ore Reserves and Grades of Principal Mines (Deposits)

Name of Mines (Deposits)	Reserves (Million Tons)	Ore Grade				Remark
		Copper (%)	Lead (%)	Zinc (%)	Silver (g/t)	
Michiquillay	(419) 544	(0.76) 0.69	–	–	–	
Cerro Verde	108	1.00	–	–	–	enargite only
Santa Rosa	490	0.74	–	–	–	
Quellaveco	385	0.85	–	–	–	
Toque pala	220	0.88	–	–	–	known reserve
Cuajone	468	1.00	–	–	–	enargite only
Antamina	128	1.61	–	1.33	18	
Morococha	4.3	1.30	0.9	2.40	130	
Cerro de Pasco	53	–	3.6	9.2	92	
Casapalca	5.6	0.60	15 ~ 16		–	
Tintaya	(37.5) 31	(1.76) 2.03	–	–	–	gold and silver estimated to be equivalent to Corocoohuayco
Corocoohuayco	7.7	3.20	–	–	10	gold 0.5 g/t

Source: World Mining and Peruvian times, etc.

Table 3 - 2 Production Volumes of Major Metals and Ores in Peru

		1975	1976	1977
Copper	(MT)	188,450	200,100	377,500
Lead	(MT)	184,490	182,100	173,000
Zinc	(MT)	428,450	421,300	471,000
Gold	(Troy Ounce)	75,822	80,700	80,000
Silver	(Troy Ounce)	28,238,905	29,935,917	30,100,000
Iron Ores	(LT)	5,067,240	4,701,800	6,093,000

Source: World Mining, June 25, 1978

Fig. 3-3 shows the organization chart of Minero Peru.

<u>CENTROMIN PERU</u> (Empresa Minera del Centro del Perú)

Centromin Peru is a government owned company which operates 6 mines in the central region of Peru, the Cerro de Pasco, Morococha, Yauricocha, Casapalca, San Cristobal and Cobriza, in addition to the Oroya Refinery, all on an independent, self-supporting basis.

As a leading producer of principal metals in Peru, it produced 63,108 tons of copper, 89,504 tons of lead, 206,926 tons of zinc, 36,226 ounces of gold, 21,572,345 ounces of silver besides bismuth, selenium and antimony in Fiscal Year 1977.

Crude ore produced from these six mines were: 2,226,605 tons at Cerro de Pasco, 584,700 tons at Morococha, 496,372 tons at Yauricocha, 685,614 tons at Casapalca, 609,352 tons at San Cristobal and 860,356 tons at Cobriza. (Cobriza is now under construction for expansion.)

<u>SOUTHERN PERU COPPER CORPORATION</u>

The Southern Peru Copper Corporation, the largest copper producer in Peru, is an American owned company.

The company operates two mines, at Toquepara and Cuajone and also the Ilo Smeltery (smelting only). Its 1977 production volumes are as tabulated below:

	Toquepara	Cuajone
Crude Ore (thousand tons)	14,488	15,195
Crude Ore Grades (% metal)	0.91	1.41
Blister Copper (tons)	108,400	175,800

By this company alone 284,200 tons of copper was produced, which accounts for about 75% of the total production volume in Peru.

1-4 The Role of the Mining Industry in the Peruvian National Economy

The share of the mining sector in Peru's gross domestic product has been below 10% until now, as shown in Table 3-3, but by 1979 it is forecast to reach 11%. In terms of percentage increase over each previous year, the 1977 generated value recorded a 30% increase over 1976 while an increase of 15% is projected for 1978 and a further increase of 11% for 1979. Its share is thus expected to keep on growing.

The crucial role played by this sector however lies in its foreign exchange earnings, for it currently accounts for more than 50% of the country's total exports.

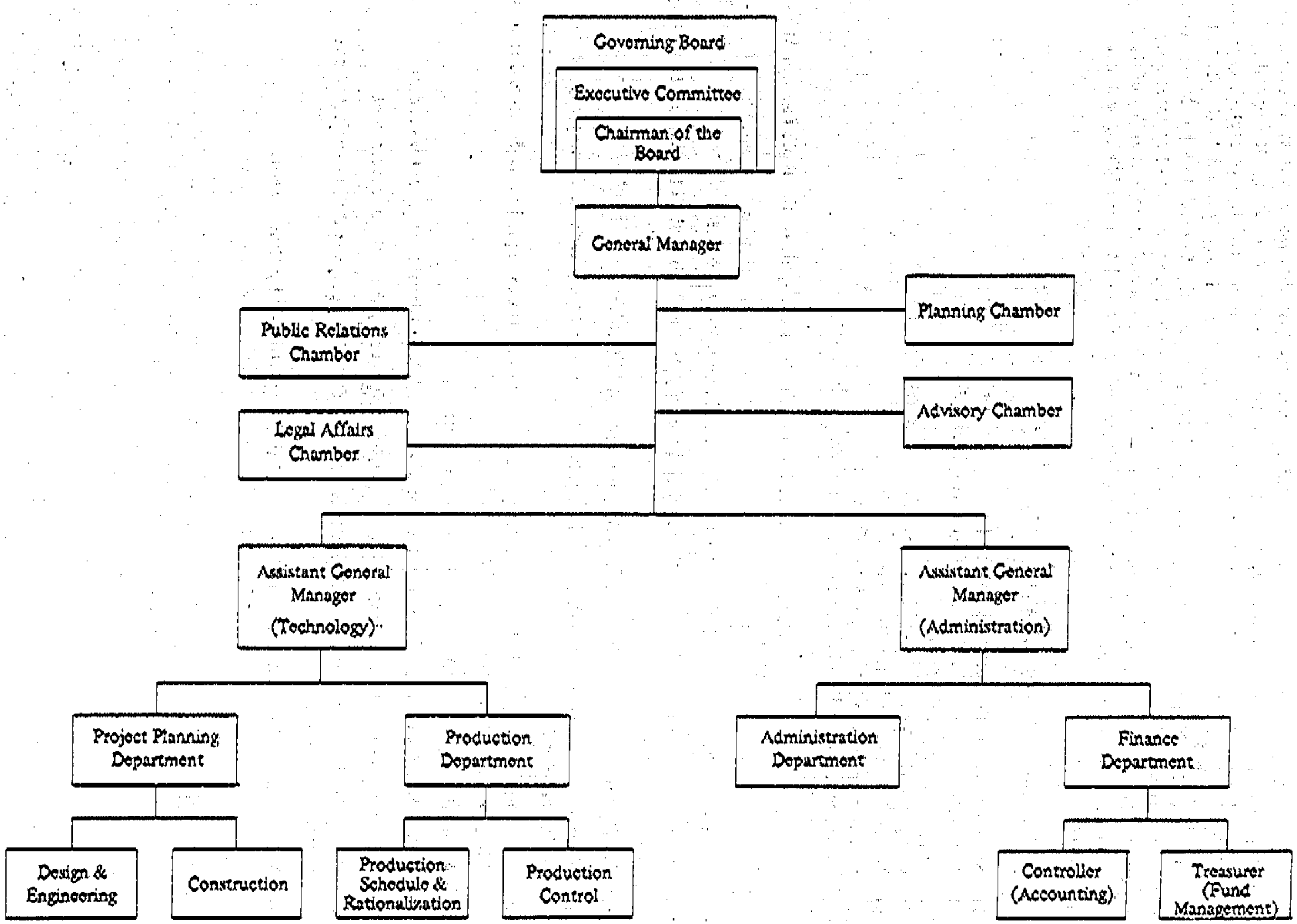
Table 3 - 3 <u>Gross Domestic Product</u>

(Unit: Million Soles)

Industrial Sector \ Fiscal Year	1977		1978 (Projected)		1979 (Forecast)	
	Value	%	Value	%	Value	%
Agriculture & Stock Farming	41,152	12.9	41,317	13.2	42,391	13.3
Fishery	2,897	0.9	3,068	1.0	3,617	1.1
Mining	26,501	8.3	30,582	9.7	33,854	10.7
Manufacturing	78,844	24.7	75,217	23.9	75,217	23.7
Construction	16,690	5.2	15,659	5.0	15,689	4.9
Other Miscellaneous	153,645	48.0	148,451	47.2	146,963	46.3
Total	319,729	100	314,334	100	317,731	100

Source: Ministry of Economy and Finance

Fig. 3-3 Organization Chart of Minero Peru



1-5 Government Policies for Mining Development

The Velasco Administration, inaugurated in October 1968, has made several innovations in the country's economic structure and also regulated foreign capital with a view to change the operating form of the mining industry, which until then had been controlled by a few groups and foreign capital, so that direct participation by the people of Peru would become possible. The intent is as witnessed in the Basic Law for Mining (Decreto Ley No. 18225) promulgated on April 14, 1970 and the General Law for Mining (Decreto Ley No. 18880) promulgated on June 8, 1971, which in essence establishes state control of enterprises (restrictions on foreign equity) and labor's participation in management. For a complete understanding of the Peruvian government's policies on mining, the Basic Law for Mining and the General Law for Mining will serve as most important references.

The Basic Law for Mining stipulates:

(1) State ownership of concessions (mining lots),
(2) Minimum equity participation of 25% by Peruvian capital,
(3) Copper refining by the State,
(4) Compulsory sales obligation of ores to State-operated refineries,
(5) Nationalization of minerals transaction,
(6) Government authority to determine selling prices,
(7) Establishment of Minero Peru as a public mining corporation, etc.

On the other hand, the General Law for Mining stipulates the spirit of the Basic Law for Mining in a more specific way as outlined below:

(1) Priority shall be given to national interest on all mineral resources development.

(2) Mining communities (comunidad Minera) shall be established and labor shall be allowed to participate in management.

(3) The right for development shall be valid only for a period of 5 years.

(4) If the national government takes part in a joint venture, the equity ratio shall normally be 51%, the minimum being 25%.

(5) Reinvestment of up to 300 million soles per annum shall be tax-exempt. For medium- and small-scale mines, other tax benefits shall also be granted.

(6) A special tax system shall be applied to mining income.

(7) Various benefits shall be granted to joint ventures in which the national government takes part.

(8) Commercialization of minerals shall, in principle, be performed by the national government.

(9) Mining development programs and capital investments for mining projects shall be subject to government approval.

(10) The mining activities of the national government shall be performed by Minero Peru.

As given above, the General Law for Mining touches on the problem of nationalization which is of special importance since it is a complete reversal from the previous Mining Law (D.L. No. 11357) promulgated in 1950 which encourages the investment of foreign capital.

The new policy of discouraging foreign capital, however, has not necessarily proved successful for Peru in promoting her subsequent economic growth. Instead, it has become a major factor for pressuring the Peruvian economy, and during the last couple of years there is growing indication that the government will revert to its old policy of encouraging the inducement of foreign capital again. Principal government organizations related to the mining sector are as follows:

MINISTERIO DE ENERGIA Y MINAS

The Ministry of Energy and Mining was established on April 1, 1969 in accordance with D.L. No. 17271. Its actual functions and authorities are as stipulated in the Organization Law for the Energy and Mining Sections. D.L. No. 21094 promulgated on February 4,1975. Fig. 3-4 shows the organization chart of the Ministry.

According to the national budget for Fiscal Year 1978 approved by D.L. No. 22049, the total revenues and expenditures were equally estimated at 289,740.6 million soles, of which the Ministry of Energy and Mining was appropriated with current account expenditures of 463.2 million soles and capital account expenditures of 4,342.5 million soles, adding up to a total of 4,857 million soles. (Note: The budget was revised in August 1978. 358.3 billion soles was estimated for total expenditures and the Ministry of Energy and Mining's appropriation increased to 5 billion soles.)

Also, of the total public investment projects amounting to 34,277.7 million soles, those with which the Ministry of Energy and Mining are concerned are 6,214.7 million soles appropriated to Minero Peru, 7,224.5 million soles to Electro Peru and 4,319.6 million soles to Petro Peru, totalling 17,758.8 million soles, which accounts for more than half of all the government's public investment for the year.

In addition to the Ministry, there are other public institutions and organizations that belong to the energy and mining sections as shown below:

Petro Peru

Electro Peru

Instituto Científico y Tecnologico del Minero

Junta de Control de Energia Atómica

The Institute of Energy and Electrical Engineering Studies

Serricio National de Geologia y Mineria

Registro Público de Mineria

1-6 Government Policies for Industrialization of Mineral Resources

The government of Peru has formulated a policy of further enhancing the value added for export by stepping up and strengthening its metal refining and processing capabilities.

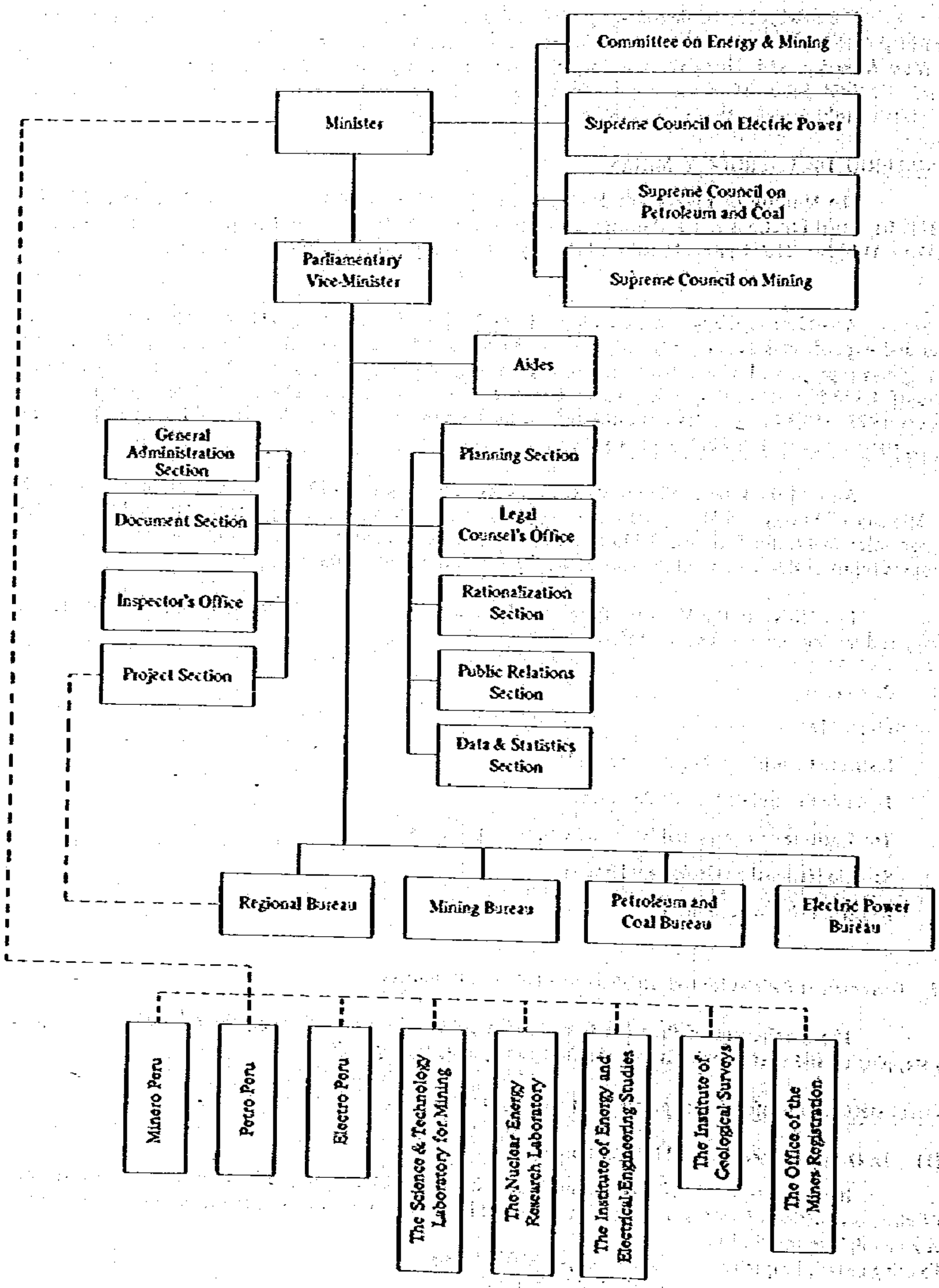
Current status and reinforcement programs of refining facilities

(1) La Oroya Refinery (owned by Centromin Peru)

It is an integrated refinery for smelting and refining of copper and lead, smelting and electrolysis of zinc, production of gold, silver, bismuth and other by-product metals as well as chemical compounds such as zinc sulphate and the like.

Existing installed capacity:	Blister copper 60,000 tons/year	
	(cathode 40,000 tons)	
	Lead	80,000 tons/year
	Zinc	70,000 tons/year

Fig. 3 - 4 Organization Chart of the Ministry of Energy and Mining (Ministerio de Energy y Minas)



(2) Ilo Refinery (Southern Peru Copper Corporation)

This refinery, owned by the Southern Peru Copper Corporation, processes concentrates that come from the Toquepara and Cuajone Mines. The volume of concentrates processed annually is 12 million tons, and its blister copper production capacity is 350 thousand tons a year. The majority of the blister copper produced here is sent to the nearby Ilo Refinery of Minero Peru, while the remainder is exported as is.

(3) Ilo Refinery (Minero Peru)

This refinery, which began operating in 1976, is the most modern electrolytic refining plant built by Mitsui & Co., Ltd. and Furukawa Electrical Engineering Co., Ltd. of Japan. Its presently installed capacity is 150 thousand tons a year, which the Minero Peru plans to double. The company is now working on its financing plan. Should this expansion project materialize, it will mean the emergence of a gargantuan electrolytic refining plant with a capacity of 300 thousand tons a year.

(4) Cajamarquilla Refinery (Minero Perú)

It is a zinc refinery plant to be constructed by Minero Peru at Cajamarquilla located in the suburbs, 20 km from Lima. The construction is scheduled to start this year. It will have a capacity of 100 thousand tons a year.

2. Current Status of the Project Mines Surveyed

2-1 Overview of the Project Area

In the project area covered by this survey are 4 copper deposits, the Quechua deposit which is being explored by a Japanese enterprise, the Coroccohuayco deposit being explored jointly by a Japanese-Peruvian team, the Tintaya deposit which is scheduled for development by Minero Peru and the Atalaya Mine currently being operated by a private Peruvian enterprise, all of which are located within a distance of about 10 km of each other. Fig. 3-5 shows the location of these deposits and mines.

This area which is located in the southern part of Cuzco Department is, in road distance, about 100 km west of Ayaviri Station, about 120 km south of Sicuani Station and about 260 km north of Arequipa Station of the Southern Peru Railway which connects Port Matarani, a principal port in southern Peru, with the inland city of Arequipa (el. 2,329 m), Puno on the Lake Titicaca near the Bolivian border (el. 3,827 m) and with cities such as Ayaviri (el. 3,824 m), Sicuani (el. 3,520 m) and Cuzco, the ancient capital of Inca (el. 3,399 m), all of which are located along the Andes mountain system.

The road leading to this area from Arequipa and Ayaviri is built directly on the lake sediments of the Tertiary Period, and during the rainy season when the road becomes muddled, traffic is often held up. By contrast, the road from Sicuani is serviceable throughout the year. The altitude of the environs is high, ranging between 4,000 m to 4,100 m. There is no big town in the Province except for Yauri with a population of anywhere between 4,000 and 5,000 and Hector Tejada with a population between 2,000 and 3,000.

Climate

According to the meteorological data recorded at Coroccohuayco during 1974 and 1977, the maximum monthly precipitation of 271.5 mm was recorded in January, 1976, while the minimum monthly precipitation was zero in July 1975. The monthly average precipitation for both the dry and rainy seasons is as shown in Table 3-4, according to which the annual precipitation seems to be in the range of about 800 mm.

Fig. 3-5 Location Map of Objective Mines and Deposits

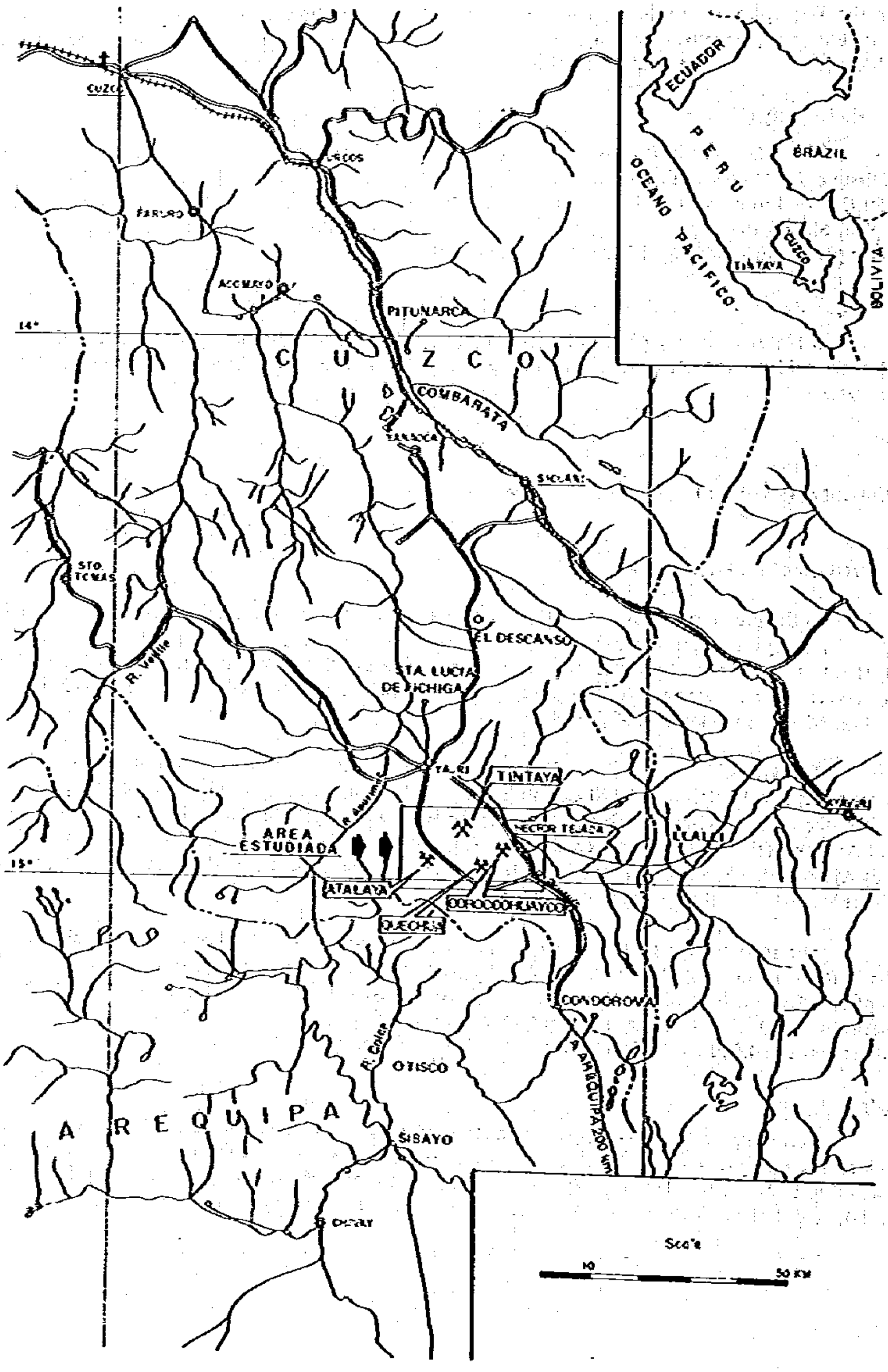


Table 3-4 Precipitation in the Project Area

(Unit: mm)

	1975	1976	1977
Monthly Average			
Dry Season (May–Nov.)	25.1	15.8	2.8
Rainy Season (Dec.–Apr.)	140.8	207.6	126.2
Annual total precipitation	764.0	956.8	–

As for temperature, the highest of 26.0°C was recorded in October 1974 while the lowest of –13.3°C was recorded in July 1975. Table 3-5 presents the monthly average temperatures.

Table 3-5 Monthly Average Temperatures

(Unit: °C)

	1	2	3	4	5	6	7	8	9	10	11	12
The Highest	13.8	13.0	14.3	15.3	13.1	13.7	14.5	15.7	15.0	17.8	17.9	16.1
The Lowest	2.6	3.2	4.0	–0.7	–3.7	–6.7	–7.0	–6.2	–1.3	–2.9	–1.7	1.9
Difference	11.2	9.8	10.3	16.0	16.8	20.4	21.5	21.9	16.3	20.7	19.6	14.2

The lowest daily temperature is recorded in the early morning. As the sun rises, the temperature felt by the body is higher than it actually is when exposed to the direct rays of the sun.

Inhabitants

The ethnic composition of the population of Peru is 49% Indios (Indians), 37% Mestizos, 12% white and 1% of others; but in this area, the inhabitants are almost 100% Indios, mostly of the Quechuan tribe, so that the Quechuan language is the only tongue in which adequate communication is possible.

Topography

The area is located within the Yauri Basin, and deposits are found at depths of several tens of meters to 400 m underneath softly rolling hills which are mostly used for farming and livestock raising by the Indios. As for vegetation, trees are hardly in sight.

Economic Environment

The Atalaya Mine, which is currently in operation, is the only activity in the area that can be called a 'modern industry' while more than 95% of the inhabitants depend on farming and livestock for their sustenance. Being restricted by annual average temperature of 10°C or lower and other adverse meteorological conditions, they are compelled to resort to extensive farming methods so that their agricultural productivity is extremely low by comparison to the neighboring provinces.

As for livestock raising, mostly tame alpine animals such as alpaca and llama as well as sheep and cattle are being reared, but their current productivity is very low. Among the livestock produce, wool is the important source of the farmers' income.

2-2 Overview of the Project Mines and Deposits Surveyed

2-2-1 General Regional Geologic Conditions and Deposits in the Project Area Surveyed

The area is composed of the early to mid-Cretaceous system of the Mesozoic Era, which are retained as "inlier" in the Yauri Basin, and also of neutral to basic batholith and acidic porphyry rocks which penetrate the inlier, all of these being surrounded by the lake sediments of the late Tertiary Period.

The stratigraphy of the Laramani Massif east of the Yauri Basin is composed from the bottom in the order of Huancane Reddish Sandstone formation, Moho formation (mainly Ayabacas Limestone) and shale and sandstone of Muñani ~ Catacucho formation, while the west is composed of the topmost part of the Yura group Huarhuani quartzite stratum, Murco shale and sandstone formation, and Ferrobamba Limestone formation.

Of the two stratigraphic systems, the Huarhuani and Murco formations roughly correspond to the Huancane formation while the Ferrobamba formation to the Moho formation, but there is a distinct difference between these two systems in terms of lithography or fossil facies, which suggests that transgression in those times had proceeded from west to east. Although it is certain that the sedimentary rocks beong to the latter part of the Mesozoic Era, no exact age can be assigned with accuracy.

In terms of lithofacies, the area in which mineral reserves are deposited resembles the stratigraphy of the west side of the Yauri Basin, having layers comparable to each of the Huarhuani, Murco and Ferrobamba formation and directly covered by lake sediments of Descanzo formation.

Igneous activity is observed in plutonic rocks of the early to late Cretaceous Period and porphyry rocks of the late Cretaceous Period to the early Tertiary Period. Of plutonic rocks, there are 3 batholiths in the Yauri-Velille area which, in the order of oldness, are called Tintaya batholith (10 km x 20 km, absolute age 144 x 10^6), Velille batholith (105 x 10^6), and Pichingua batholith (74 x 10^6, 86 x 10^6) respectively. The Tintaya batholith's southern edge extends into the Coroccohuayco area and is composed of pyroxene diorite and gabbro. The Pitingua batholith is mainly composed of quartz diorite and granite diorite, while the Velille batholith is composed of diorite and monzonite, showing gradual shifts toward shallower lithofacies.

Porphyritic rocks are distributed in the form of stocks and veins, and mainly consist of monzonites and their absolute age in each of the Coroccohuaico, Tintaya, Quechua, Atalaya areas ranges between 25 x 10^6 and 73 x 10^6, indicating that these were mainly of the Palaeogene period.

In addition, Tacaza volcanic rocks of the mid-Tertiary Period are widely distributed, and their lithologic characters range widely from andesite, dacite to rhyolite, etc.

In the inlier of the Yauri Basin including Coroccohuayco, copper mineralization associated with hyperabyssal to plutonic igneous activities, as explained above, are pronounced as are evidenced by the existence of the skarn type deposit group such as the Tintaya Mine and the Atalaya Mine in the northwest, and the large stockwork deposits (including some skarn type) like the adjacent Quechua Mine to the south which, together with the Coroccohuayco mineralized zone of skarn type deposits (partially include stockwork deposits), form a huge copper deposit belt.

2-2-2 Overview of Each Mine in the Project Area Surveyed

(1) Coroccohuayco Mine

Jointly surveyed by the Peruvian and Japanese Government (Metal Mining Agency of Japan team) between 1971 and 1973.

Joint prospecting and trial boring were carried out by Minero Peru and the Overseas Mineral Resources Development Co., Ltd. of Japan during 1974 and 1977. Boring activities totalled 38 holes and 14,346 m in extension of which 23 holes totalling 9,558 m were drilled in the skarn type deposit belt.

The mine is of skarn type deposit with reserves of 7.7 million tons, having 3.2% copper grade and some gold and silver.

The mine plans to produce 1,000 tons daily by underground method.

(2) Quechua Mine

The Mitsui Metal Mining Co., Ltd. performed the exploration during 1972-78, with boring tests of 65 holes totalling 14,939 m in extension and exploratory mining of 930 m.

The mine is of porphyry copper type deposit, reportedly to have reserves of 80 to 100 million tons with copper grade of between 0.8% to 1.0%.

The plan is to produce 5,000 to 8,000 tons daily by the open pit method.

(3) Tintaya Mine

Prospecting was first started by Andes Exploration Co. in 1918. Until the mine was trasferred to Minero Peru in 1970, most of the boring activities were performed by the Cerro de Pasco Co.

The mine consists of 4 deposits, namely Chabuca, Chabuca Este, Inflexion and Zona Nueva, and so far, 305 holes, 28,971 m in extension at Chabuca and Chabuca Este and 68 holes, 17,794 m in extension at Inflexion and Zona Nueva have been drilled.

The deposits are of the skarn type, and Chabuca and Chabuca Este are composed mainly of oxide ores while Inflexion and Zona Nueva of sulfide ores.

The H.A. Simons International Ltd. of Canada started on the Feasibility Report in 1976, finished the Basic Engineering in June 1978 and they are now under final review by Minero Peru.

According to the basic engineering, the main objective is to process sulfide ores at Inflexion and Zona Nueva, whose reserves are reported to be 31 million tons of the 2.03% copper grade or 37.5 million tons of the 1.76% copper grade, based on which a daily production of 8,000 tons is planned. The estimated reserve is considered to increase, easily reaching 65 million tons without fail.

Minero Peru considers the Tintaya project as one of its top priority projects and hopes to begin development at the earliest possible time.

(4) Atalaya Mine

The mine is owned and operated by the Atalaya Mining Company since 1970.

It is a skarn type deposit and is being mined by underground method at the rate of 105 m a day, producing 450 tons of ore a day with copper grade of 2.6%.

Monthly production of concentrates with 30.5% copper grade stands at 800 tons, which is carried by 8-10 ton trucks to the Sicuani Station, from where the concentrates are shipped by rail to Port Matarani.

Power is supplied by a captive diesel generator with an installed capacity of 1,675 kW. At present, 262 people are employed.

3. Basic Assumptions for Infrastructure Development Planning

As a necessary prerequisite for formulating the infrastructure development program, basic assumptions such as mining methods at each mine, operating rate, transportation volumes of concentrates, materials and supplies, fuels, power and water requirements, number of employees, economic life of mine, etc. were determined as summarized in Table 3-6. The data for Atalaya Mine were supplied by the mine during interviews and as for Tintaya Mine, the planned figures were provided by Minero Peru. The feasibility report was developed by H.S. Simons (International) Ltd. of Canada.

As for both Coroccohuayco and Quechua Mines, the data were based on the tentative planning figures that were available at this time as a sort of pre-feasibility report. Particularly for the Quechua Mine, the plan is still in flux, ranging between 5,000 tons to 8,000 tons of daily production, but the maximum figure was adopted for this purpose.

Table 3 - 6 Basic Elements for Infrastructure Development Study

	1 Atalaya	2 Tintaya	3 Coroccohuayco	4 Quechua	Remark
Mining method	Underground	Concurrent Open cut and Underground	Underground	Open cut	
Operating rate (Ton/Day)	450	8,000	1,000	8,000	
Haulage volume (Ton/Year)	12,200	212,000	28,500	141,000	
Concentrates (Ton/Year)	9,600	152,000	20,000	92,000	
Materials & supplies (Ton/Year)	1,000	15,000	2,500	15,000	
Fuel (Ton/Year)	1,600	45,000	6,000	34,000	
Equipment & material during construction (Ton)	–	50,000	5,000	30,000	Max. unit ϕ3m, 20 tons
Installed power capacity (kW)	1,675	15,000	5,200	15,000	Firm power ≒x 0.75
Annual power consumption (MWh)	6,000	90,000	20,000	68,000	
Water requirements (Ton/Day)	1,500	8,800	3,000	12,500	Fresh water only
Industrial use (Ton/Day)	1,000	7,000	2,000	11,300	
Household use (Ton/Day)	500	1,800	1,000	1,200	
No. of employees (Person)	262	900	600	650	
Economic life of mine (Year)	8	15	15	15	

Note:
1) Figures for Atalaya are partially estimated.
2) For 2, 3, 4, based on currently available plans.
3) Regarding the economic life of each mine, a longer period of operation seems possible for 2 and 4 based on their estimated ore reserves, but a life of 15 years was assumed as a basic condition for the current infrastructure planning.
4) The timing of construction for all of 2, 3 and 4 remain uncertain, but since it will be impossible to formulate the infrastructure development program without first determining the time, the following assumptions were made:

   2...... 1980 - 1982
   3...... 1983 - 1985
   4...... 1986 - 1988

4. Recommendations for Further Detailed Studies

Within the Project Area, in addition to the Atalaya mine which is currently operating, there are several promising deposits. Although it is not at present certain when the latter will be developed, it is presumed that in consultation with Minero Peru and private companies concerned, there will be development of the Tintaya mine in 1980-82, of the Coroccohauyco mine in 1983-85, and of the Quechua mine in 1986-88. It is further presumed based upon consultations, that the scale of operation; volumes of ore, materials and fuel transported; annual power requirements; water requirements; number of employees; and life of the mines will be as shown in Table 3-6.

From the viewpoint of economics it is desirable that the same type of ore to be produced at each of the mines be processed at the same concentration facilities. For the same reason, it is recommended that a single machine shop and repair shop be established to serve all of the mines.

The Tintaya and Coroccohauyco mines will use the same source for water, but a more detailed study will be necessary regarding surface runoff and influent water.

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CHAPTER 4

ELECTRIC POWER DEVELOPMENT

CHAPTER 4 ELECTRIC POWER DEVELOPMENT

1. Electric Power In Peru

1-1 Current Power Supply Conditions

1-1-1 Power Supply Equipment Capacity

In 1975, the power generation capacity was 2,358.8 MW in Peru, which represented 159.7 W per person. The power consumption was 7,486.2 GWh, or 507 kWh per person.

Table 4-1 shows the changes in capacity of nationwide power generation facilities between 1952 and 1975. In the 10 years from 1966 to 1975, there was an expansion of about 1.6 times. Of the total power generation capacity of 2,358.8 MW in 1975, 1,397.3 MW or 59.2% was provided by hydroelectric facilities, and 961.5 MW or 40.8% by thermal power plants.

Among these power generation facilities, 62.3% were those of power companies and 37.7% were private. There is a gradual tendency for power company generation facilities to increase. The industry which used the most private generation equipment was the mining industry.

There are four adiministrative electric power regions in Peru: the northern, central, southern and eastern regions as shown in Fig. 4-1. Table 4-2 shows the power generation facilities in each of these regions in 1975. The percentages of total facilities in each region were as follows: 22.2% in the northern, 63.4% in the central, 13.4% in the southern and 1.0% in the eastern regions. More than half of the power generation facilities concentrated in the central section which includes Lima and accounts for 65% of the nation's industrial production. The eastern region has only 1.0% of the power generation facilities but this region is covered with the forests which spread over the Amazon river area and has only a scattering of small towns. The power in the eastern region is all supplied by small-scale generation equipment.

However, the theoretical water power of the rivers in this region (the Marañon, Apurimac and Ucayali Rivers) was 106 GW at the time of a 1965 survey, which is 85% of the total of 125 GW for Peru as a whole. As the economy of the country develops in the future, this will become the most promising hydroelectric power region in the country.

1-1-2 Power Systems and Transmission Networks

Fig. 4-2 shows the main existing or planned power systems in Peru. The main power plants such as the Mantaro Power Plant (current output: 342 MW, future output: 798 MW), Huinco Power Plant (output: 260 MW) and Callahuanca Power Plant (output: 367 MW) are connected to 20 kV power lines which supply power to the Lima capital region.

In the north, there is a system which connects the Canon del Pato Power Plant (current output: 100 MW, future output: 150 MW), and the Chimbote and Trujillo regions, and in the south, there is the Machu-Picchu system in which the 40 MW output of the Machu-Picchu Power Plant in Cuzco Department is sent by 138 kV power lines as far as the city of Cuzco. The Machu-Picchu system is a completely independent system which supplies power only to the city of Cuzco and its suburbs. At present there is a plan to increase the capacity of the Machu-Picchu Power Plant which will raise its output to 109.9 MW.

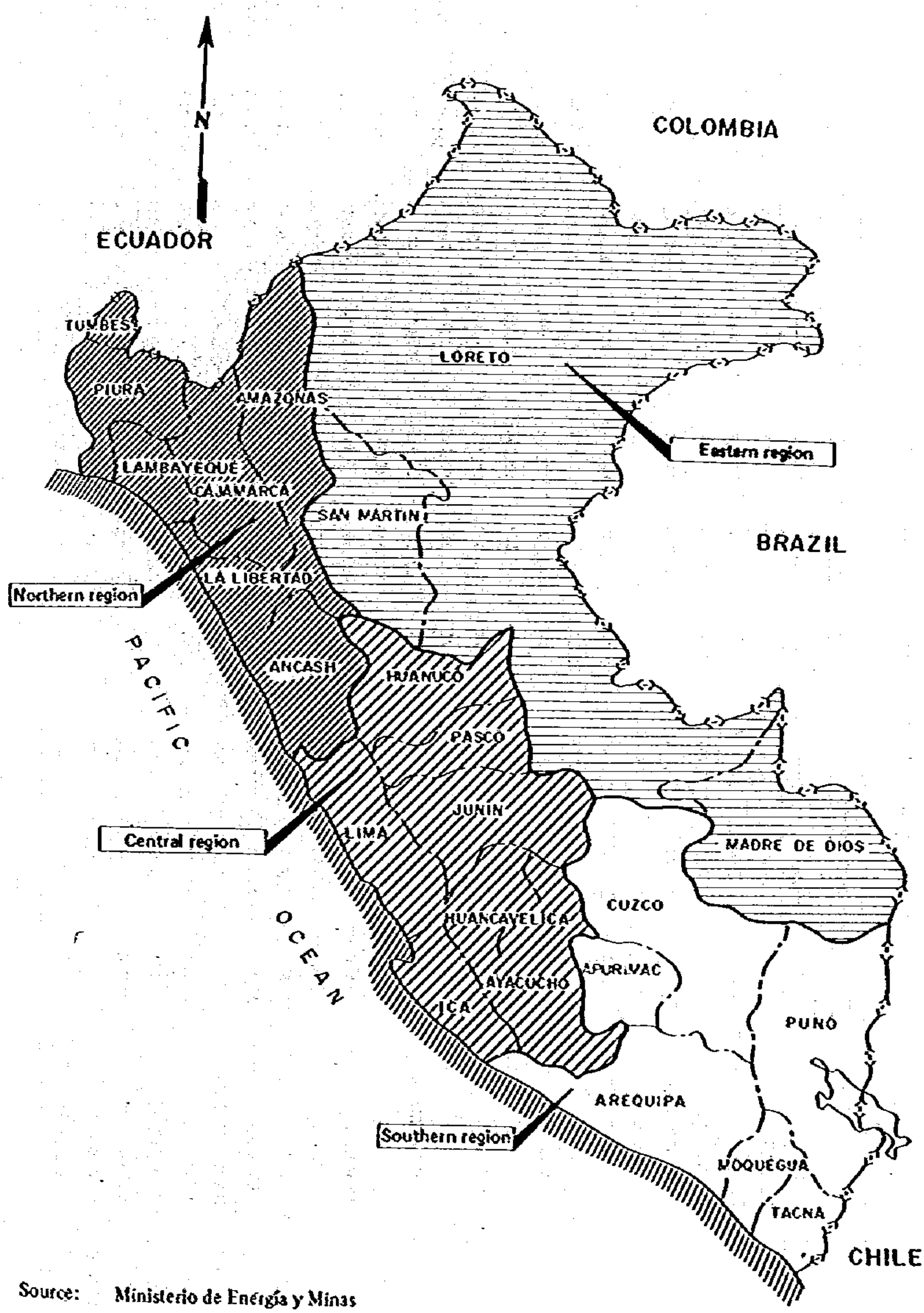
In addition to the above systems, there are many small scale independent systems with small power plants of the diesel or hydroelectric type which supply power to cities and towns.

Table 4-1 Changes in Power Generation Equipment Capacities (nationwide) (1952 – 75)

Year	Power company generation equipment (MW)			Private power generation equipment (MW)			Total (MW)		
	Hydroelectric	Thermal	Total	Hydroelectric	Thermal	Total	Hydroelectric	Thermal	Total
1952	114.4	44.4	158.8	83.6	80.7	164.3	198.0	125.1	323.1
1954	113.6	59.2	172.8	104.7	113.0	217.7	218.3	172.2	390.5
1956	135.6	70.3	205.9	116.1	138.3	254.4	251.7	208.6	460.3
1958	213.1	77.6	290.7	187.8	174.2	362.0	400.9	251.8	652.7
1960	221.8	126.6	348.4	193.7	236.6	430.3	415.5	363.2	778.7
1962	247.6	147.8	395.4	196.2	274.5	470.7	443.8	422.3	866.1
1964	342.2	138.2	480.4	197.1	375.4	572.5	539.3	513.6	1,052.9
1965	495.4	147.6	643.0	197.6	456.2	653.8	693.0	603.8	1,296.8
1966	572.7	158.2	730.9	199.6	493.2	692.8	772.2	651.5	1,423.7
1967	670.1	166.5	836.6	200.8	521.6	722.4	870.9	688.1	1,559.0
1968	676.6	167.7	844.3	238.5	523.7	762.2	915.1	691.4	1,606.5
1969	677.1	174.0	851.1	241.5	559.8	801.3	918.6	733.8	1,652.4
1970	681.1	181.5	862.6	241.5	573.0	814.5	922.6	754.5	1,677.1
1971	747.7	226.3	974.0	241.5	581.2	822.7	989.2	807.5	1,796.7
1972	810.9	264.7	1,075.6	245.9	608.5	854.4	1,056.8	873.2	1,930.0
1973	1,038.1	282.0	1,320.1	240.1	593.7	833.8	1,278.3	875.6	2,153.9
1974	1,149.3	281.9	1,431.2	239.5	594.9	834.4	1,388.0	876.8	2,265.7
1975	1,156.3	311.5	1,467.8	240.9	650.0	890.9	1,397.3	961.5	2,358.8

Source: Ministerio de Energía y Minas

Fig. 4 - 1 Administrative Electric Power Regions



Source: Ministerio de Energía y Minas

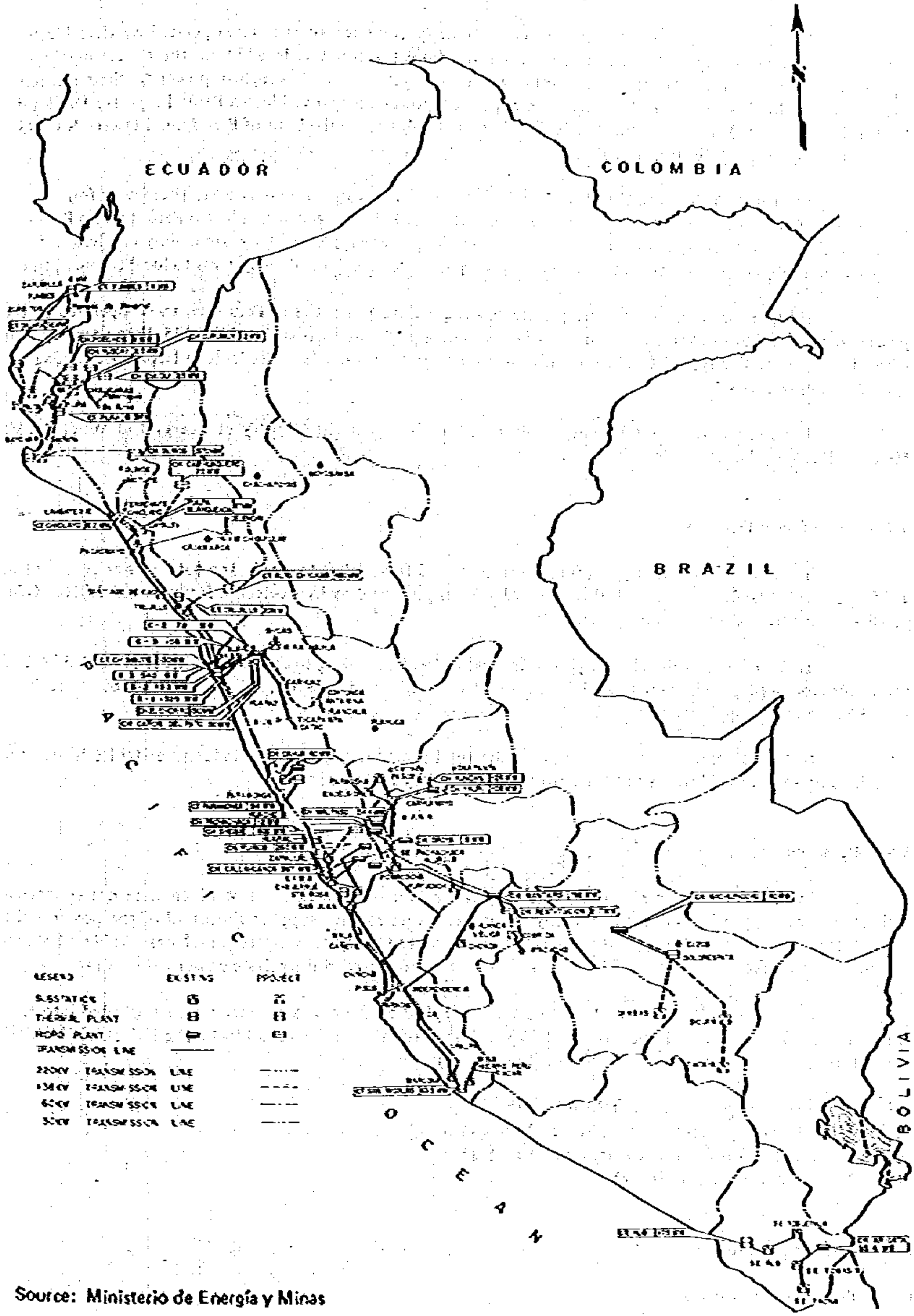
Table 4-2 Power Equipment Capacities in Each Department in 1975

(Unit: kW)

Region	Department	Power company generation equipment			Private power generation equipment			Total			
		Hydro-electric	Thermal	Total	Hydro-electric	Thermal	Total	Hydro-electric	Thermal	Total	Ratio
NORTE	TUMBES		8,442	8,442		463	463		8,905	8,905	.377
	PIURA	440	36,274	36,714		70,282	70,282	440	106,556	106,996	4.535
	CAJAMARCA	1,279	6,051	7,330	3,270	2,953	6,223	4,549	9,004	13,553	.574
	LAMBAYEQUE		25,473	25,473		44,769	44,769		70,242	70,242	2.977
	AMAZONAS	96	832	928		127	127	96	959	1,055	0.044
	LA LIBERTAD	1,572	26,517	28,089	188	88,686	88,874	1,760	115,203	116,963	4.958
	ANCASH	103,120	69,759	172,879	2,122	30,253	32,375	105,242	100,012	205,254	8.701
CENTRO	HUANUCO	520	4,828	5,348	88	8,180	8,268	608	13,008	13,616	.577
	LIMA	587,786	59,631	647,417	10,912	80,344	91,256	598,698	139,975	738,671	31.314
	PASCO	452	275	727	123,393	8,362	131,755	123,845	8,637	132,482	5.616
	JUNIN	10,062	7,338	17,400	90,247	13,316	103,563	100,309	20,654	120,963	5.128
	HUANCAVELICA	344,527	666	345,193	6,106	14,809	20,915	350,633	15,475	366,108	15.520
	ICA		5,374	5,374		110,556	110,556		115,930	115,930	4.914
	AYACUCHO	1,584	3,563	5,147	1,470	2,069	3,539	3,054	5,632	8,686	.368
SUR	APURIMAC	2,961	793	3,754	12	591	603	2,973	1,384	4,257	.184
	CUZCO	43,878	3,447	47,325	1,024	3,295	4,319	44,902	6,742	51,644	2.189
	AREQUIPA	21,806	20,173	41,979	1,942	27,592	29,534	23,748	47,765	71,513	3.051
	MADRE DE DIOS		930	930		54	54		984	984	0.041
	PUNO	323	10,943	11,266	160	6,729	6,889	483	17,672	18,155	0.769
	MOQUEGUA	171	1,623	1,794		125,398	125,398	171	127,021	127,192	5.392
	TACNA	35,796	50	35,846		5,422	5,422	35,796	5,472	41,268	1.749
ORIENTE	LORETO		16,122	16,122		5,409	5,409		21,531	21,531	.912
	SAN MARTIN		2,396	2,396		387	387		2,783	2,783	.117
	TOTAL:	1,156,373	311,500	1,467,873	240,934	650,046	890,980	1,397,307	961,546	2,358,853	100.000

Source: Ministerio de Energía y Minas

Fig. 4 - 2 Main Power Networks



Source: Ministerio de Energía y Minas

1-1-3 Characteristics of Electrical Power Companies and the Electrical Power Industry

The electrical power industry in Peru formerly consisted of the state-operated Servicio Eléctrico Nacional (SEN) which supplied power to 28 areas throughout the country. In addition, there were municipally operated systems such as the Mantaro, Santa and Tacna systems which supplied power to their respective municipalities. In September, 1972, a new stateoperated power company, Electró Perú: Empresso Publica del Sector de Energia y Minas "Electricidad del Perú", was established on the basis of Presidential Decree No. 1952. It went into operation from January, 1973.

Electro Perú absorbed the SEN and all of the municipally operated networks. There were formerly 25 private power companies but at present, all but eight of them have merged with Electro Perú. Electro Perú sells power to these private companies for the purpose of public power supply and they are mainly involved in direct supply to large users such as factories or direct supply by small scale independent systems to local communities.

Up to 1965, there were more private power generating facilities in Peru than those operated by the power companies, but since then, the company facilities have gradually increased and in 1975, they accounted for 60% of the whole. The types of industry with private power generation facilities include large scale mining and agricultural enterprises.

The main governmental agency dealing with electricity is the Ministry of Energy and Mines (MEM: Minestro Energia y Minas).

1-2 Current Power Demand

Table 4-3 shows the figures for power generated from 1960 to 1975. The total power generated in 1975 was 7,486.2 GWh, of which 5,470 GWh or 73.1% was generated by hydroelectric facilities and 2,016.2 GWh or 26.9% came from thermal power plants.

Table 4-4 shows the electric power demand in 1975 according to application. Industry took 32.6% of the whole, followed by mining with 28.1%, household applications with 18.9%, commerce with 3.8%, agriculture with 3.8% and other applications with 12.8%.

In Cuzco Department, about 82% of the total power is consumed by industry and 11% is used for household applications. Almost all of the power is consumed by these two fields.

1-3 Electricty Charges

In Perú, there were formerly many electrical power companies, most of which were not connected with others and supplied power independently. At present, Electro Perú supplies almost all of the power in the country and the remainder is supplied by private companies. The fee systems differ in each case. Table 4-5 shows part of the power fees (effective as of 18 May 1978) for Electro Perú and the private power companies.

In the case of Electro Perú, the power is supplied to the entire country which is divided into four blocks (Pliego Tarifario I to Pliego Tarifario IV) and the fees are set for each block. The industrial electrical power fees applied in the Cuzco are as follows (Fee No. 35).

(1) For maximum power - S69.70 S/kW/month
(2) For active power from 10 to 22 hours - 2.65 S/kWh
(3) For active power from 22 to 10 hours - 1.65 S/kWh
(4) For reactive power - 1.30 S/kVA/h

1-4 Power Source Development Plan

1-4-1 Power Generation Plan

The power source development plans in Peru have been centered on the mining industry and there are about 45 plans to construct new and add to hydroelectric and thermal power plants up to 1990.

Table 4-3 Nationwide Generated Power (GWh) in 1952 – 75

(Unit : GWh)

Year	Industrial power generation equipment			Private power generation equipment			Total		
	Hydroelectric	Thermal	Total	Hydroelectric	Thermal	Total	Hydroelectric	Thermal	Total
1952	*	*	461.1	*	*	590.4	875.4	176.1	1,051.5
1954	*	*	565.5	*	*	797.2	1,032.6	330.0	1,362.7
1956	*	*	685.7	*	*	938.7	1,184.9	439.5	1,624.4
1958	*	*	892.8	*	*	1,118.4	1,398.6	612.6	2,011.2
1960	*	*	1,173.1	*	*	1,474.8	1,794.2	853.8	2,647.9
1962	1,197.5	202.6	1,400.1	745.5	910.2	1,655.7	1,943.0	1,112.8	3,055.8
1964	1,338.9	285.7	1,624.6	941.2	1,136.5	2,077.7	2,280.1	1,422.2	3,702.3
1965	1,681.8	146.4	1,828.2	984.5	1,193.6	2,178.1	2,668.0	1,338.3	4,006.3
1966	1,801.0	162.8	1,963.8	1,026.0	1,376.2	2,402.2	2,827.0	1,539.0	4,366.0
1967	2,078.6	177.4	2,256.0	1,089.3	1,424.3	2,513.6	3,167.9	1,601.7	4,769.6
1968	*	*	2,525.3	*	*	2,513.0	3,487.0	1,551.3	5,038.3
1969	*	*	2,785.8	*	*	2,502.4	3,701.5	1,586.7	5,288.2
1970	*	*	2,929.7	*	*	2,599.1	3,820.6	1,708.2	5,528.8
1971	3,092.8	204.0	3,296.8	1,190.0	1,462.1	2,652.1	4,282.9	1,666.0	5,948.9
1972	3,231.1	294.1	3,525.2	1,207.7	1,556.4	2,764.1	4,536.3	1,753.0	6,289.3
1973	3,567.1	324.7	3,892.2	1,201.5	1,561.6	2,763.1	4,769.0	1,886.3	6,655.3
1974	3,980.3	335.2	4,315.5	1,240.0	1,719.6	2,959.6	5,220.4	2,054.8	7,275.2
1975	4,281.2	384.5	4,665.7	1,188.8	1,631.7	2,820.5	5,470.0	2,016.2	7,486.2

(*) No data

Source: Ministerio de Energía y Minas

Table 4-4 Power Consumption by Category in Each Department (1975)

(Unit: kWh)

Department	Public lighting	Domestic lighting	Commerce	Industry	Agriculture	Mining	Fishing	Others	Loss
TUMBES	584	2,703	1,159	876				17	2,921
PIURA	4,259	26,786	5,343	162,916		785		13,551	16,371
CAJAMARCA	1,110	4,050	1,665	631		8,086		349	2,872
LAMBAYEQU	10,613	26,794	9,216	80,415	21,128			2,061	20,966
AMAZONAS	92	250	151					9	66
LA LIBERT	11,361	48,590	6,136	220,308	35,751	15,833	952	7,145	40,936
ANCASH	5,158	17,420	7,152	251,297	3,868	15,835	25,641	2,573	43,700
HUANUCO	770	5,542	1,152	2,494		26,376		174	4,701
LIMA	170,256	896,164	173,063	1,055,514	101,652	283,112	36,344	464,494	369,040
PASCO	7,681	30,966	202	1,352		210,894		6,563	18,468
JUNIN	36,971	19,662	4,974	76,341	30	606,300		9,540	76,677
HUANCAVEL	1,170	6,355	12			68,905		78	14,381
ICA	20,010	16,393	8,827	9,124	21	331,997	18,271	712	57,049
AYACUCHO	831	812	58	1		8,157		6	109
APURIMAC	626	1,765	434	361				6	459
CUZCO	5,003	22,234	4,862	167,624		5,842		76	17,157
AREQUIPA	11,958	52,451	9,171	74,775	1,423	35,297	2,984	4,888	23,365
M DE DIOS	57	195	98						50
PUNO	1,328	3,787	2,969	10,709		4,439		1,064	3,370
MOQUEGUA	1,088	27,147	1,612	18,162		171,810	1,789	2,538	13,675
TACNA	2,252	25,785	1,675	8,345	317	65,791		32,083	46,705
LORETO	2,111	14,171	8,090	13,770		876		1,419	10,566
SAN MARTIN	279	951	333	129				1,114	538
TOTAL	295,568	1,251,973	248,354	2,155,144	164,190	1,860,335	85,981	550,460	784,142

Source: Ministerio de Energía y Minas

Table 4-5 Electric Power Changes (Electro Perú and Private Power Companies)

TARIFA NO.	Tipo de consumo y características del suministro	NIVELES TARIFARIOS Y SU APLICACION SEGUN EMPRESAS 1	2	3
33	Industrial: Carga contratada mayo de 999 kW. Suministro con alimentación nominal superior a 2,300 y menor de 30,000 voltios. Máxima Demanda (mínimo mensual facturable 60% de la carga contratada) Energía Activa: 10 a 22 haras 22 a 10 haras Energía Reactiva	S/ 728.00 kW-mes 3.15 kWh 1.90 kWh 1.90 kVarh Empresa Energía de Piura Empresa Energía de Chimbote Coserelec: Sectores Ica, Chincha, Pisoc, Supe y Chiclayo.	S/ 727.95 kW-mes 3.15 kWh 1.90 kWh 1.90 kVarh SEAL – AREQUIPA ELECTROLIMA S.I. de Huancayo ELECTROPERU-Todos los P.T.	
34	Industrial: Carga contratada mayor de 999 kW. Suministro con alimentación a la tensión nominal de 30,000 a 60,000 voltios. Máxima Demanda (mínimo mensual facturable 60% de la carga contratada) Energía Activa: 10 a 22 haras 22 a 10 haras Energía Reactiva	S/ 633.00 kW-mes 3.00 kWh 1.70 kWh 1.65 kVarh SEAL – AREQUIPA ELECTROLIMA, ELECTROPERU - Todos los P.T.		
35	Industrial: Carga contratada mayor de 999 kW. Suministro con alimentación a la tensión nominal de más de 60,000 voltios. Máxima Demanda (mínimo mensual facturable 60% de la carga contratada) Energía Activa: 10 a 22 haras 22 a 10 haras Energía Reactiva	S/ 569.70 kW-mes 2.65 kWh 1.65 kWh 1.30 kVarh ELECTROPERU, Todos los P.T.	S/ 569.70 kW-mes 2.65 kWh 1.65 kWh 1.25 kVarh ELECTROLIMA	
36	Venta a Paramonga: Mínimo 13'900,000 kWh Exceso Caldero Eléctrico	S/ 35'954,400 Mes 2.45 kWh 0.88 kWh HIDRANDINA		

Source: Ministerio de Energía y Minas

These power source development plans are mainly for the central region. The first stage of Mantaro Hydroelectric Power Plant construction (output: 342 MW) to meet increasing demand in the Lima region has been completed and future projects concerning a second stage (output: 114 MW) and a third stage (output: 342 MW) have been planned. Table 4-6 shows main power generation plans.

1-4-2 Power Transmission Plans

In conjunction with the Mantaro Hydroelectric Power Plant plan, large scale power lines with a total length 955 km for a voltage of 220 kV when the connecting power lines are completed. Currently, a single 220 kV line about 400 km long is under construction between Lima and the northern industrial city of Chimbote and completion is planned for 1981. With the completion of this line connecting Lima and Chimbote, the central and northern regions will be connected and this should contribute greatly to stable power supply.

The plans in the southern region include a power transmission line to connect Tacna and Arequipa (voltage: 138 kV, length: 130 km); the Majes - Arequipa line in conjunction with the Majes Project (voltage: 220 kV, length: 85 km); and a transmission line from the Machu-Picchu Power Plant to the planned Tintaya mine at the southern end of Cuzco Department (voltage: 138 kV, length: 308 km). Figs. 4-3 and 4-4 shows locations of electrical equipment and system diagram after addition to Machu-Picchu system.

Table 4-6 Main Power Generation Plans

(Unit: MW)

Region	Plan	Output	Year of Completion	Remarks
Northern	Alto Chicama No. 1	160	1983	Thermal
	Alto Chicama Nos. 2, 3	320	1984	"
Central	Mantaro No. 4	114	1978	Hydroelectric
	Mantaro Nos. 5, 6, 7	342	1979	"
	El Chorro	150	1985	"
	Yuncan	126	"	"
	Sheque No. 1	150	1986	"
	Sheque No. 2	150	1987	"
	Sheque Nos. 3, 4	300	1988	"
	Olmos No. 1	151	1989	"
	Olmos No. 2	212	1990	
Southern	Chilina No. 3	10	1979	Steam
	Arequipa No. 1	16.5	"	Diesel
	Ilo	66	1980	Steam
	Arequipa No.2	16.5	1981	Diesel
	Charcani No. 5	135	1983	Hydroelectric
	Machu-Picchu (Addition)	69.9	1981	"
	Quishuarani	46	1987	"
	Lluta (Majes Project)	274	1985	"
	Lluclla (Majes Project)	382	1990	"

Source: Ministerio de Energía y Minas

2. Power Supply Plan for the Copper Mines

2-1 Power Requirements of the Mines Concerned

The mines involved in this plan are the Tintaya, Coroccohuayco and Quechua mines. Table 4-7 shows the estimated electrical power requirements for these mines. These mines are all copper mines and the main power requirements are for crushing, ore transport, lighting, housing and industrial water intake.

Table 4 - 7 Estimated Power Requirements for 3 Mines

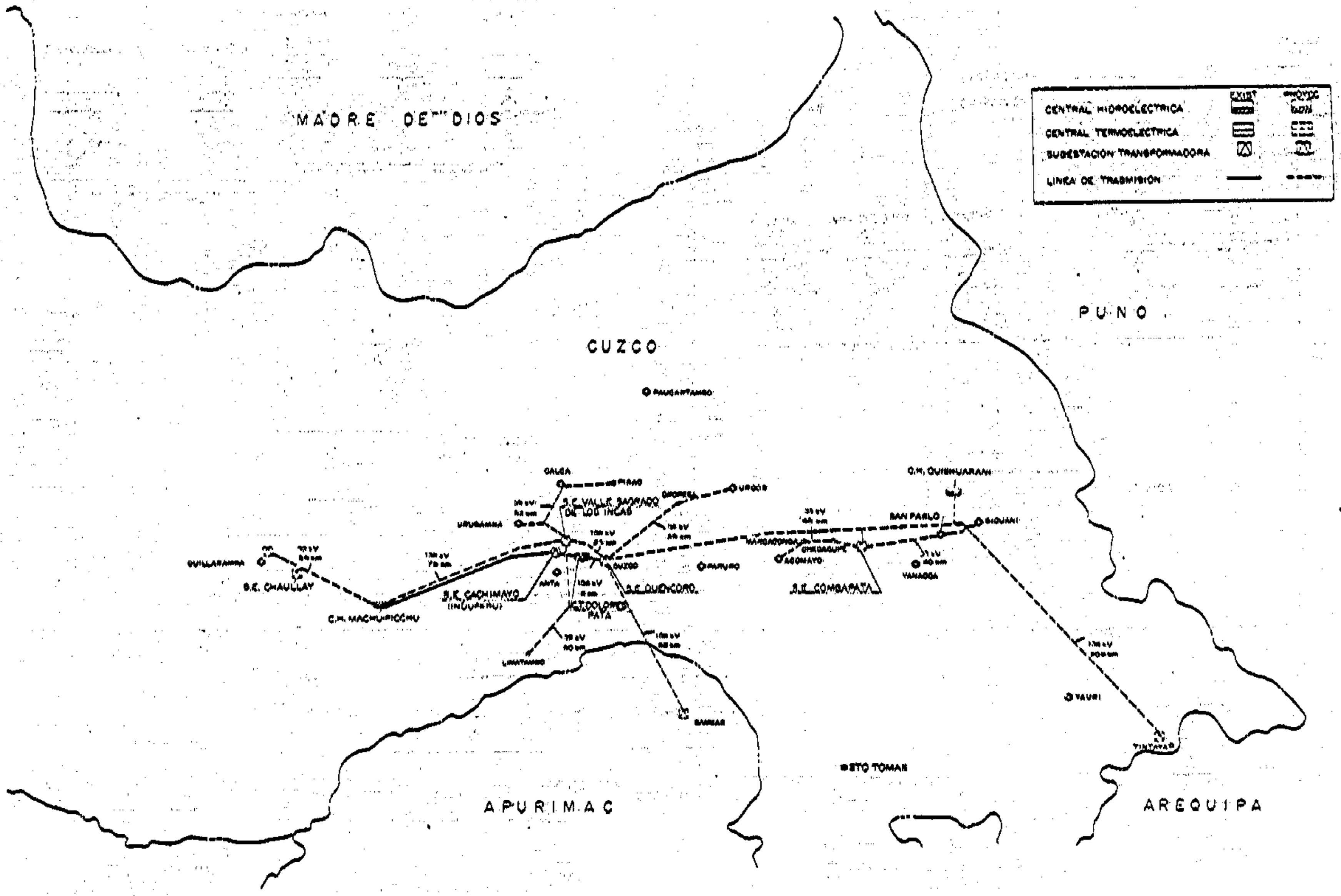
Item \ Mine	Unit	Tintaya	Coroccohuayco	Quechua
Start of operation	Year	1,982	1,985	1,988
Capacity of mine	Ton/day	8,000	1,000	8,000
Equipment capacity	kW	15,000	5,200	15,000
Maximum power	kW	12,000	4,160	12,000
Annual power consumption	MWh	90,000	20,000	68,000

Note: The difference in the power consumption between the Tintaya and Quechua mines is the difference in power used for ore transport.

2-2 Demand and Supply Balance in the Regions Concerned

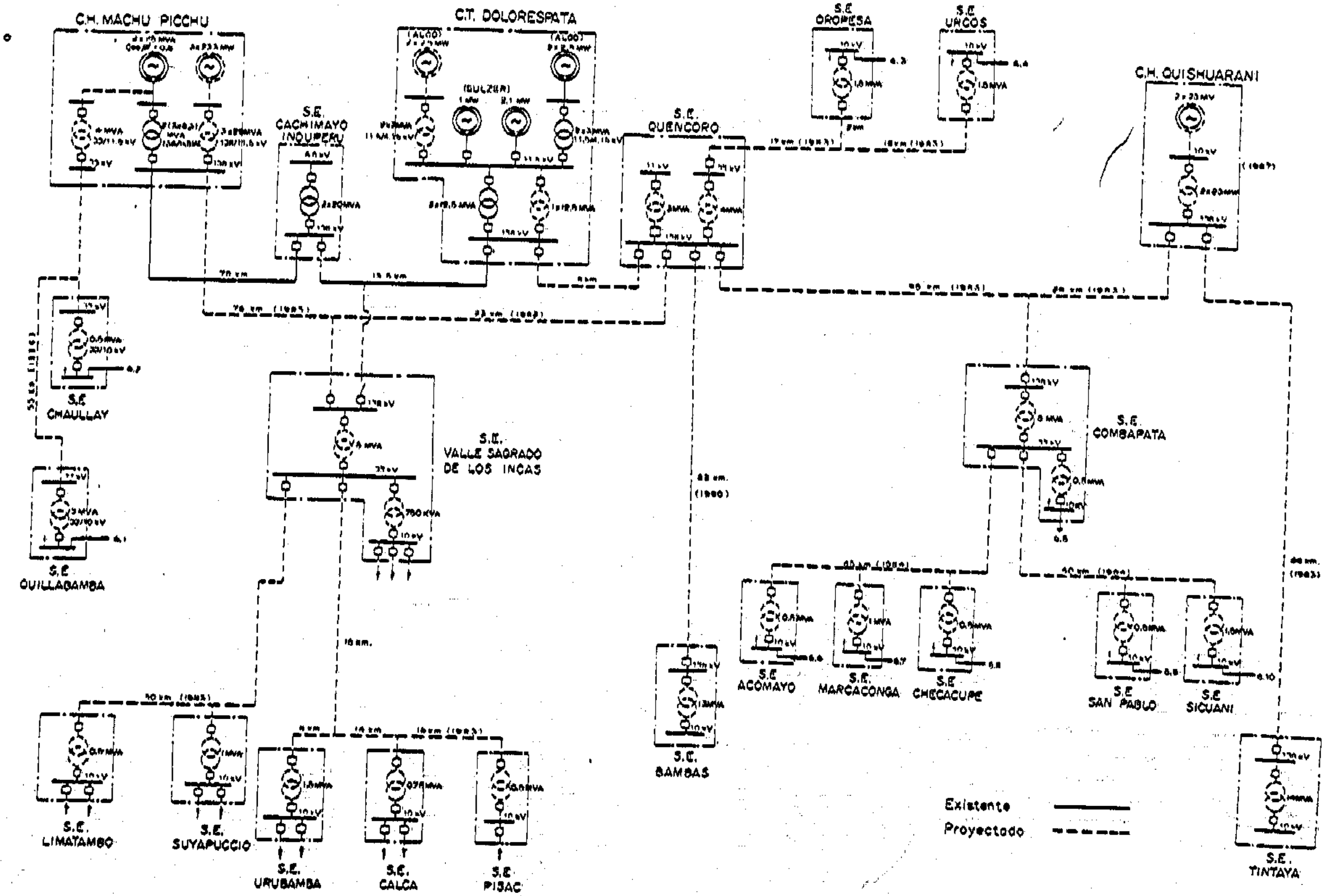
According to Table 4-2, the capacity of both hydroelectric and thermal power generation facilities in Cuzco state was only 51,644 kW in 1975. The main plants supplying this power were the Machu-Picchu Power Plant (output: 40 MW) and the Dolores Pata Diesel Power Plant (output: 3.4 MW), along with various other diesel and hydroelectric generation facilities providing independent power supplies for various areas.

Fig. 4 - 3 Locations of Electrical Equipment after Addition to Machu-Picchu System



Source: Ministerio de Energía y Minas

Fig. 4 - 4 System Diagram after Addition to Machu-Picchu System



Source: Ministerio de Energía y Minas

The Machu-Picchu power system is shown in Figs. 4-5 and 4-6. The demand for various industries and maximum power from 1960 to 1975 are shown in Table 4-8. The estimated kW balance from 1978 to 1990 is shown in Table 4-9 and Fig. 4-7, and the kWh balance is shown in Table 4-10.

From Table 4-9, it is evident that the biggest load for this system, about 65% of the total, is the Cachimayo fertilizer plant.

2-3 Methods of Power Supply to the Mines

Currently, the Atalaya copper mine is in operation about 20 km to the south of Yauri, and it is supplied by diesel power generation equipment. According to the Feasibility Study Report for the Tintaya mine prepared by the H.A. Simons (International) Ltd. in Canada, the power required for the Tintaya mine can be supplied by diesel power generation equipment, but from an overall consideration of the power supply to the three mines in this report: the Tintaya, Coroccohuayco and Quechua mines, the following four methods might be feasible:

(1) Increasing the output of the Machu-Picchu Power Plant
(2) Power supply from the power station for the Majes project
(3) New diesel power generation facilities
(4) New geothermal power generation facilities
(5) New hydroelectric power generation facilities

The following paragraphs give an outline of these four methods.

2-3-1 Increasing the Output of the Machu-Picchu Power Plant

To cope with future increases in power requirements of mines, it is planned to increase the capacity of the Machu-Picchu Power Plant and construct a new 138 kV power transmission line to the Tintaya mine. This line is to be extended to both the Coroccohuayco and Quechua mines to supply them with power.

(1) Power generation facilities

The dam will be left as it is and one new sedimentation basin and iron pipeline will be constructed. Three new Pelton wheels with outputs of 23.3 MW will be added. Together with the current output of 40 MW, the total output will become 109.9 MW. The annual power output will increase from 280 GWh to 830 GWh.

(2) Power transmission and substation facilities

In Cuzco Department, the Quencoro Substation will be newly constructed together with a 138 kV power line to connect this substation to the Machu-Picchu Power Plant. Along this line, various substations including the Los Incas and Bambas substations will be constructed.

The Quencoro substation and Tintaya mine will be connected by a 138 kV power line and the Combapata substation will be constructed along this line.

In the above plan, the anticipated load of the Quechua mine is 15 MW (MEM plan value). However, as shown in Fig. 4-7, when the Quechua mine comes into operation in 1988, it will be absolutely essential to introduce a new power source other than the Quishuarani Power Plant (first stage output: 46 MW) currently planned because of the lack of necessary power.

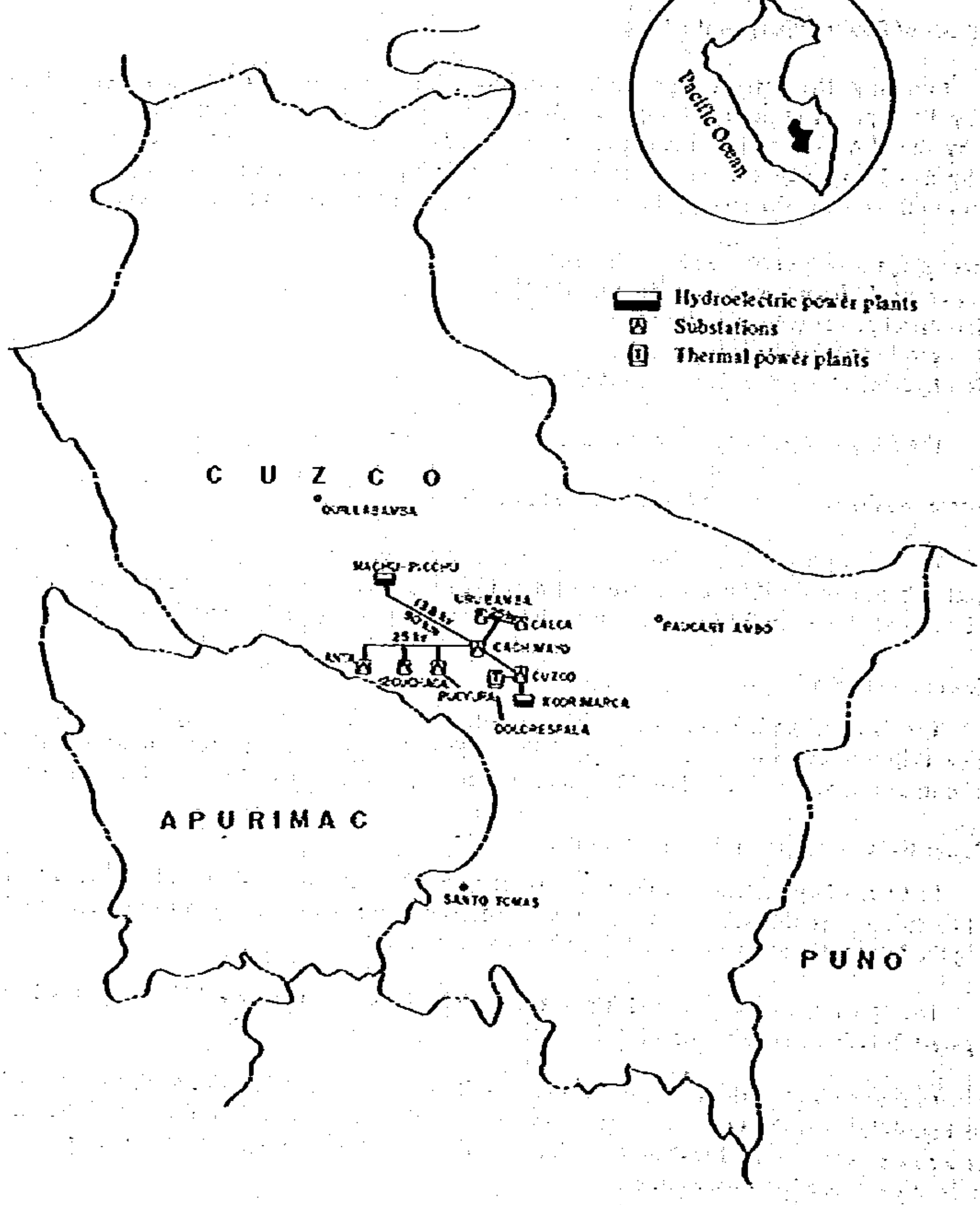
The length of the power transmission line from the Machu-Picchu Power Plant to the mine is 308 km and since the line will pass over highlands, the next surveys must include technical investigations concerning power supply reliability with respect to system instability, corona loss, voltage drops, etc.

2-3-2 Power Supply from the Power Station for the Majes Project

There is also a project known as the Majes Project for development of a power supply for large scale agricultural development using irrigation in Arequipa in the south. The main goals of this plan are as follows:

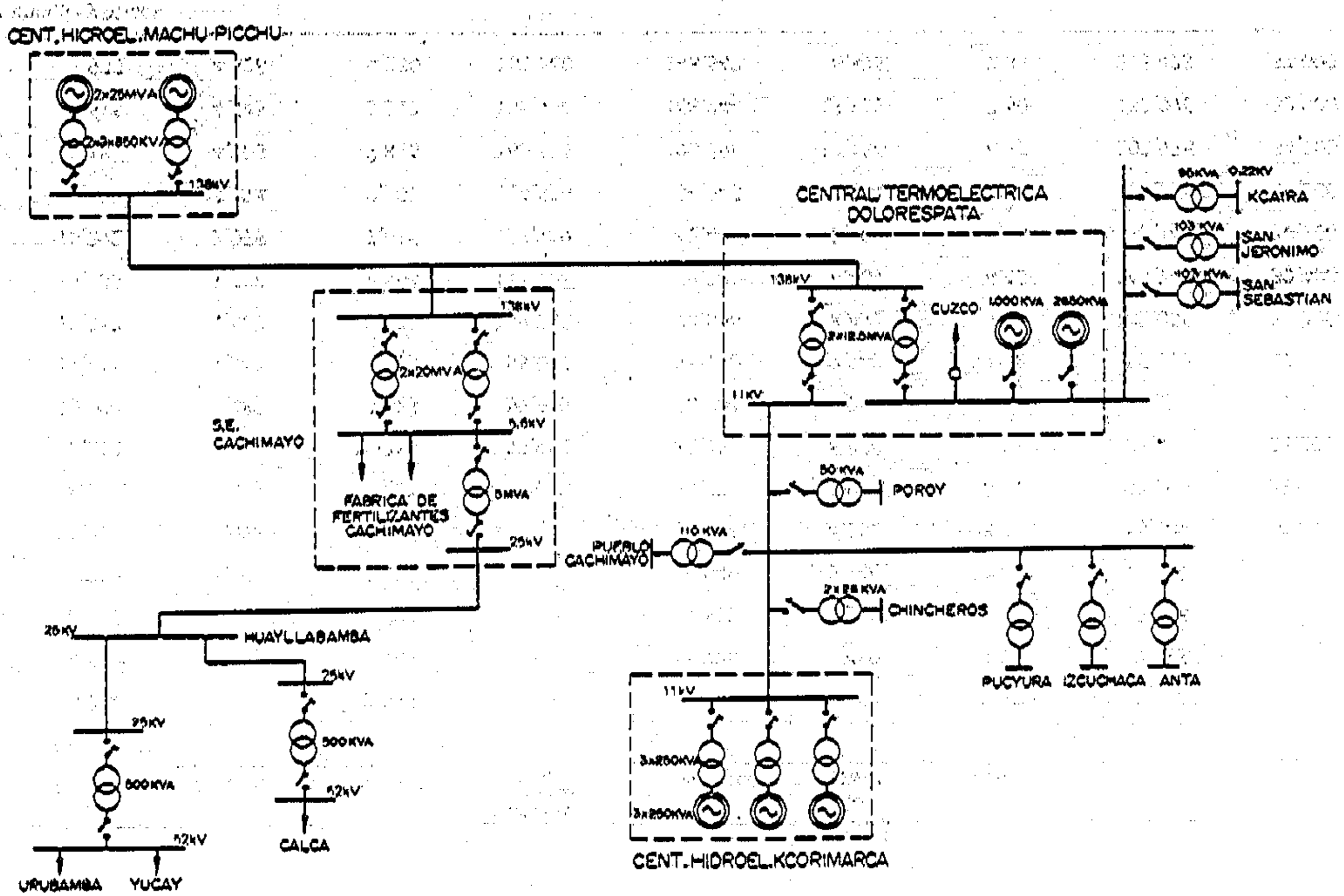
(1) Integrated regional development and promotion of agricultural production for 60,000 ha by irrigation
(2) Settlement of newly developed land by 150,000 persons
(3) Contribution to the development of mining resources, industry and various businesses in Arequipa.

Fig. 4 - 5 Machu-Picchu Power Networks – Cuzco (1975)



Source: Ministerio de Energía y Minas

Fig. 4 - 6 Machu-Picchu Power System Diagram — Cuzco (1975)



Source: Ministerio de Energía y Minas

Table 4-8 Power Requirements of Each Industry and Maximum Power Consumption in the Machu-Picchu (Cuzco)

Year	Public lighting	Domestic lighting	Commerce	Industry	Cachimayo Fertilizer Plant	Sub-Total	Loss (MWh)	Ratio	Total	Max. power (kW)
1960	676	4,266	626	2,535		8,103	657	7.50	8,760	
1961	891	4,837	835	2,163		8,726	459	4.99	9,185	
1962	996	5,757	868	1,892		9,513	1,312	12.12	10,824	
1963	1,016	6,202	1,008	1,823		10,049	2,740	21.42	12,789	
1964	999	6,939	1,078	2,635		11,651	4,558	28.12	16,209	4,600
1965	1,118	8,117	1,337	2,221	71,642	84,435	7,964	8.61	92,399	23,000
1966	1,500	8,812	1,453	10,255	59,952	81,972	6,470	7.31	88,442	22,000
1967	1,876	10,000	1,489	3,823	59,713	76,901	6,298	7.56	83,199	21,200
1968	2,015	11,416	1,567	5,113	55,059	75,170	9,942	11.68	85,112	27,100
1969	2,077	12,367	1,607	8,273	149,240	173,564	8,491	4.66	182,055	31,200
1970	2,494	14,283	1,738	9,548	111,208	139,271	6,469	4.43	145,740	30,400
1971	3,490	15,292	2,075	7,615	133,969	162,441	10,702	6.18	173,143	30,700
1972	4,309	15,627	3,174	7,307	124,526	154,943	11,281	6.78	166,224	29,500
1973	4,416	17,186	4,203	7,816	160,175	193,796	14,180	6.81	207,976	34,700
1974	4,801	19,615	4,545	3,317	135,966	168,244	13,852	7.60	182,096	32,800
1975	4,896	21,933	4,828	4,230	162,660	198,547	16,875	7.83	215,423	37,000

Source: Ministerio de Energía y Minas

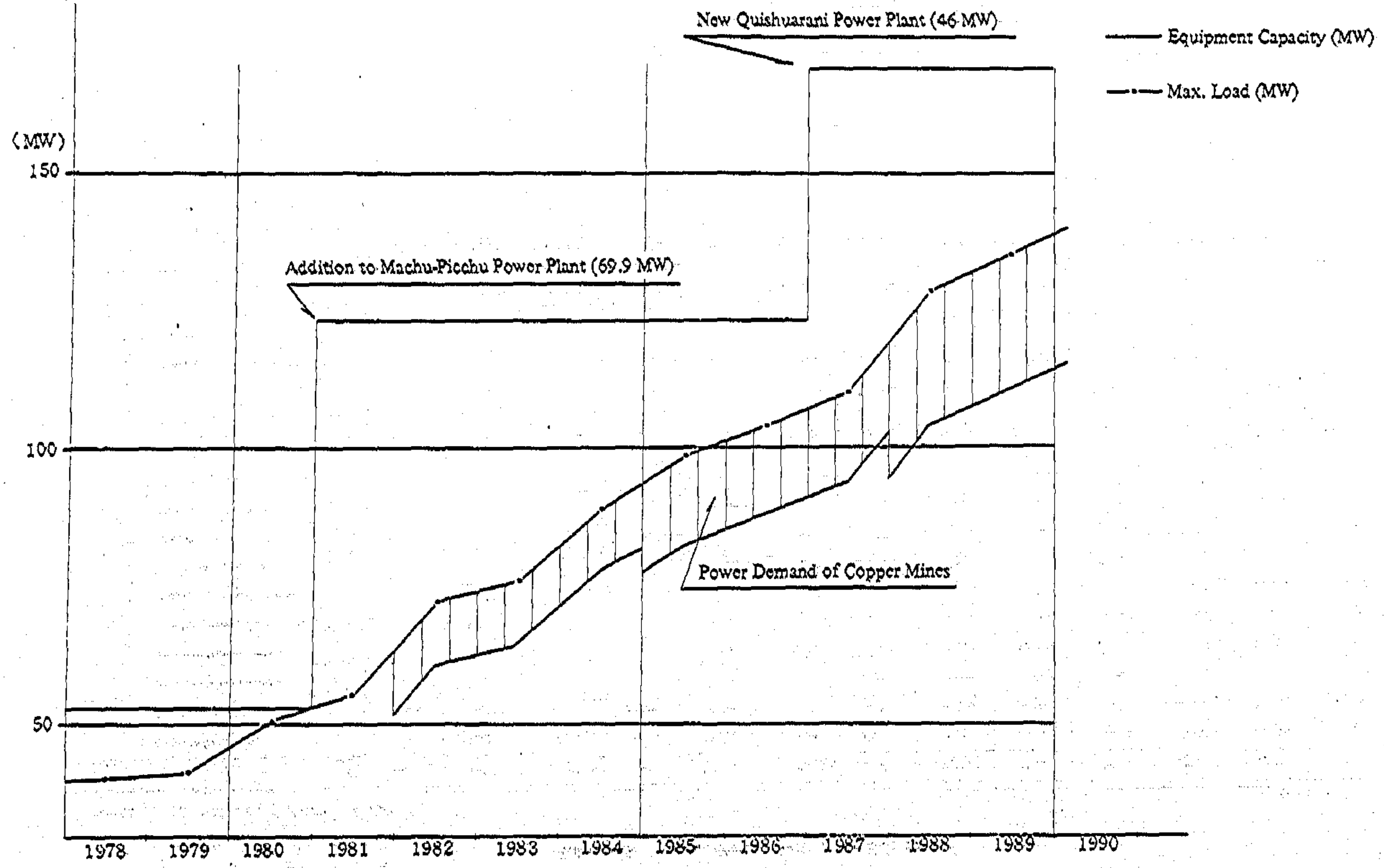
Table 4-9 Machu-Picchu System kW Balance

(Unit: kW)

		1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
DEMANDA MAXIMA (A)	Cuzco-Valle Sagrado	14,323	15,476	16,714	18,051	19,495	21,054	22,729	24,558	26,522	28,644	30,956	33,410	36,083
	Fertilizantes Cachimayo	26,000	26,000	34,000	34,000	34,000	34,000	34,000	34,000	34,000	34,000	34,000	34,000	34,000
	Proyecto Minero Bambas	-	-	-	-	-	-	11,000	11,000	11,000	11,000	11,000	11,000	11,000
	Proyecto Minero Tintaya	-	-	-	-	12,000	12,000	12,000	12,000	12,000	12,000	12,000	12,000	12,000
	Proyecto Minero Corocohuayco	-	-	-	-	-	-	-	4,160	4,160	4,160	4,160	4,160	4,160
	Proyecto Minero Quechua	-	-	-	-	-	-	-	-	-	-	12,000	12,000	12,000
	Fca. Tejidos Maranganí	-	-	-	340	340	340	340	340	340	340	340	340	340
	Quillabamba	-	-	-	-	1,510	1,640	1,704	1,772	1,843	1,916	1,993	2,072	2,155
	Otros Núcleos Urbanos	-	-	-	2,237	6,284	6,915	7,357	7,671	8,003	8,145	8,505	8,781	9,064
	Nuevos Proyectos	-	-	-	-	-	-	-	3,137	6,438	10,110	13,731	17,673	21,791
	TOTAL SISTEMA	40,329	41,476	50,714	54,628	73,629	75,949	89,130	98,638	104,306	110,315	128,685	135,436	142,593
POTENCIA INSTALADA (B)	Existente	53,100	53,100	53,100	53,100	53,100	53,100	53,100	53,100	53,100	53,100	53,100	53,100	53,100
	Ampliación de C.H. Machupicchu	-	-	-	69,900	69,900	69,900	69,900	69,000	69,900	69,900	69,900	69,900	69,900
	C.H. Quishnarani	-	-	-	-	-	-	-	-	-	46,000	46,000	46,000	46,000
	TOTAL	53,100	53,100	53,100	123,000	123,000	123,000	123,000	123,000	123,000	169,000	169,000	169,000	169,000
(B)-(A)		+12,771	+11,624	+2,386	+68,372	+49,371	+47,051	+33,870	+24,362	+18,694	+58,685	+40,315	+33,564	+26,407

Source: Ministerio de Energía y Minas

Fig. 4 - 7 Machu-Picchu System kW Balance (1978 ~ 90)



Source: Ministerio de Energía y Minas

Table 4 - 10 Machu-Picchu System MWh Balance

(Unit: MWh)

		1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
CONSUMO DE ENERGIA (A)	Cusco-Valle Sagrado	57,312	61,091	66,853	72,201	77,977	84216	90,953	98,229	106,087	114,574	123,740	133,640	144,331
	Fertilizantes Cachimayo	174,000	174,000	256,000	256,000	256,000	256,000	256,000	256,000	256,000	256,000	256,000	256,000	256,000
	Proyecto Minero Bamboa	-	-	-	-	-	-	50,000	50,000	50,000	50,000	50,000	50,000	50,000
	Proyecto Minero Tintaya	-	-	-	-	90,000	90,000	90,000	90,000	90,000	90,000	90,000	90,000	90,000
	Proyecto Minero Chorocohuayco	-	-	-	-	-	-	-	20,000	20,000	20,000	20,000	20,000	20,000
	Proyecto Minero Quechua	-	-	-	-	-	-	-	-	-	-	68,000	68,000	68,000
	Fca. Tejido - Maranganí	-	-	-	893	893	893	893	893	893	893	893	893	893
	Quillabamba					6,031	6,551	6,807	7,078	7,362	7,654	7,961	8,277	8,608
	Otros Núcleos Urbanos				11,757	33,028	36,345	38,668	40,318	42,063	42,810	44,702	46,152	47,640
	Nuevos Proyectos								16,488	33,838	53,138	72,170	92,889	114,533
	Perdidas	17,411	17,756	24,737	32,216	33,277	33,851	38,209	38,838	43,946	44,717	45,460	46,224	47,123
	Total	248,723	252,847	347,590	373,067	497,206	507,856	571,530	617,844	650,189	679,786	778,926	812,075	847,128
ENERGIA DISPONIBLE	Producción Energetica (Año Nominal) (B)	372,124	372,124	372,124	923,215	923,215	923,215	923,215	923,215	923,215	1,245,583	1,245,583	1,245,583	1,245,583
	(B) - (A)	+123,401	+119,277	+24,534	+550,148	+426,009	+415,359	+351,685	+305,371	+273,026	+565,797	+466,657	+433,508	+398,455
	Producción Energetica (Año Seco) (B')	372,124	372,124	372,124	744,124	744,124	744,126	744,124	744,126	744,124	1,066,492	1,066,492	1,066,492	1,066,492
	(B') - (A)	+123,401	+119,277	+24,534	+371,057	+246,918	+236,268	+172,594	+126,280	+93,935	+386,706	+287,566	+254,417	+219,364

Note: Power plant capacity is for 3 power plants: the Machu-Picchu hydroelectric, Dolorespata diesel and Quishuarani hydroelectric power plants.

Source: Ministerio de Energía y Minas

The planned power generation is more than 600,000 kW. This is to be supplied by two new power plants for irrigation waterways: the Lluta (output: 270 MW) and Llucila (output: 382 MW) power plants. The areas to be supplied include Arequipa, Cerro Verde, Moquegua, Tacna, Puno and Santa Rosa. The first stage of this Majes Project for agricultural development is now under construction.

2-3-3 Construction of New Diesel Generation Facilities

The Tintaya mine, which will be the first to come into operation, will be supplied with power by seven diesel generators (one of which will be a spare) with an output of 5,350 kW (at an altitude of 4,000 m) and will be connected to the other mines by 66 kV transmission lines.

Establishing independent diesel power generation equipment at each mine will require that spare generators be placed in each mine and common equipment such as fuel tanks, auxiliary devices and cranes will be necessary in each mine. This would increase construction costs and would also result in operation and maintenance costs of double or more when compared with a single facility. Therefore, the establishment of a power plant at the Tintaya mine, the first to be opended, has been investigated.

In the case of diesel power generation, the main problem is securing the fuel oil. When the three mines all start operating, it anticipated that the maximum daily fuel consumption will reach about 150 kiloliters. The fuel can be transported by rail from Matarani port to Sicuani and from Sicuani to the mine by truck, but in both cases, there is the problem of flooding in the rainy season and the necessity of adequate facilities in all cases.

2-3-4 New Geothermal Power Plants

In the Quisicollo area about 30 km southwest of Yauri, a geothermal zone has been confirmed. It might be possible to construct geothermal power plants in this zone and supply the three mines by 66 kV power lines.

Various types of investigations are underway at present, but the results of more detailed investigations are required to determine potentialities. This output should be considered as the mine power supply no matter what the output. (Refer to Chapter 7, Geothermal Power Generation for details.)

2-3-5 New Hydroelectric Power Plants

The Apurimac and Salado rivers flow near the mines. In the present survey, site surveys were impossible but the possibility of dam construction to supply power to the three mines in narrow valley about 2 km to the north of Yauri was investigated using maps. Since the backwater region is a wide-ranging plane, many fields, houses and roads would be flooded and dam construction in this area appears to be impossible.

The Lake Langui y Layo is 15 km to the south of Sicuani and at present, the Hercca Power Plant which supplies power to Sicuani (output: 800 kW) and the Marangani Power Plant (output: 736 kW) which supplies the Marangani textile factory with power are in operation.

One method to supply power to the mines would be to construct a dam at the debouchement of this lake, build a new power plant downstream and supply the power with 138 kV power lines (length: 70 km). However, many fields and at least two villages would be flooded due to the rising water level in the lake. At present, there seems to be little possibility of constructing an independent power plant from the standpoint of economy. However, since the economy might be improved if the construction of a multi-purpose dam to be used for irrigation and industrial water supply is investigated, it will be necessary to collect data including topographical maps and hydraulic material in the future.

2-3-6 Comparison

The advantages and disadvantages of these five possibilities may be compared as follows.

(1) Although its feasibility must be ascertained by the future implementation of a detailed survey, if geothermal power generation proves to be feasible, it would require the lowest unit construction cost of all (for 30 MW, about US$1,250 per kilowatt) and the lowest production cost of all (US$0.03-0.04/kWh; see Table 7-11).

(2) The next most advantageous method is to supply power by means of transmission lines from a hydropower plant to be built or to be built at a larger scale than originally planned. Two alternatives are presented: supply from the Machu-Picchu Power Plant, or from the Majes Project plants. On the basis of the distances involved, the latter is preferred. Because the contents of the Majes Project became known at a point quite near to the completion of the present study, it was not possible to investigate its implications thoroughly, or to have a satisfactory exchange of opinions with authorities concerned. However, since at the present time the feasibility of geothermal power generation has not yet been determined, it is our desire to request the responsible agencies to consider the project area of this study as falling within the range of power supply planning under the Majes Project.

(3) Diesel power generation is inferior in terms of costs to purchasing power, but because economies of scale would not be obtained by contracting a hydropower plant solely for satisfying the mine's requirements, it would be the most expensive method of all. There is also a problem in that a considerable area would become submerged as a result of building a dam.

2-4 Comparison of Power Costs

2-4-1 Prerequisites for the Comparison

In the previous section, four methods of power supply were outlined. With respect to the proposal for construction of a geothermal power plant, comparisons will be made with the other proposals next year since the survey is still in progress. In the cases of the proposal for construction of a hydroelectric power plant, investigations concerning multi-purpose utilization will be carried out in the next stage of the survey. Here, a comparison of power costs will be made between the construction of a diesel power plant and an addition to the Machu-Picchu Power Plant.

The prerequisites for calculation of the power costs are as follows:

(1) The start of operation of the three mines will be 1982 for the Tintaya mine, 1985 for the Coroccohuayco mine and 1988 for the Quechua mine.

(2) The life of each of these mine will be 15 years.

(3) The life of the electrical equipment such as diesel power generation equipment and power transmission lines will be 15 years to match the life of the mines.

(4) The main equipment and materials will be imported.

(5) The imported main equipment and materials will be exempt from customs duties.

(6) When the construction costs are calculated, consideration will be given to the actual site construction conditions and the suitability under current conditions, and the calculation will be based on an estimation of unit prices of equipment and materials.

(7) The price increase rate will be calculated as 7% per year.

(8) In calculations of the economic costs, the discount rate will be 10% and the interest rate for the financial costs will be 7%.

(9) In the diesel fuel price (B heavy oil), the price used for calculations of the financial costs will be the curmet purchase price for the Atalaya mine. The price used to calculate the economic costs will be the price obtained by adding transport costs (US$0.12) to the international price at Callao port (US$0.09).

(10) For the power charges, Tarifa No. 35 [1)] in Table 4-5 will be applied and the electrical fees will be for the case where the load curves are assumed to be as in Table 4-15.

Note: 1) The diesel fuel price (B heavy oil) at the port of Callao used in calculating the economic costs has been estimated as US$0.09/liter. The transport cost of US$0.12/liter is the cost of transport between Callao and Tintaya by tanker truck.

2-4-2 Power Costs in case of New Diesel Power Plant

The diesel power generation facilities will all be located at the Tintaya mine and they will be introduced in three stages in keeping with the times of opening of each of the mines. The following is an outline of the power facilities and the method of introducting them.

In the first stage, four diesel generators (of which one will be a spare) with an output of 5,350 kW (output at an altitude of 4,000 m), outdoor switching equipment (circuit breakers, disconnecting switches, etc.) and a transformer (capacity: 18.75 MVA) will be installed at the Tintaya mine in 1982, the year when the Tintaya mine will start operation.

Common facilities such as the power plant structure, the crane (maximum load: 40 tons) and the fuel tanks will be introduced in this first stage and their construction costs will be born by the three mines in proportion to the power each mine uses.

The fuel tank capacity will make possible 10 days of continuous operation of the six diesel generators at the time when the three mines start operation.

The second stage will involve the introduction of one diesel generator (output: 5,350 kW), outdoor switching equipment (circuit breakers and disconnecting switches) and one transformer (capacity: 26 MVA) at the Tintaya mine in 1985, the year when the Coroccohuayco mine starts operation. In addition, 66 kV power lines will be constructed (total length: about 11 km) for connection with the Coroccohuayco mine. Outdoor switching equipment and one transformer (capacity: 6.5 MVA) will be provided at the Coroccohuayco mine.

The construction costs of the outdoor switching equipment, transformer and 66 kV power lines installed in Tintaya will be born by the Tintaya and Coroccohuayco mines in proportion to the power used by each mine.

For the third stage, two diesel generators (output: 5,350 kW) will be installed at the Tintaya mine in 1988, the year of opening of the Quechua mine. The Quechua mine will be connected with the Coroccohuayco mine by 66 kV power lines (total length: about 7 km). Outdoor switching equipment and a transformer (capacity: 18.75 MVA) will be installed at the Quechua mine. Fig. 4-8 shows the system diagram of the power generation facilities, Table 4-11 shows the construction costs for diesel generators and Table 4-12 shows the power costs.

Table 4-11 Construction Costs for Diesel Power Generation

(Unit: 1,000 US$)

	1978			1982	1985	1988	3 Mines
	Tintaya	Coroccohuayco	Quechua	Tintaya	Coroccohuayco	Quechua	Total
Diesel power plant	13,726	4,623	10,834	16,814	6,935	19,913	43,662
Substation	281	382	984	344	573	1,809	2,726
Power lines	–	68	386	–	102	709	811
Total	14,007	5,073	11,254	17,158	7,610	22,431	47,199

Fig. 4 - 8 System Diagram of Diesel Power Generation

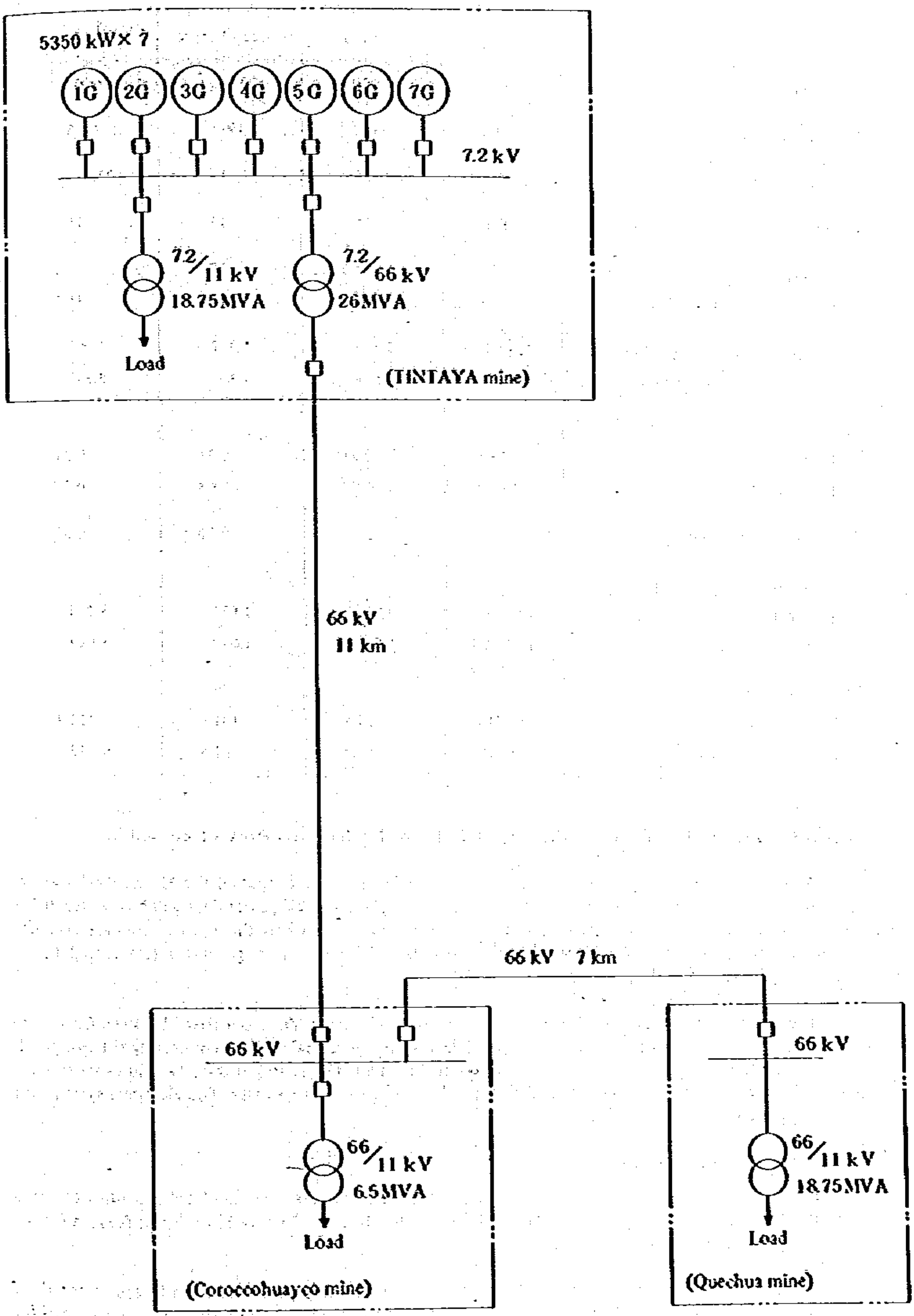


Table 4-12 Power Generation Costs for Diesel Power

Area		Unit	Tintaya	Corocсohuayco	Quechua
Annual power consumption		MWh	90,000	20,000	68,000
Start of operation		Year	1982	1985	1988
Construction costs		1,000 US$	17,158	7,610	22,431
Life of the plant		Year	15	15	15
Annual expense rate	(Economic Cost)	%	18.1	18.1	18.1
	(Financial Cost)	%	15.1	15.1	15.1
Fixed expenses	(Economic Cost)	1,000 US$	3,106	1,377	4,060
	(Financial Cost)	1,000 US$	2,591	1,149	3,387
Fuel costs					
Economic Cost		US$/ℓ	0.21	0.21	0.21
Financial Cost		US$/ℓ	0.08	0.08	0.08
Fuel consumption per kWh		lit.	0.30	0.30	0.30
Annual expenses					
– Economic Costs		1,000 US$	8,776	2,637	8,344
– Financial Costs		1,000 US$	4,751	1,629	5,019
Power generation costs					
Economic Cost		US$/MWh	97.5	131.9	122.7
Financial Cost		US$/MWh	52.8	81.5	73.8

2-4-3 Power Costs for the Case Where the Capacity of the Machu-Picchu Power Plant is Increased

At present, the mining companies are planning to increase the output of the Machu-Picchu Power Plant to meet increased demand in the future. According to this plan, 138 kV power lines will be constructed as far as the Tintaya mine. The power costs have been calculated for the case where these power lines are extended to the other two mines and the power of the three mines is obtained from the same generator. (Refer to 2-3-3 for an outline of the plan to add to the power plant.)

The power line routes used for the calculation were along the Vilcanota River between Cuzco and Sicuani, along the Herrca River between Sicuani and El Descanso and in straight lines connecting the two points between El Descanso and each of the three mines (refer to Fig. 4-9). The routes of the power lines are through highlands at altitude of 3,500 m and over. Supports will be steel towers in all cases. The electrical systems for each of the mines are shown in Fig. 4-10.

(1) Calculation of Financial Costs

In the calculation of the financial costs, the fees for the power used are calculated according to Tarifa No. 35 in the Electric Fee Table (refer to 1-3) which came into effect on 18 May 1978. These fees are for the case where the power is purchased in Cuzco.

The construction costs include the construction costs of the power lines from Cuzco to the three mines divided proportionally according to the power used by each of the mines, with the construction costs for the outdoor switching equipment and transformer at each mine added.

Fig. 4 - 9 Outline of Power Line Route

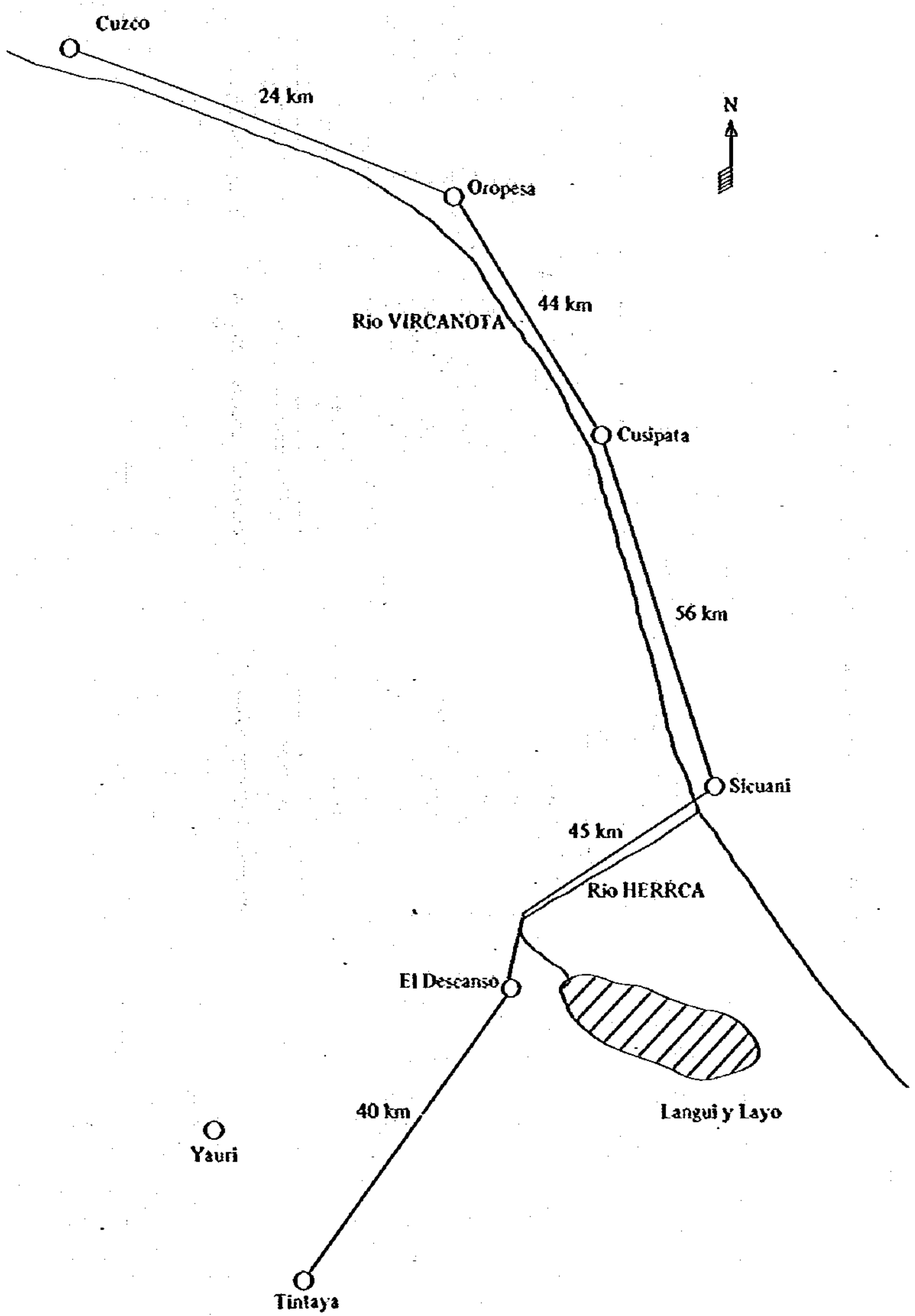


Fig. 4 - 10 System Diagram of Electrical Equipments for Each Mine

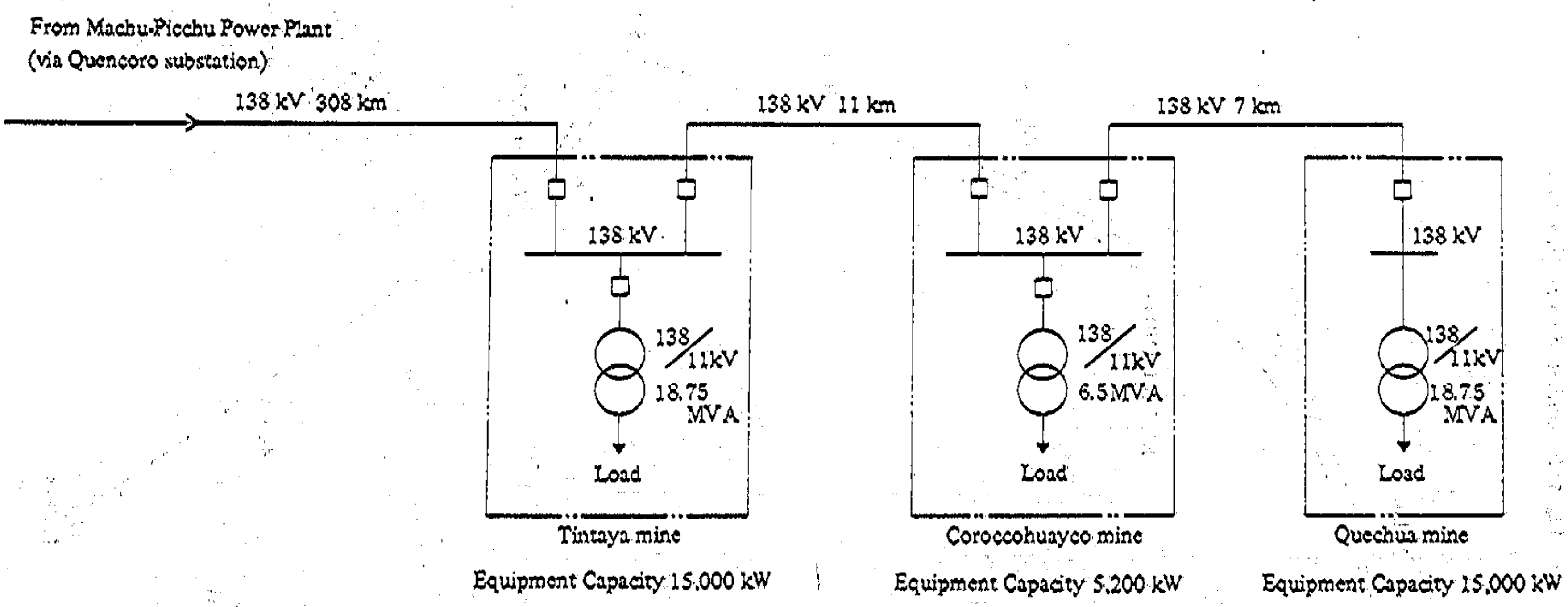


Table 4-15 shows the power (financial) costs in the case where the power is purchased.

(2) Calculation of economic costs

In the calculation of the economic costs, the construction costs are the total of (a), (b) and (c) below:

(a) The total of the construction costs for the addition to the Machu-Picchu Power Plant and the power lines from the power plant to Cuzco divided by the proportion of power used by Cuzco and each mine, i.e. the construction costs in proportion to the power used by each mine.
(b) Construction costs of the power lines from Cuzco to each of the three mines.
(c) The construction costs for the outdoor switching equipment and transformer at each mine.

Table 4-13 shows the construction costs for the addition to the power plant, Table 4-14 shows the economic costs and Table 4-15 shows the financial costs.

Table 4-13 Construction Costs for Addition to Machu-Picchu Power Plant

(Unit: 1,000 US$)

	1978			1982	1985	1988	3 Mines
	Tintaya	Coroccohuayco	Quechua	Tintaya	Coroccohuayco	Quechua	Total
Power plant addition construction	6,726	2,243	6,726	8,239	3,365	10,089	21,693
(Total for 3 mines)		(15,695)					
Substation construction	860	450	855	1,054	675	1,283	3,012
(Total for 3 mines)		(2,165)					
Power line construction	10,200	3,400	10,200	12,495	5,100	15,300	32,895
(Total for 3 mines)		(23,800)					
Total	17,786	6,093	17,781	21,788	9,140	26,672	57,600

Note: The power plant addition construction costs of US$15,695 x$10^3$ represent the total Machu-Picchu Power Plant construction cost of US$30,000,000 divided proportionally between the equipment capacity for the three mines (35.2 MW) and the power plant addition (69.9 MW).

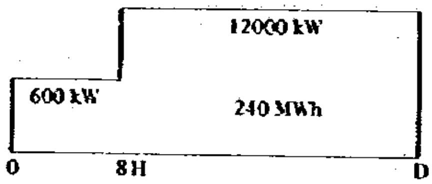
Table 4 - 14 Power Costs (Economic Cost)

	Unit	Tintaya	Coroccohuayco	Quechua
Annual power consumption	MWh	90,000	20,000	68,000
Start of operation	Year	1982	1985	1988
Construction costs	1,000 US$	23,317	9,779	34,975
Life of equipment	Year	15	15	15
Annual cost rate	%	15.1	15.1	15.1
Annual costs	1,000 US$	3,521	1,476	5,281
Power purchasing costs	US$/MWh	39.1	73.8	77.7

Table 4-15 Power Costs (Financial Cost)

Area	Unit	Tintaya	Coroccohuayco	Quechua
Annual power consumption	MWh	90,000	20,000	68,000
Start of operation	Year	1982	1985	1988
Construction costs	US$ x 10^3	8,061	4,851	12,168
Life of equipment	Year	15	15	15
Annual expenses	%	12.9	12.9	12.9
Rate of power line loss	%	5	5	5
Power transmission costs per MWh	US$/MWh	31.6	52.3	44.1
Power fees per MWh	US$/MWh	20.8	20.8	20.8
Power purchasing costs	US$/MWh	52.4	73.1	64.9

(Electrical charges for Tintaya mine)



kW Charges

$569.7^{S.} \times 1/30 \times 12{,}000^{kW} = 227{,}800^{S.}$

kWh Charges

$2.65^{S.} \times 12^{H} \times 12{,}000^{kW} = 381{,}600$

$1.65 \times 8 \times 600 = 79{,}200$

$1.65 \times 4 \times 12{,}000 = 767{,}800^{S.}$

Active component total $767{,}800^{S.}$

Reactive Component (P.F. 0.9)

$240 \times 10^{3\,kWh} \times 0.43 \times 1.3^{S.} = 134.160^{S.}$

$$\frac{134.160 + 767.800}{240 \times 10^3} = 3{,}758 \text{ S./MWh}$$

$= 20.8$ US$/MWh

2-4-4 Distribution of Construction Costs

The consturction costs will be divided between 65% foreign investment and 35% local investment. The local investment will take into consideration the wages of local workers, the expenses for foreign workers staying at the site, the costs of materials such as cement and reinforcing rods which can be obtained in Peru, and the cost of transport of imported materials in Peru. The rest will be foreign investment. The distribution of the construction costs is shown in Table 4-16.

Table 4-16 Construction Cost Distribution

(Unit: 1,000 US$)

	Tintaya mine		Coroccohuayco mine		Quechua mine	
	Foreign currency	Local currency	Foreign currency	Local currency	Foreign currency	Local currency
New diesel power plant	11,153	6,005	4,947	2,663	14,580	7,851
Total for each mine	17,158		7,610		22,431	
Total for 3 mines			47,199			
Addition to Machu-Picchu Power Plant						
Additional power generation equipment	5,355	2,884	2,187	1,178	6,558	3,531
New power lines	8,807	4,742	3,754	2,021	10,779	5,804
Total for each mine	21,788		9,140		26,672	
Total for 3 mines			57,600			

2-4-5 Comparative Effects of Power Costs

When the costs of self-generation of power by diesel generators and the costs of purchasing power from the Machu-Picchu Power Plant are compared, purchase of the power appears to be more economic at present. However, there is the possibility of a drop in output temporarily in a drought year and this could effect the operation of the mines. At present, investigations are underway concerning the possibility of a geothermal power plant. Further detailed investigations and cost comparisons will be necessary, including those concerning diesel generation, before it is decided which power supply will be used for the three mines.

2-5 Preparatory Investigations Concerning the Machu-Picchu System

This investigation was planned by Electro Perú and various problem points involved in the supply of power from the Machu-Picchu Power Plant, which is considered to be the most economical and reliable form of power supply, are discussed.

The basic power transmission plan will include the construction of a single new 138 kV line from the Machu-Picchu Power Plant to the Quencoro Substation in keeping with the increased capacity of the Machu-Picchu Power Plant. One new 138 kV line will be built from the Quencoro Substation to the Tintaya mine and power will be supplied to the Tintaya, Coroccohuayco and Quechua mines. The main power source of this system will be only the Machu-Picchu Power Plant until 1988 when the Quechua mine is to start operationg. The Dolores Pata Diesel Power Plant can be considered as a reserve power plant because of its scale. Power supply to the Tintaya and Corocchuayco mines will all be from the Machu-Picchu Power Plant via the 308 km power line.

Therefore, various problems involved in long-distance power transmission such as voltage drops, the Ferranti effect and corona noise must be investigated beforehand.

Fig. 4-11 shows an outline of the Cuzco power system in 1985.

(1) Voltage drops

In 1985, there is a possiblity that there will be a voltage drop of about 9% at the Quencoro Substation and maintenance of the same voltage at the Tintaya Substation as at the Quencoro Substation.

Therefore, there is no problem of a voltage drop between the Quencoro and Tintaya substations because the power demand is relatively small when compared with the voltage transmitted, but the voltage drop between Machu-Picchu and Quencoro will be about 9% because of the large power demand. It will be possible to maintain 95% of the voltage on the secondary 11.0 kV side of the Tintaya and Coroccohuayco mines by raising the transformer taps by 5% in the Machu-Picchu Power Plant. This voltage drop of 9% should have no effect on the motor load for mining operation.

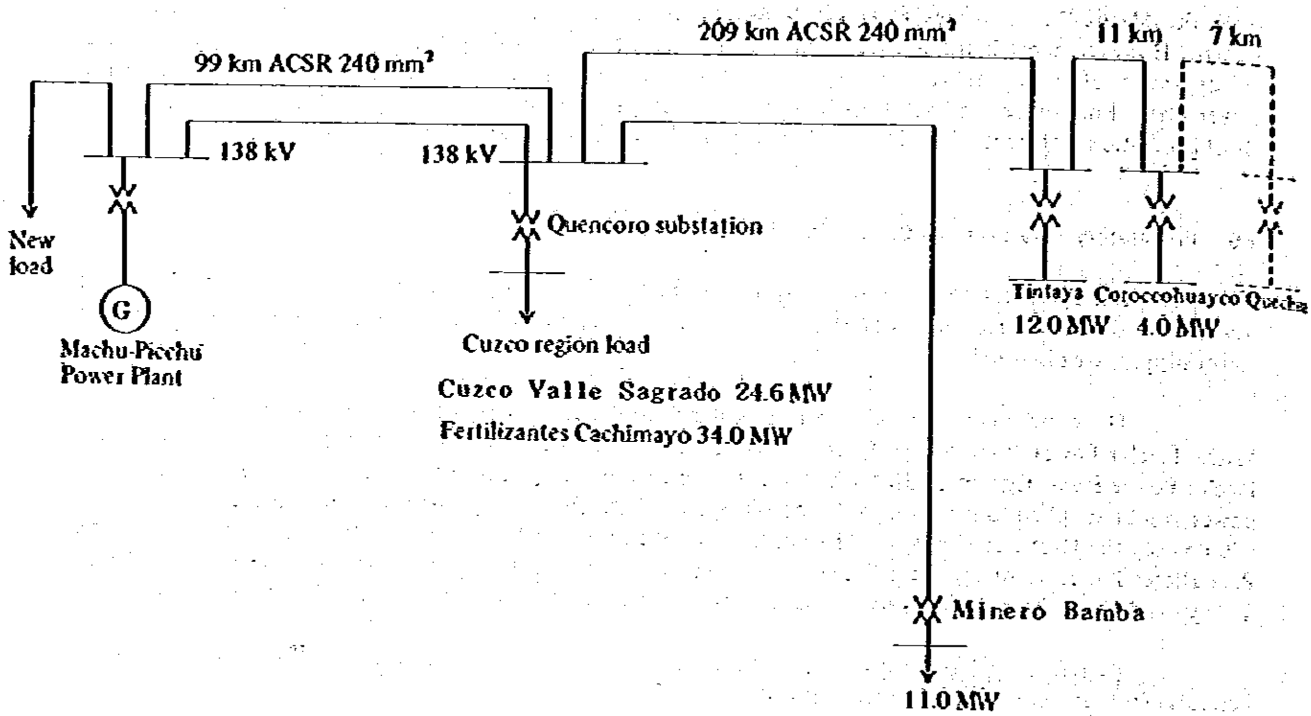
(2) Ferranti effect

In cases where the power requirements of the Tintaya, Coroccohuayco and Quechua mines become very small due to some accident or other abnormality, the voltage in equipment on the 138 kV side of the Tintaya mine will be increased by the capacitance to ground of the power line. This increase is estimated to be about 4% and no special consideration need be given to it in the equipment design. However, special care must be taken with the insulation design to provide resistance to high altitudes.

(3) Corona noise

With the decrease in air density due to the high altitude, the potential gradient on the wire surface drops as the air insulation breaks down. In the existing Machu-Picchu Power System, ACSR 240 mm^2 wires have been selected and the problem of corona noise can be dealt with by selecting wires of the same size for the 138 kV line from the Quencoro Substation to the Tintaya mine. In the future, it will be necessary to investigate the power line routes, the range of radio interference caused by corona noise and the size of the wires.

Fig. 4 - 11 Cuzco Power System (1985)



Source: Ministerio de Energía y Minas

2-6 Communication Plan

At present, radios of the 100 W output class are used for communication between the three mines and Lima. It will be possible to use these radios after the mines start operating.

It will be desirable to provide power line transmission telephone equipment utilizing the power transmission lines for communications among the mines. There should also be wire telephone equipment (40-circuit automatic exchange) for communication within the mine premises. Table 4-17 shows costs of communication system construction.

Table 4 - 17 Costs of Communication System Construction

(Unit: 1,000 US$)

Item \ Mine	Tintaya		Coroccohuayco		Quechua	
	Foreign currency	Local currency	Foreign currency	Local currency	Foreign currency	Local currency
Communication equipment (including construction costs)	133	71	163	87	199	107

3. Recommendation for Further Detailed Studies

The results of this survey have indicated that purchasing power from the Machu-Picchu Power Plant is the most economical. However, detailed investigations which were impossible this time must be performed in the future since no goals have been established for raising the funds required for the Machu-Picchu Power Plant expansion plan and details of the new Quishuarani Power Plant (amount of power generated annually, fund raising goals, etc) are not clear at present.

In the Majes Project, only the construction related to agriculture is underway at present, but since there is a possibility of using it as a power source for the three mines, it is necessary to investigate the Lluta and Luclla power plants, including power line routes. The following items should be included in the next detailed survey:

(1) Detailed survey of the possibility of a geothermal power plant.

(2) Transport route survey in both seasons concerning fuel oil transport for diesel power generation.

(3) Detailed survey of the plans to expand the Machu-Picchu Power Plant and construct the new Quishuarani Plant, especially construction schedules for both plants with respect to the start of operation of the three mines, the time of the start of operation, construction fund raising goals and the amount of power generated annually.

(4) Site investigation of the power line route from the Machu-Picchu Power Plant to the mines.

(5) System technical investigation of the power lines (voltage variations, corona noise, etc.)

(6) Detailed investigation of the Lluta and Lluclla power plants in the Majes Project.

(7) Route site survey for power lines from the Lluta and Lucla power plants to the three mines.

CHAPTER 5

DEVELOPMENT OF ROADS

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1. Situation of Roads in Peru

1-1 Present State of Road Networks

The Andes mountains has an average altitude of 1,000 meters across the central part of Peruvian territory from north to south. So, its territory presents three district regions: the littoral region, the mountainous region and the forested region.

Concerning the roads, there is only the "Pan American Highway" extending from north to south in the littoral region. The "Pan American Highway" has facilities that connect it with the important cities far from the littoral. This situation is clearly seen as a direct consequence of the difficult geographical conditions on one side and for the economic activities of the country on the other.

The main cities of economic importance are situated in the littoral region, accompanying the "Pan American Highway". Because the economic center of Peru surrounds the capital, Lima, the roads in this region are quite good, not different from the other developed countries.

In contrast, the road condition of the interior region is precarious. There are very few roads that interconnect partially with the littoral region. Principally, the forested region is not explored, and the roads do not exist there.

The volume of traffic has been increasing as the country develops economically and as the roads become saturated as a transportation menas. For the economic development of Peru, the roads must be improved.

1-2 The Road and Its System

1-2-1 The Situation of Road

Peru has an extension of 57,000 km road, but only 5,900 km are paved. The whole extension 2,650 km of the "Pan American Highway" is paved, and so, the interior region presents a extremely low percentage of paved road.

The region surrounding the capital, Lima, the center of economic activities is well provided by good roads. Some of them have 4 lanes and even 6 lanes. But in the interior, the roads have 1 lane or at most 2 lanes.

The main obstacle to transportation occurs in some mountainous and forested regions roads, during the rainy season (from December to April). The inundation and the consequent bad condition of the roads obstruct the traffic in some parts.

In 1966, the toll road system has been established in order to supplement the budget for roads facilities. Actually, the toll road system is used in 15 routes inside the country. Table 5-1 shows the development of road extension network. Fig. 5-1 presents the Peru's road network map.

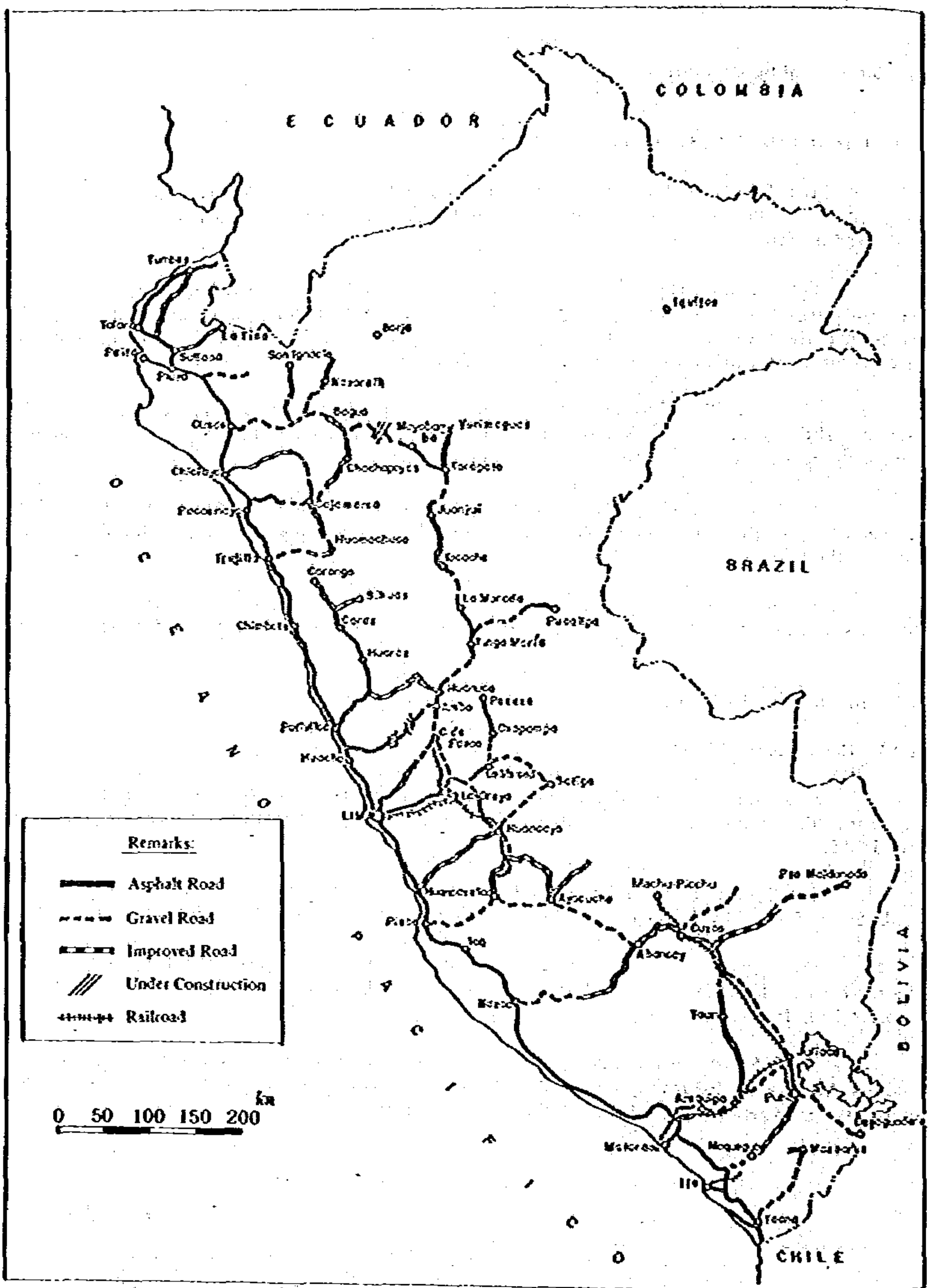
Table 5 - 1 Development of Road Extension Network

(Unit: km)

Year	Paved Road	Gravel Road	Improved Road	Track	Total
1965	4,334	6,449	11,645	20,389	42,817
1970	4,857	8,654	13,905	22,889	50,306
1977	5,949	11,929	14,650	24,412	56,940

Source: Ministerio de Transportes y Communicaciones

Fig. 5 - 1 Road Network of Peru



Source: Plan Director de Transportes, 1977 – 1986

1-2-2 Road Network System

The roads have been planned and administered according to their degree of importance and characteristics.

(1) National Route – connection roads between important cities, also between important cities and harbors or frontiers. The roads are very important for the national interest.

(2) Department roads – connection roads between important areas inside the state. They are fundamentally important from both an economical and a social point of view.

(3) Urban roads – are the roads inside the cities and so on.

According to the service level, the roads has been organized and systematized as follows:

(1) Multiple lane highway (more than 2 lanes in each direction) – has been planned for a traffic volume over 4,000 vehicles per day.
(2) Class 1 -- has been planned for traffic volume of 2,000 to 4,000 vehicles per day.
(3) Class 2 – for a traffic volume of 200 to 400 vehicles per day.
(4) Class 3 – for a traffic volume less than 400 vehicles per day.
(5) Other roads – traffic volume not calculated.

Basically, these criteria are appropriate for national and department roads. For the urban roads, including the (4) and (5) criteria above mentioned, other standards have been established.

1-2-3 Present Situation of Road Network

The main roads of major importance are well equipped, but most of the other ones are poorly equipped. This can be observed in the river region, where there are many places with no bridges or only bridges for very low load conditions. In the latter case, the big obstacle is the restriction placed upon high tonnage vehicles.

During the rainy season, in the plain region, there are places with poor soil condition, and the ground has neither been conveniently treated nor well drained. Consequently, there are parts where traffic becomes impossible due to the inundations. But, if maintenance were to be performed, these roads could be normally utilized, during the dry season.

Along extensions inside the mountainous region, places of tumble down danger can be observed, because of imperfect treatment of the surface of a slope section. There are also some sections without or guard rails that cannot insure the safety of the traffic flow.

Asphalt is used in the pavement of roads in their totality, and excluding construction recently finished, some areas with holes and damaged parts in the asphalt can be observed. This is due probably to the fact that the ground has not been conveniently treated. In contrast to these roads in a precarious state, other roads are well equipped with wide road lane and shoulder and can handle traffic satisfactorily even though they are paved with gravel.

In 1970, the government of Peru established road criteria to orient the road project. The synthesis of this criteria, the objective of which is to develop roads with a high service level, is stated as follows. Table 5-2 and 3 represent the standard data of road and standard value of roads' geometrical structure.

Table 5 - 2 Standard Data of Road Shoulder

Traffic Volume / Design Speed	Less than 50 vehicles/h		50 ~ 100		100 ~ 200		200 ~ 400		400 over		Shoulder Width (m)	
	a	b	a	b	a	b	a	b	a	b	Standard Size	Minimum Size
30 km/h		5.5 m									1.20 m	0.75 m
40											1.20	0.75
50					6.0 m						1.80	1.20
60								6.6 m			1.80	1.20
70											2.40	1.50
80											2.40	1.50
90									7.3 m		3.00	1.80
100											3.00	1.80
110											3.00	1.80

Note: a: Low traffic flow on urban and state roads
b: High traffic flow on important state roads

Source: Ministerio de Transportes y Comunicaciones

Table 6-3 Standard Value of Roads' Geometrical Structure

Design Speed	Minimum Radius of Curvature (m)			Maximum Grade of the Slope (%)		
km/h	1	2	3	1	2	3
30	30	25	27	6.0	10.0	8.0
40	60	45	50	6.0	10.0	8.0
50	90	75	80	6.0	10.0	8.0
60	130	110	120	6.0	10.0	8.0
70	190	160	170	6.0	9.5	8.0
80	250	220	230	6.0	9.0	8.0
90	330	280	300	6.0	8.5	8.0
100	420	380	380	6.0	8.0	8.0
110	530	475	475	6.0	8.0	8.0

Note: 1; Desirable Value
2; Special Value
3; Special value in case of great number of heavy vehicles

Source: Ministerio de Transportes y Comunicaciones

1-3 Traffic Volume

1-3-1 Number of Privately Owned Vehicles

During the past few years in Peru, there was an 5–7% increase in the number of privately owned vehicles, according to Table 5-4. But the number per capita is still very low, 1 vehicle per 35 persons, and most of the vehicles are for industrial and/or commercial use. The individual use of vehicles is restricted only to the regions of the capital.

But, actually, the increase rate of vehicles has slowed due to the high price of the vehicles themselves and gasoline. Despite this fact, there is a possibility of increase in the number of privately owned vehicles, depending on the stabilization of the economic condition of the country. Table 5-4 represents the increase in the number of privately owned vehicles.

1-3-2 Traffic Volume

Fig. 5-2 presents the traffic volume on the main road in Peru. We can observe that even on most of the national routes the traffic volume is only a few hundred vehicles per day. Even between main cities, the traffic volume is 1,000–3,000 vehicles per day, and excluding inside the city, there are no traffic jams.

1-4 Construction, Conservation and Administration of the Roads

Construction, maintenance and administration of the roads are performed by the central government, under the jurisdiction of the Ministerio de Transportes y Comunucaciones (MTC), the organization of which has been presented in the Fig. 5-3. The department of surface transportation is responsible for the roads.

The regional organization is composed of 7 regional main offices and 26 states offices. In reality, in these offices, the construction, maintenance and administration of federal and regional roads are organized.

The regional office have all rights concerning maintenance and administration. But concerning construction, the main office does the planning, and the regional offices are responsible only for the execution of the project.

Table 5-4 Increase in the Number of Privately Owned Vehicles

(Unit: 1,000 vehicles)

Year	Privately Owned Vehicles	Commercial Use Vehicles	Total	Percentage Increase Over Last Year
1967	180	105	285	1.114
1968	191	107	298	1.048
1969	203	112	315	1.053
1970	213	116	329	1.044
1971	222	119	341	1.037
1972	234	124	358	1.052
1973	250	132	382	1.064
1974	266	140	406	1.064
1975	285	149	434	1.066
1976	301	155	456	1.052
1977	312	158	470	1.032

Note: The population of Peru in 1977 was 16,300,000.
Per Capita Index: 370/16,300 = 1/35 vehicles/person

Source: Parque de APIA informacion venta de vehiculos e importaciones

Figs. 5-3 and 4 represent the principal organizations. Outside these organizations, the army also executes a considerable part of road projects.

Table 5-5 represents the estimated value of the road network. The actual situation is that it is not possible to have a perfect and multiple facilities road system because of the low percentage of national budget for the roads.

Table 5-5 Estimated Budget for Road Expansion

(Unit: M. Soles)

Year	Construction		Improvement		Maintenance & Administration	
	km	Cost	km	Cost	km	Cost
1977	248	*3,125	138	1,694	55,507	1,050
1978	271	*3,962	175	1,930	56,642	1,270

Note: * What can be considered improvements are also included.
Source: Ministerio de Transportes y Comunicaciones

1-5 Road Construction Planning

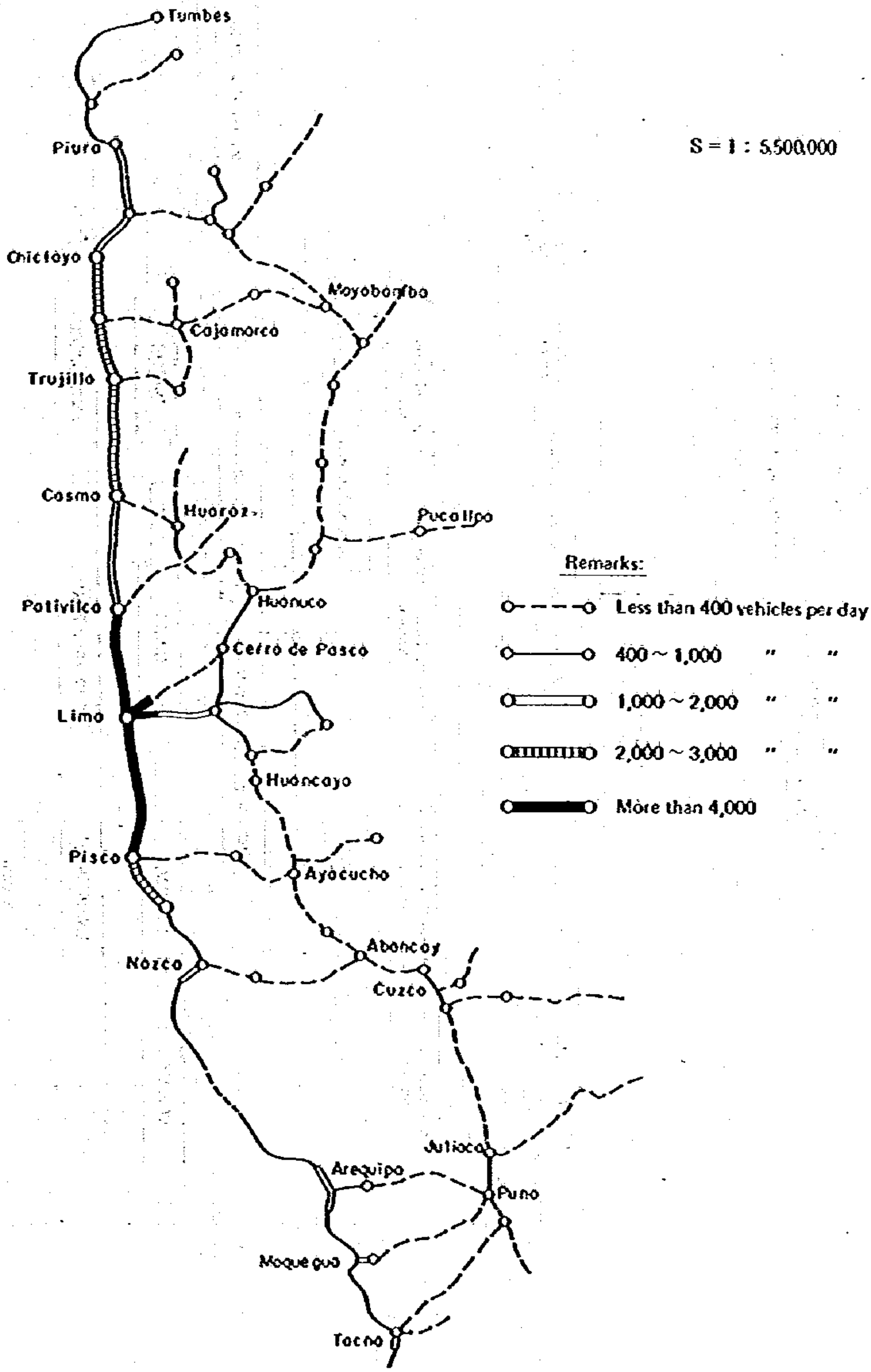
As part of the economic development planning of the country, the government of Peru has established and is executing "Four Year Planning for the Development of New-Nations". This started in 1975, and because it was finished in 1978, the government is faced with the preparation of "Five Year Planning", that will be under way in 1979.

The present "Four Year Planning" was organized considering very important investments in the road facilities, because this was considered to be of fundamental importance for the economy. This orientation would also be under way in the next "Five Year Planning".

Including these planning efforts, the Ministry of Transport and Communications is also elaborating upon other planning for the Ministry of Transport and Communications for the period 1971-86. The objective is to solve the problem of increasing demand for transportation in the future.

Tables 5-6 and 7 represent the planning of road facilities in this project.

Fig. 5 - 2 Traffic Volume on the Main Road (1977)



Source: Ministerio de Transportes y Comunicaciones, TRANSITO, 1977

Fig. 5-3 Organization Chart of M.T.C. (Central)

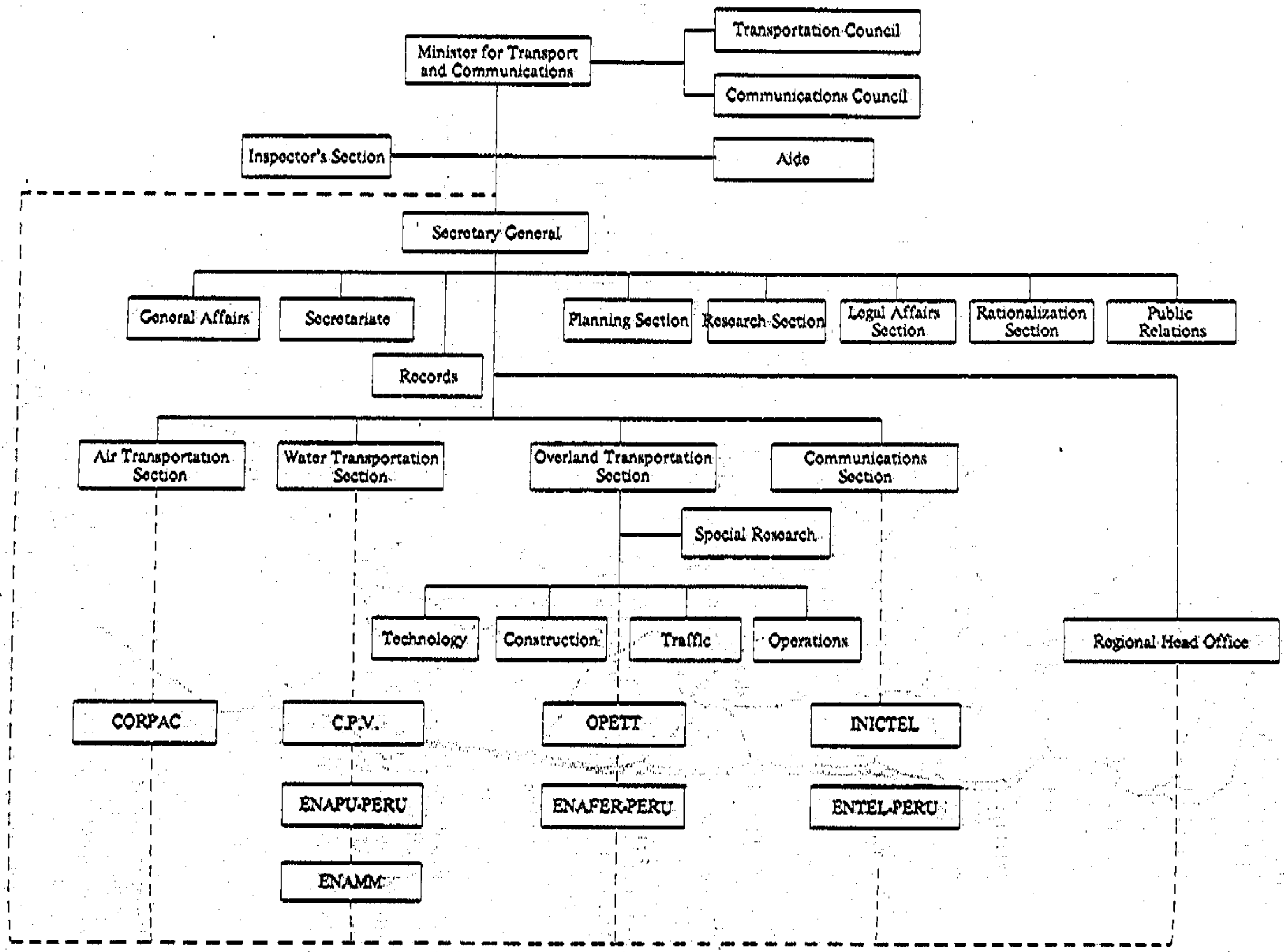


Fig. 5・4 Organization Chart of M.T.C. (Regional)

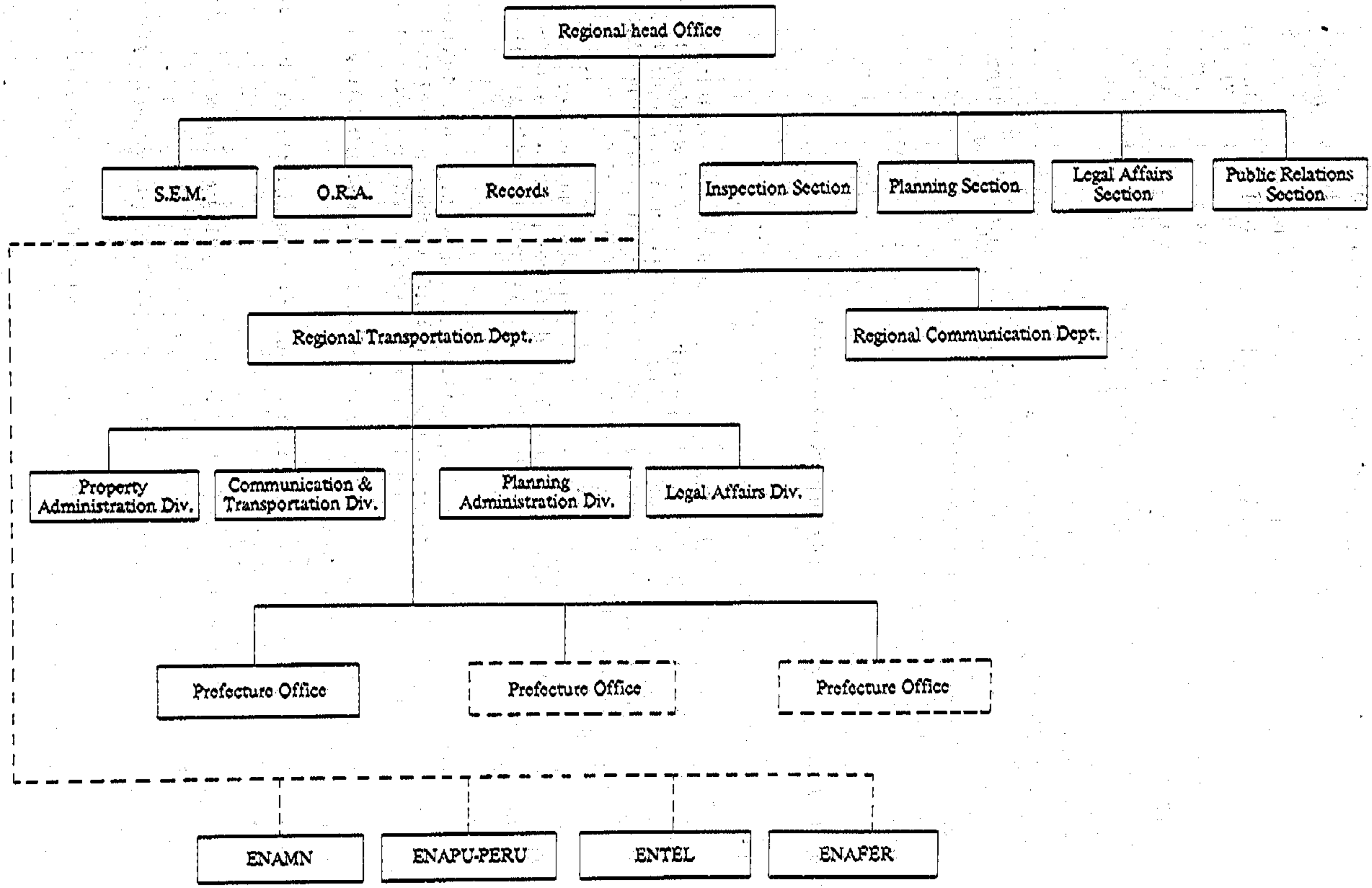


Table 5-6 Road Facilities Planning by Area (1977 – 86)

(Price in 1976)

Area	Paved Road	Gravel Road	Total	Cost
	(km)	(km)	(km)	(M. Soles)
North Region	577	213	790	9,016
Central Region	903	641	1,544	7,589
East Region	0	134	134	1,049
South Region	445	296	741	6,273
(Urcos ~ Pte. Inambari)		(296)		
(Puno ~ Ilave)	(56)			
(Moquegua ~ Mazocruz ~ Desaguadero)	(389)			
Total	1,925	1,284	3,209	23,027

Note: Road expansion indicates that this was concluded.

Source: Plan Director de Transportes, 1977 – 1986

2. Road Development Accompanying the Exploration of Copper Ore

2-1 Location of Roads under Development

The copper ore to be explored is located in Espinar, in the south region of Cuzco Department. In a straight line, Espinar is 180 km from Cuzco, which is the most important city in the interior region. Espinar is also 180 km from Arequipa, the principal city of littoral region, and 90 km from the important harbor of Matarani as the crow flies. As Espinar is located in an isolated and distant region and on a 4,000 m high plateau, the facilities of the road network are quite precarious. During the rainy season, vehicles cannot pass.

For the development of the mine, it is necessary to transport a great quantity of construction materials, concentrate ore, fuel and machines between Espinar and the harbor of Arequipa city. Presently, a railroad and a major highway connect Matarani – Arequipa – Juliaca – Cuzco, and so, access is possible up to 90 km away from the mines.

The road connecting the cities of Arequipa and Juliaca, however, has long parts in which there are many bends and steep grades. The railroad also presents the same unfavorable conditions. With the future increase in traffic volume, it is quite difficult to accept that this situation will be adequate for the transportation of ores.

Due to the location of the mines and the condition of the roads, we can conclude that improvements in the local transport conditions are absolutely necessary.

As a transportation menas, it can be thought that there are two options, one being roads alone and the other being roads and railroads together.

To decide which one is more advantageous, it is necessary to consider the general condition of railroads and the harbor. But at this time, such an investigation has not been performed.

Therefore, the present report presents a study of both types of transportation, considering the ideal situation of roads.

In this region, there are many mines and great opportunities to develop agricultural and cattle-breeding activities in this extended plain area.

Table 5-7 Planning of Investment per by Road (1977 – 86)

(Unit: M. Soles, Price in 1976)

	DESCRIPCION	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	TOTAL
	Total	2,324	3,400	3,462	2,776	2,532	1,484	1,576	2,121	2,279	1,973	23,927
1	North Region	1,084	1,817	1,824	1,382	1,315	215	307	460	459	153	9,016
	Tambo Grande-La Tina								153	153	53	459
	Sechura-Desvío Lambayeque	100	221	221								542
	Acceso Bayóvar											
	Olmos - Corral Quemado	435	715	715	715	715						3,295
	Corral Quemado-Quebrada Honda							195	195	195		585
	Quebrada Honda-Pte. Ingenio	50	60	–	–	–	111	112	112	111		556
	Rio Nieva - Tarapoto	239	70									309
	Corral Quemado-Ayar Manco	60	150	150	140							500
	Tembladera - Cajamarca	70	40									110
	Santa - Caraz			177	177							354
	Pativilca - Huaraz - Caraz	130										130
	Shorey - Pte. Pallar.		319	319								638
	Mejoramiento tramos críticos Panamericana Norte.	–	242	242	350	600	104					1,538
2	Central Region	1,145	1,185	1,039	717	717	340	340	832	637	637	7,589
	La Oroya - Las Vegas		282									282
	Cerro de Pasco-Huánuco	445	55									500
	Seyán - Ambo			192	192	192						576
	Huánuco-T. María-Pucallpa	700	663	662								2,025
	Las Vegas - La Merced									145	145	290
	Satipo - Pto. Ocopa								164	164	164	492
	Izcuchaca-Huancavelica								164	164	164	492
	Huancavelica-Empalme Pisco-Ayacucho								164	164	164	492
	Pisco - Ayacucho				340	340	340	340	340			1,700
	Izcuchaca - Ayacucho		185	185	185	185						740
3	South Region	20		200	500	500	929	929	829	1,183	1,183	6,273
	Nazca - Abancay									354	354	708
	Urcos - Pte. Inambari				300	300	300	300	300	300	300	2,100
	Pte. Inambari-Pto. Maldonado	20										20
	Urcos - Juliaca						277	277	277	277	277	1,385
	Puno - Ilave						52	52	52	52	52	260
	Moquegua-Mazocruz-Ilave-Desaguadero			200	200	200	300	300	200	200	200	1,800
4	East Region	75	398	399	177							1,049
	Tarapoto - Yurimaguas	25	176	177	177							555
	Campanilla - La Morada	50	222	222								494

Source: Plan Director de Transportes, 1977 – 1986

The transportation route would, therefore, not be exclusively for the mines at Espinar, but would also be an important element in the development of agricultural and cattle-breeding activities. For this reason, studies of development of the roads have been performed, considering the future development of this region. Fig. 5-5 presents the location of the mines to be explored.

2-2 Development of the Region and Parallel Projects

The present region is located in a plateau, under unfavorable climate and soil conditions. Actually, other than cattle-breeding and mine exploration, there are no other appropriate industries. Excluding the statements mentioned below, there is no objective development project. But the wide unexplored areas offer for the future a very good possibility to develop agricultural and cattle-breeding activities. Fig. 5-6 presents the location of the parallel project.

(1) Development of mine exploration

As shown in Fig. 5-6, this region offers many mines and multiple possibilities for future development. To link the refinery of the littoral region with the harbor the transportation mode could be either the railroad or the road.

(2) Majes Project

As part of general development program of the south region of Peru, the Majes project has as its main objective the development of agriculture on a large scale using the irrigation system of grassy plain in Siguas and Majes. The latter two places are located on the west side of the department of Arequipa. The fundamentals of this project are stated below:

i) General development of the region using irrigation and also installation of parallel facilities in a 60,000 ha. area.
ii) Settlement of 150,000 persons in the irrigation region.
iii) 600,000 kW electrical power station installation, to provide for industrial development and exploration of Mines in the department of Arequipa.

This large scale irrigation planning, quite rare for South America, will be performed in two steps.

As the first step, construction of infrastructure is practically concluded, while the construction of channels of the Condorona dam has just started and is supposed to be concluded in 1982. Following this, the second step of the project will be started. The conclusion of this project is expected in 1986.

Summary of the Project

(1)	Irrigation area:	grassy plain of Majes	35,000 ha
		grassy plain of Siguas	22,000 ha
		area of Achoma	3,000 ha
		Total	60,000 ha
(2)	Dam construction:	Condoroma	200×10^6 m^3
		Angostura	$1,000 \times 10^6$ m^3
(3)	Electrical power production:		600,000 kW
(4)	Production:	agriculture, cattle-breeding, dairy products	
(5)	Planned population:	150,000 persons	

Fig. 5-5 Location of Mines to be Explored

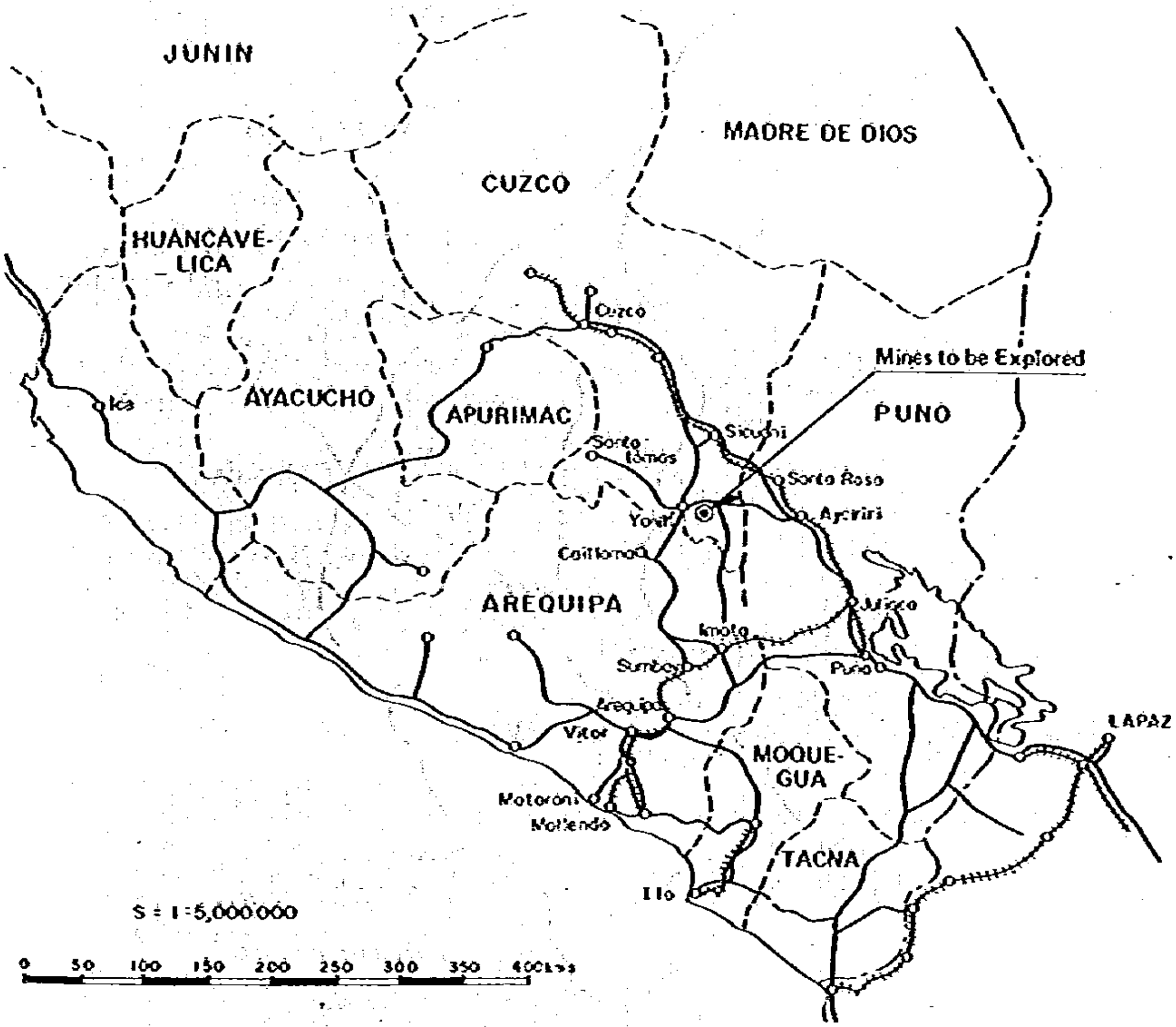
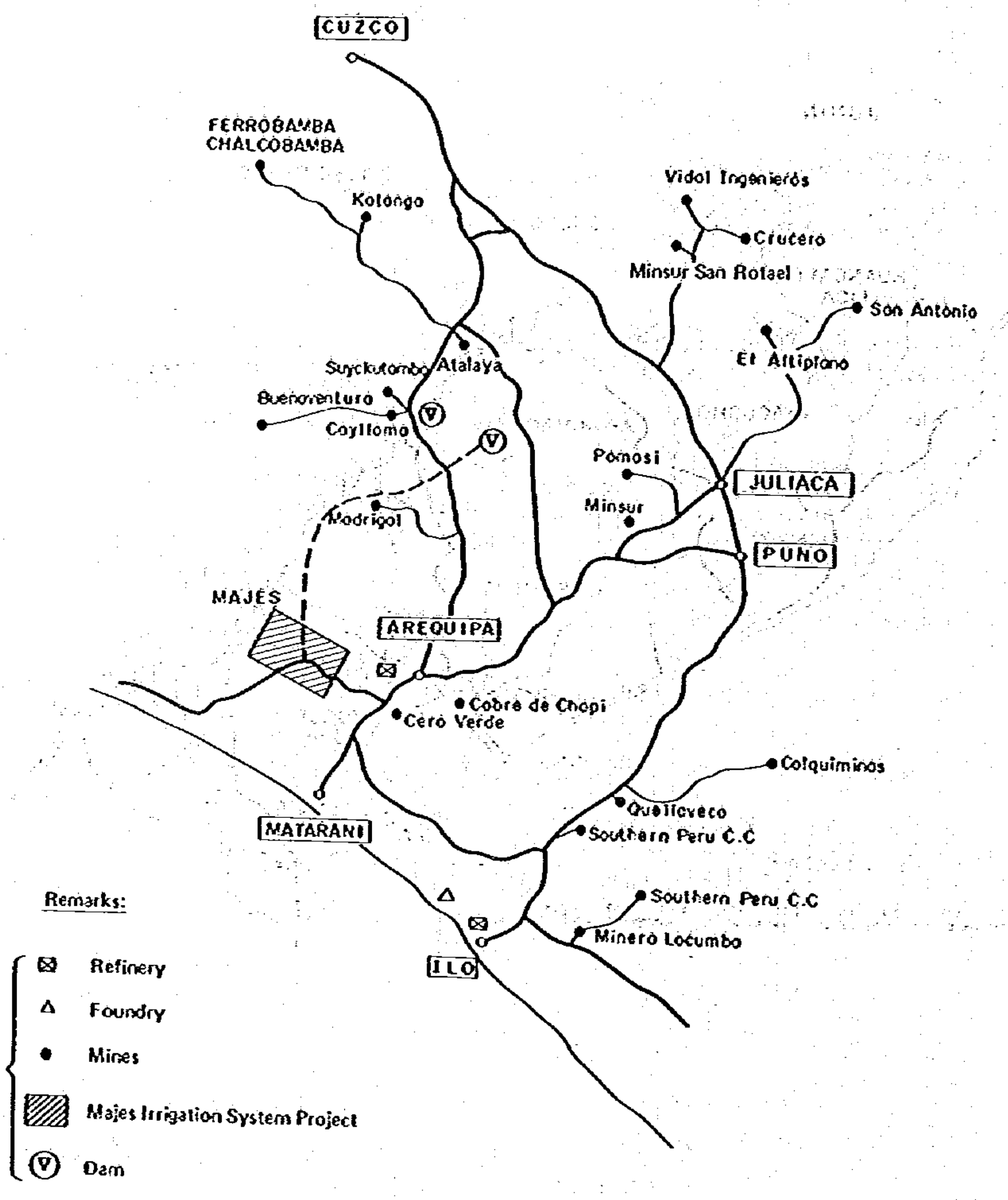


Fig. 5-6 Location of Parallel Projects



(6) Cost: 1,030 x 10^6 dollar (current price)
{50% investment by government of Peru
{50% investment by 5 foreign banks

(7) Execution: MACON – constructor, that has planned the Majes project, formed by construction companies of 5 investor countries.[1)]

2-3 Transportation Route and Its Present Situation

As transportation routes for the mines, the following routes can be proposed (also refer to the Fig. 5-7).

(a) Mine (road) Sicuani (railroad) Matarani
(b) Mine (road) Ayaviri (railroad) Matarani
(c) Mine (road) Imata (railroad & road) Arequipa (railroad & road) Matarani
(d) Mine (road) Sibayo (road) Sumbay (railroad & road) Arequipa (railroad & road) Matarani
(e) Mine (road) Ayaviri (road) Puno (road) Ilo

Among the routes above mentioned, (e) is the harbor route to Ilo harbor.

Another transportation alternative, other than Matarani and Ilo harbor, should be decided following a general investigation of the harbors themselves and of the roads and railroads. The examination of the harbors and railroads is going to be performed at the next opportunity. Therefore, in this work, considering the conditions of access to Matarani harbor, an analysis of this route will be reported.

2-3-1 Road Conditions

The road conditions of the transportation route mentioned before will be presented in the following.

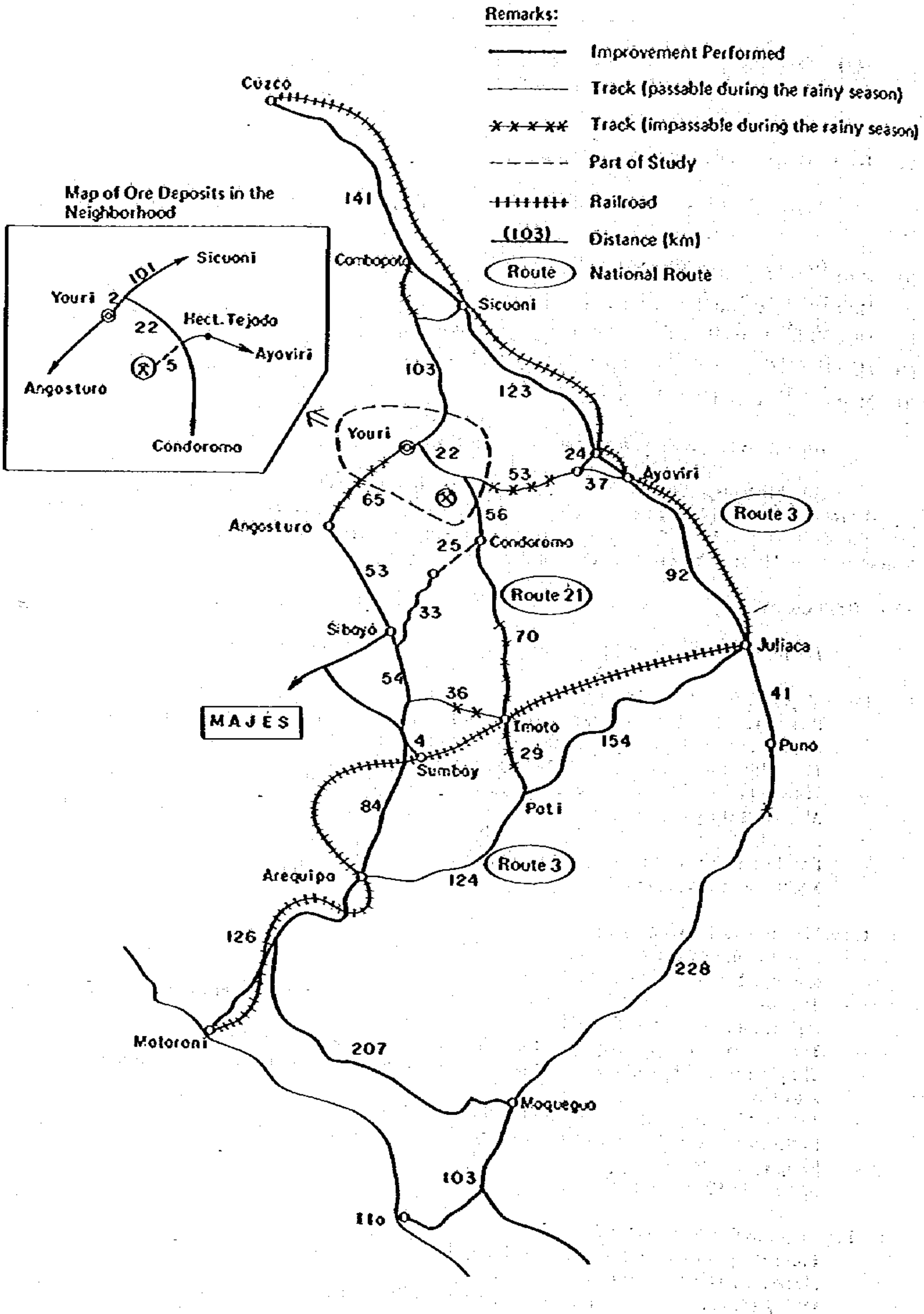
(a) From Mine to Sicuani (L = 128 km)
- Presently, it is utilized as transportation route for concentrate ore from Atalaya and Catanga reserves, all year long. During the rainy season, this is the only access route in this region.
- The width of the road is 5-8 m, but as it extends to the mountainous region, there are many curves.
- There are relatively speaking not so many steep and sharp curves.
- Almost all the pavement conditions are satisfactory, but there are sections where pavement has to be changed.
- For the time being, there are bridge facilities.
- 3,650 – 4,350 m plateau altitude.

(b) From Mine to Ayaviri (L = 95 km)
- Actually, during the dry season, it is possible to transit all this extension by jeep. But in the rainy season, it becomes impossible for vehicles.
- The roads is narrow especially in the mountainous region, where it has 3 m width. But in the plain region, the road has a 5 – 6 m width.
- The mountainous region is quite steep, with numerous small curve radii.
- The plain area of Ayaviri is about 37 km, which has in principle some facilities for agricultural activities.
- There are bridges, but impassable for heavy trucks. (4 bridges)
- In the mine areas, there are no irrigation facilities, and the road ground is quite fragile, in spite of it being a plain region.
- 3,950 – 4,450 m plateau altitude.

(c)-1 From mine to Condoroma (L = 61 km)
- From the plain region, the altitude suddenly increases to 4,600 m. In this part there are great rock blocks, and as the road is narrow, it is quite dangerous.
- During the dry season, this route connects Espinar Province to the region of Arequipa, and there are also regular bus lines.

Note : 1) The 5 investor countries are: Sweden, England, Spain, South Africa and Canada.

Fig. 5 · 7 Present Situation of Transportation Route



- The width of the road is 3-5 m, but in the mountainous region it becomes narrow with small curve radius and condinuous steep slope.
- There is one place without a bridge.
- 3,980 – 4,700 m plateau altitude.
- Even in the plain region, the road ground is fragile. As there is no treatment of river bed, it becomes impassable for vehicles during the rainy season.

(c)-2 From Condoroma to Imata (L = 70 km)

Before, there were mines in Condoroma, and a dam for irrigation was constructed along this route. Consequently, this road was utilized as a transportation route.

- 4,450 – 4,700 m plateau altitude, but as there are many parts in valley, these regions are quite wet during the dry season, and so the road ground is very weak.
- During the rainy season, the vally region becomes so wet that it is not possible to facilitate the traffic.
- The topography presents many ups and downs, but the road follows a straight line.
- With variation the width of the road is relatively wide, 4-8 m.
- Imata is connected to the railroad.

(c)-3 From Imata to Arequipa (L = 153 km)

- Between Imata and Arequipa is almost the desert region, and there are some parts without a road form.
- Between Pati and Arequipa, there is National Route 3, but a difference of 2,100 m in altitude is observed. From Arequipa there is one 30 km section, which presents a lot of U-shaped curves. The road is also narrow, with weak ground, so it appears to be very dangerous.
- There is one tunnel with a very small section (L = 85 m) that has only a 3.5 m width, constituting a serious obstacle for the transportation of large scale material.
- A 3.5 – 10 m width, excepting the mountainous region, is large enough.
- 2,350 – 4,450 m plateau altitude.

(c)-4 From Arequipa to Matarani (L = 126 km)

- Well equipped road, with asphalt pavement.
- There is one tunnel with a large section.
- There are continuous sharp curves on the way down to Matarani.

(d)-1 From mine to Angostura (L = 90 km)

- The facility conditions are precarious, and actually the road is in a precarious state with a very low traffic volume.
- The section that follows the ravine of Apurimac is narrow with rolling stones and rock blocks.
- As there are no bridges on several rivers of the region including the Apurimac river, there is absolutely no throughfare for vehicles during the rainy season.
- The road's ground in the plain region of Yauri is quite weak.
- The width is 3.5 m, but in most of its extentions it is quite narrow, with a 3–4 m width.
- 3,950 – 4,500 m plateau altitude.
- The grade with some exceptions is level.

(d)-2 From Angostura to Sibayo (L = 53 km)

- This route has in principle some facilities, and it is utilized as transportation route for ores and as a local route.
- Majes intends to construct a dam in Angostura, and for this reason the road has facilities.
- The road is relatively large with a 4-6 m width.
- In the sector descending to Sibayo there are steep U-shaped curves.
- 4,200 – 4,700 m plateau altitude.

(d)-3 From Sibayo to Sumbay (L = 54 km)

- This road is for use in the Majes project, and it has in principle some facilities.
- The road was constructed with 2 lanes of class 3 connecting to the Condoroma dam. This was planned as part of the Majes project and bifurcates in Callalli.
- Close to Sibayo, this road joins with the road planned in the Majes project.
- Excepting one part, the road is large with a 4-8 m width.
- The road surface is relatively good.

- In the rainy season, it periodically becomes impassable for vehicles, as there is no treatment of the river bed.
- At the 4th km, one branch goes to Sumbay and connects with the railroad. Of this point, the loading and unloading facilities of Madrigal Mine will be installed.

(d)-4 From Sumbay – Arequipa (L = 84 km)
- It has been installed and is administered as an access route for the Majes project.
- The width 7-12 m is quite large.
- On the way down to Arequipa, there are long parts with U-shaped curves. But as they are well improved, there are not many problems.
- 4,300 – 2,350 plateau altitude.

(e)-1 From Ayaviri – Puno (L = 133 km)
- The road is National Route 3 and between Ayaviri and Juliaca it is covered with gravel. Between Juliaca and Puno, the road is paved with asphalt. Its facilities have also been completed, and it offers good conditions for traffic.
- Large width 9 – 12 m.
- Plain surface without slope.
- 3,950 – 4,050 m plateau altitude.

(e)-2 From Puno to Ilo (L = 331 km)
- This road is just now under construction, and excepting the bridge over Caliente river, it presents good traffic conditions.
- The construction of the bridge over Caliente river is expected to be completed very soon.
- It has relatively very few slopes, and it could serve as one of the main roads in the future.

2-3-2 Present Traffic Condition

Table 5-8 indicates the number of vehicles, and the Fig. 5-8 represents the traffic volume of the region and of the transportation route.

We can observe that the number of vehicles in the Department of Arequipa is slightly higher than the average of the country, but as opposed to the other departments the number of vehicles is lower than the average.

The traffic volume between the Department of Cuzco and the littoral region on the National Route 3 is quite low. It can be stated that in this region the roads are practically not explored.

In the regions where such statistics are not known, the volume of traffic estimated by observation. In these roads some parts are impassable for vehicles during the rainy season.

Table 5-8 Number of Vehicles by Locality

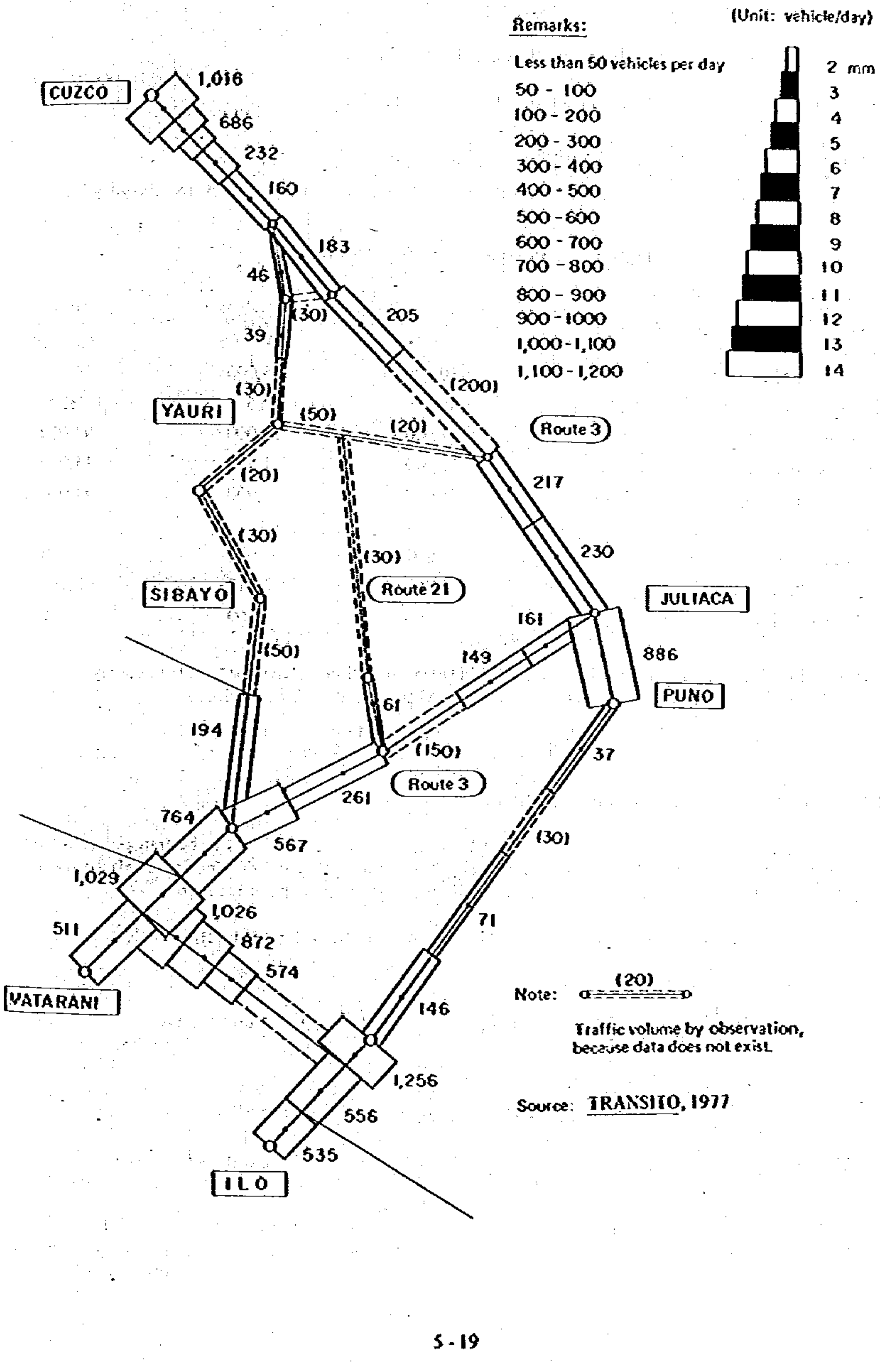
(Unit: vehicle)

Area (Department)	Private Owned Vehicles	Commercial Use Vehicles	Total	Population (1,000 person)	Average per Capita (persons/vehicle)
Arequipa	13,969	9,896	23,865	619	25
Cuzco	6,683	8,835	15,518	829	53
Madre de Dios	61	83	144	28	192
Moquegua	637	613	1,250	86	68
Puno	2,650	3,338	5,988	897	149
Whole Country	312,314	158,377	470,691	16,300	35
Lima	217,618	69,409	287,027	4,339	15

Note: In December, 1977.

Source: Parque de APIA informacion venta de vehiculos e importaciones

Fig. 5 - 8 Map of the Connection Roads' Traffic Volume (1977)



2-4 Continuous Increase of Traffic Volume

A continuous increase of traffic volume is expected accompanying the mines exploration. Table 5-9 has been evaluated considering the traffic volume relative to mines.

The traffic volume resulting from the mines is divided into:

(1) Traffic volume generated during the installation of mine facilities.

(2) Traffic volume caused during the operation of the mines.
   a) Transportation of material, machines, fuel and concentrate ore.
   b) Transportation of daily necessities for the mining town, locomotion for work and everyday life.

Table 5-9 Basic Table of the Transport to Mines

	Atalaya	Tintaya	Coroccohuayco	Quechua
(Construction of Mines)	–	'80 ~ '82	'83 ~ '85	'86 ~ '88
Construction Materials (t)	–	50,000	5,000	30,000
(Construction of Mine)	In Operation	'83 ~	'86 ~	'89 ~
Pure Ore (t/year)	9,600	152,000	20,000	92,000
Machines (t/year)	1,000	15,000	2,500	15,000
Fuel (kℓ/year)	1,600	45,000	6,000	34,000
(Mine Town)				
Worker Population	–	900	600	650
Dependent Population	–	3,960	2,640	2,860
Mobile Population	–	90	60	65

Note: 1) The structure material is not included in the construction material made in the country.
2) In the figures for fuel, diesel for the electrical power station is not included.

2-4-1 Traffic Volume Caused during the Installation of Mines

During the period of mine installation, it became necessary for machines to be transported for construction and prospecting for installation of ore dressing sites, for reception and distribution of electricity, subsidiary equipments and material for house construction in the region of Arequipa or the harbor.

Excepting the utilization of trucks with 12 t. cargo, the traffic volume is presented below:

(1) Tintaya (period : 1980–82)

$$\frac{50{,}000\ t.}{3\ \text{years} \times 365\ \text{days}} - 0.7\ (\text{percentage of production}) - 12\ t. \times 2 = 12\ \text{vehicles/day}$$

(2) Coroccohuayco (period : 1983–85)

$$\frac{50{,}000\ t.}{3\ \text{years} \times 365\ \text{days}} - 0.7 - 12\ t. \times 12 = \text{vehicles/day}$$

(3) Quechua (period : 1986–88)

$$\frac{30{,}000\ t.}{3\ \text{years} \times 365\ \text{days}} - 0.7 - 12\ t. \times 2 = 8\ \text{vehicles/day}$$

24-2 Traffic Volume Due to the Installation of Mines

Other than the transportation of ores, fuel and other parts of materials, there was also the transportation of food and daily necessities, during the construction of mines. With the settlement of mine villages, traffic volume was also generated by everyday living and amusement.

(a) Transport of concentrate ore, fuel, materials.

All the materials excepting the concentrate ore could be transported by the unloaded trucks on the way back to the mines. As a consequence the traffic volume would not be increased. Considering the dimensions of the concentrate ore reserves, we estimated that transport trucks of 12 t. cargo for Quechua mine and 20 t. for the other ones could be utilized.

1 Tintaya (period : 1983 - ~)

$$\frac{152{,}000\ \text{t.}}{365\ \text{days} \times 20\ \text{t.}} \div 0.7\ (\text{percentage of production}) \times 2 = 60\ \text{vehicles/day}$$

2 Coroccohuayco (period : 1986 - ~)

$$\frac{20{,}000\ \text{t.}}{365\ \text{days} \times 12\ \text{t.}} \div 0.7\ (\text{percentage of production}) \times 2 = 14\ \text{vehicles/day}$$

3 Quechua (period : 1989 - ~)

$$\frac{92{,}000\ \text{t.}}{365\ \text{days} \times 20\ \text{t.}} \div 0.7\ (\text{percentage of production}) \times 2 = 36\ \text{vehicles/day}$$

(b) Commutation traffic volume

As the mine village has been planned to be built in an area close to the mountain, the traffic volume of commuters would originate from the region of Yauri. Considering that everyday 10% of workers would be commuting, buses with 45 person capacity are proposed.

$$\frac{2150\ \text{persons} \times 0.1}{45\ \text{persons/vehicle}} \times 2 = 10\ \text{vehicles (bus)/day}$$

(c) Commuting

In the everyday commuting, trips for shopping and amusement are mentioned. For this purpose there are some facilities at the mine village, even though it is supposed that on average most people will monthly go to Cuzco, Juliaca or Arequipa.

(d) Transport to working sites

It is supposed that a vehicle of the mines will go back and forth everyday to Cuzco, Juliaca or Arequipa in order to accompany the development of the works at the mines.

3. Choice on the Transportation Route

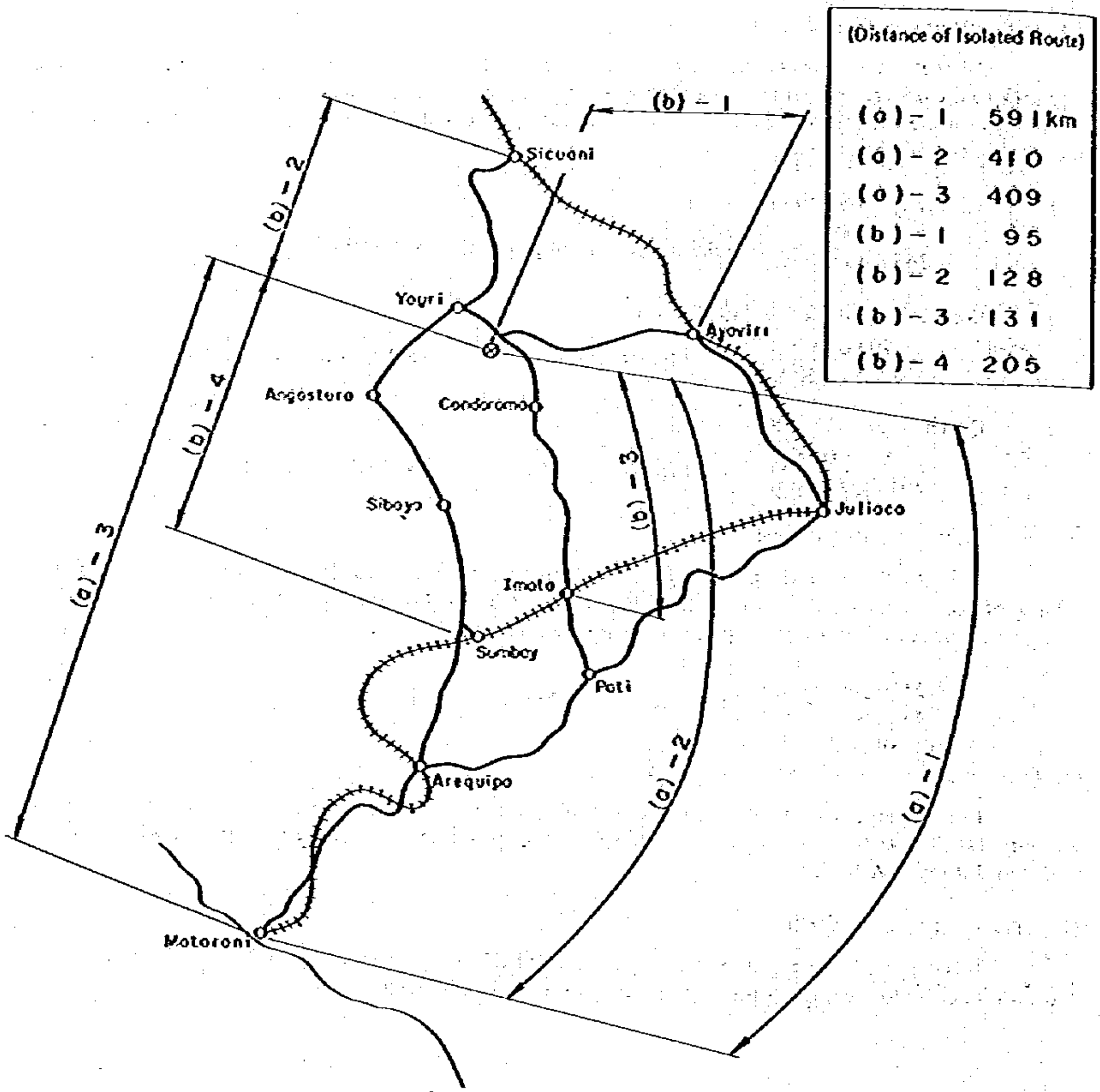
3-1 Comparison Route

Comparing the actual road situation and their improvement possibilities, the transportation route to be utilized is fundamentally the actual roads in use.

Therefore, in doing an analysis of a comparison route, considering the transportation possibilities, the transportation route to be utilized is fundamentally the actual roads in use.

Therefore, in doing an analysis of a comparison route, considering separately the transportation route utilizing only roads and the transportation route mainly employing both roads and railroads, the following results are stated below (Fig. 5-9).

Fig. 5-9 Map of Transportation Route



a) Transportation route only by road

1). Mine – ayavirl – Juliaca – Matarani
2) Mine – Condoroma – Imata – Matarani
3) Mine – Sibayo – Sumbay – Matarani

b) Transportation route by road and railroad

1) mine – Sicuani – (railroad) – Matarani
2) mine – Ayaviri – (") – "
3) mine – Imata – (") – "
4) mine – Sumbay – (") – "

3-2 Single Route Plans of Road

Among the three route plans mentioned below, Route (a)–1 via Juliaca has already been improved for the most part and may fulfil the requirements of a transport route. As apparent in Fig. 5-9, however, it is considerably longer in distance than the other routes, so it is undesirable as a mass transport route for the future. Therefore, in comparison with the parallel railroad, it is unthinkable to use this route as a transport route, considering that railroad transport is generally more advantageous than road transport if the distance to be traveled is the same.

Consequently, (a)–2 and (a)–3 are to be compared. Table 5-10 shows the comparison by items.

Judging from this table, there is little difference in distance, construction cost and travel cost between the two routes. The differences between these two routes consist in the feasibility of ensuring traffic in the rainy season, the effects on regional development and the relation to other projects.

Firstly, concerning Route (a)–2, there are many parts that become marshy during the rainy season around Imata and in the basins of highland areas, and even if improvements were carried out it would be difficult to ensure the traffic conditions for large trucks in the rainy season. On the other hand, the ground condition of Route (a)–3 is comparatively good, and so improvement there will make the traffic in the rainy season less anxious. Along Route (a)–3 at present there are already developed mines and many villages. In addition, there is a possibility of future development of agriculture and cattle-breeding in the Yauri Plain. Considering these points points Route (a)–3 is more attractive.

Besides, the most considerable point about Route (a)–3 is the Majes project. In the first place,the road between Sibayo and Angostura dam, which is scheduled to be used as a maintenance road is to be improved in the future. In the second place, as the main-road of the Majes project is to join this route in the proximity of Sumbay, the section from this junction to Arequipa has largely been improved into a two-lane and is scheduled to be used in the future. The section between Sibayo and the junction has also been improved in outline as a road for the construction of Condoroma dam and so on.

Considering that in this context this route plan will reduce the construction cost and the maintenance cost by the adjustment to the Majes project and that the efficient use and management can be expected, it is concluded that Route (a)–3 is the best between the two routes.

3-3 Route Plans of Road Connecting with Railroad

Route (b)–1 has already been improved in outline at present, but it is insufficient as a transport route for the future and needs to be widened and made better. Many parts of Route (b)–2 are not improved yet, so these parts need fundamental improvement.

Such are the conditions of the two routes, the improvement of Route (b)–1 will be less expensive in terms of construction than that of Route (b)–2 for its section through the mountains is long. However, the differencies slight.

Table 5 - 10 Comparison of Transport Routes

Items	(a) - 3 Mine - Sunbay - Arequipa	(a) - 2 Mine - Imata - Arequipa
Distance (Mine - Arequipa) Average altitude of road Construction cost of road Travel cost of truck	283 km 4,080 m (peak 4,650 m) US$18,059 thousand US$187/vehicle (large truck)	284 km 4,140 m (peak 4,720 m) US$16,944 thousand US$184/vehicle (large truck)
Problems in road improvement	– Widening in the Aprimac Valley will presumably meet with difficulties owing to plenty of massive rocks, but the quality of rock is comparatively soft and so it is not a decisive factor. – At present the section between Arequipa and Sibayo has been improved in outline according to the MAJES project, and hereafter the section to Angostura is scheduled to be improved.	– The improvement in the plain area is a difficult problem, and there is no suitable countermeasure for the ground and inundation treatment. – Although the overall feature of the topography is flat, there are many areas undulating locally. Therefore, for their improvements, the adoption of small-scale roundabout routes is necessary.
Future maintenance and management	– As there are many parts in common use with the mines along the route and the MAJES project, it is possible to allot a portion of the maintenance and management to agencies concerned. – The geology is relatively good, and the improvement will remove the uncertainty for the traffic in the rainy season.	– As the travel distance through the area which is likely to become marshy in the rainy season is fairy long, the traffic of large vehicles is accompanied by uncertainty. – The maintenance and management expenses are for the mines to provide.
Effects on regional development	– Compared with (a)-2 Route, mines, agricultural development, the MAJES project and many villages though in small scale, will mean that future development effects will be large.	– This route connects Espinar Country only to Arequipa. As there are scarcely any villages or industries along it, there is little prospect of further development, that is, the effects of this route are little.

On the other hand, in terms of transport cost, Route (b)–2 promises good reduction in the long run, for the distance is greatly curtailed. In terms of developmental effect also, Route (b)–2 will promise substantial contribution by connecting Juliaca, the commercial center of this region, with both Puno and Espinar, the major trading centers with Bolivia, while Route (b)–1 will have hardly any effect. Considering these additional benefits, improvement of Route (b)-2 can be conclusively stated as more effective.

By the way, in reference to Route (b)–3 and Route (b)–4 it is obvious that the route connecting Sumbay is better, as the comparison made in the previous section, "Single Route Plans of Road," established.

In comparing Route (b)–2 with Route (b)–4, Route (b)–4 would be more advantageous because the transport distance is shorter, even though evaluation is difficult unless the conditions of travel cost and transport capacity of railroad are taken into account. But the conclusion of this comparison should be formulated after the investigation of the railroad.

3-4 Selection of Transport Route

The following routes are desirable as transport routes, which are desirable as the results of the examination mentiond above:

(a) Route of Single Road

Mine – Sibayo – Sumbay – Matarani

(b) Route of Road connecting with railroad

Mine – Ayaviri (and beyond by railroad)

In considering the improvement of the transport route, it is not necessary to improve these two routes simultaneously. If further comprehensive investigation reveals that concentration on road transport is advantageous, Route (a) should be improved initially. Otherwise if emphasis on railroad transports proves to be advantageous, the improvement of Route (b) should be done first. In the latter use, however, it may be advisable to proceed afterwards with the improvement of Route (a) as a transport route in reserve.

In both cases realizing that Route (a) enables the steep reduction of travel time between the littoral region and Espinar Province and can be expected to produce effects on the road side development, the improvement of Route (a), that is the route between the mines – Sibayo – Arequipa, should be carried out.

4. Road Development Planning

4-1 Estimation of Future Traffic Volume

4-1-1 Trend of Region and Traffic Generation

The present situation of traffic in this region is, as mentioned before, in an underdeveloped state. The economic development of the region remains backward, as well. In addition presently, there is hardly any traffic, especially in the direction of Arequipa or Ayaviri, which is investigated here owing to the backward condition of the road. Even if the road is improved, a large quantity of traffic generation cannot be expected under the present conditions, judging from the industrial and economic potential of this region.

Although the future traffic demand depends on future development, the present circumstances provide no choice but to suppose that there is little hope of industrial development or city growth, except the possibility of farming and cattle-breeding can be expected in addition to the development of the mine.

As this is the state of this region, the development of the mine, the traffic generated and the improvement of the road will play a great role as a powerful trigger for the future development of this region.

4-1-2 Estimation of Traffic Volume

The estimation of future traffic volume will be made here in reference to Route (a) and (b), and the sections for estimation are simplified as follows:

Route (a)	1. Mine – Yauri
	2. Yauri – Sibayo
	3. Sibayo – Sumbay
	4. Sumbay – Arequipa
Route (b)	1. Mine – Ayaviri

The most common method of estimating traffic volume follows this procedure: the O-D traffic volume survey that helps us to grasp the actual state of traffic. Based on this data, one then estimates the future O-D traffic volume using the prospect and future economic development of the region and assigns the estimated volume to the road networks including the projected roads, so as to determine the future traffic volume.

However, there is no O-D survey data available here and this region is not in the state of development that lends itself to high accuracy. For that reason the simplified method of estimation is adopted here, which classifies traffic into the following categories by the factor of generation, estimating the volume individually.

- Ordinary traffic volume (traffic passing at present)
- Deflected traffic volume (traffic deflected from other roads by the improvement of road)
- Induced traffic volume (increase in traffic induced by improvement of the road)
- Generated traffic volume (traffic generated by the regional development in the future)

To estimate the traffic volume with this method, however, traffic and the road network should be developed to some degree, and there should be traffic data and a development plan for the future. But because these requirements in this region are scarcely fulfilled, there seems no other way, but to estimate traffic volume, except that generated from the mine development, on the bold assumption inferring from situations of similar regions.

(1) Growth rate of traffic volume

The future growth rate of traffic volume is estimated through the method of inferring from the trends of past traffic volume of relevant roads. The trends of traffic volume during the last five years in the major sections on the National Route 3 between Cuzco – Arequipa are shown in Table 5-11.

This reflects the influence of economic fluctuation as mentioned before, and it would be better to exclude this value in a long range estimation.

The average growth rate of the other years is approximately 10% per year. But judging from the fact that the nation-wide average growth rate for car possession is around 5 - 7% per year in recent years as shown in the Section 1-3, this value seems too high as the expression of a long-term trend. Consequently we assume that the growth rate will be 8% per year for the next ten years, and after that increases in geometrical proportion at the rate of 6% per year.

(2) Ordinary traffic volume

As it is obvious that the traffic between this region and Arequipa or Ayaviri will increase if the road is improved, the ordinary traffic volume is an estimate with this factor taken into account and includes the induced traffic volume

The traffic volumes for each route are presented in Table 5-12.

Table 5-11 Trend of Traffic Volume of Relevant Roads

(Unit: vehicles/day)

Section	1973	1974	1975	1976	1977				Average Growth Rate
					Total	Cars	Trucks	Buses	
Urcos	129	155	191	211	160	73	74	13	
~ Combapata	-	1.20	1.23	1.10	0.76				1.07 (1.18)
Sicuani	190	214	216	255	205	101	87	17	
~ La Raya	1.21	1.13	1.01	1.18	0.80				1.03 (1.13)
Pucara	265	250	262	288	230	103	115	12	
~ Juliaca	1.05	0.94	1.05	1.10	0.80				0.97 (1.04)
Juliaca	168	200	178	217	161	65	90	6	
~ Pati	-	1.19	0.89	1.22	0.74				1.01 (1.10)
Pati	242	235	211	268	261	105	135	21	
~ Jesus	1.25	0.97	0.90	1.27	0.97				1.03 (1.10)

Note: 1) Figures in lower line show the growth rate to the previous year.
2) The values in parentheses in the column of average growth rate are calculated from the value except that of 1977.

Source: Ministerio de Transportes y Comunicaciones, TRANSITO, 1977 M.T.C.

Table 5-12 Ordinary Traffic Volume

(Unit: vehicles/day)

Section	1977	1980	1985	1990	1995	2000
Ⓐ – ①	50	63	93	131	176	235
②	20	25	37	52	70	94
③	50	63	93	131	176	235
④	194	244	359	508	681	910
Ⓑ – ①	20	25	37	52	70	94

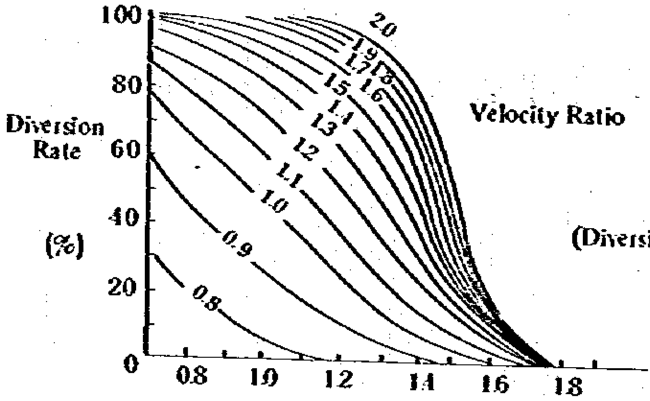
(3) Diverted traffic volume

Route (a) is to provide traffic for Cuzco or from Espinar province to Arequipa with the improvement of conditions, allowing for saving in travel time and easier traveling as compared with the present use of the National Route 3 and 21. A considerable portion of traffic on these routes will presumably be diverted onto Route (a).

Obviously, Route (b) will, as well, enable the sharp reduction of travel time from Espinar Province to Juliaca or Puno in comparison with the present use of the route via Sicuani, it is also anticipated that all traffic will be diverted onto Route (b). There is, however, scarcely any traffic in this direction at present.

The common method of calculating deflected traffic volume is the diversion rate method. The diversion rates are calculated from Table 5-13. The results of this estimation of deflected traffic volumes about the routes in question are shown in Table 5-14.

Table 5-13 Results of the Calculation of Diversion Rate



Section for Comparison	Route for Comparison	Total Distance (km)	Distance Ratio	Travel Time Required (h)	Velocity Ratio	Diversion Rate
Ⓐ Yauri ~ Arequipa	Route 3	482	0.53	11.2	1.6	100 %
	Ⓐ Route	256		7.0		
	Route 21	301	0.85	7.9	1.1	70
	Ⓐ Route	256		7.0		
Ⓑ Yauri ~ Ayaviri	Route 3 & 21	226	0.43	5.3	2.1	100
	Ⓑ Route	112		2.5		

Table 5-14 Diverted Traffic Volume

(Unit: Vehicles/day)

Origin Routes of Diversion	Traffic Volume (vehicles/day)	Diversion Rate (%)	Diverted Traffic Volume					
			1977	1980	1985	1990	1995	2000
Ⓐ from Route 3	150 x 0.3 = 45	100	45	57	83	118	158	211
Ⓐ from Route 21	30 x 0.5 = 15	70	11	14	20	29	39	52
Ⓑ from Route 3 & 21	30 x 0.3 = 9	100	9	13	19	26	35	47

The objective traffic volume for diversion are assumed as follows: on National Route 3, 30% of the cross-sectional traffic volume; on National Route 21, 50% of the cross-sectional traffic volume; and 30% for Route (b) including the induced portion.

(4) Induced traffic volume

Traffic volume caused by the accelerated use of automobiles, as the roads are improved, can be expected to increase to some extent along Route (a). But it is difficult to estimate it quantitatively because of the present economic state of this region. So, hereafter, the induced traffic volume is not estimated, for this factor is taken into account in the estimation of the ordinary and diverted traffic volume.

(5) Generated traffic volume

The other concrete development project other than the development of the mine is the Majes project. This will cause traffic generation along Route (a) and heavy traffic will be observed to the west of the junction with the Majes development road close to Sumbay. To the east of the junction only vehicles used to maintain the dam will be seen in the future. Presently this project is under construction, and there is considerable traffic generation of construction vehicles on Route (a), so the traffic generated in the future is not estimated here anew and is induced in the ordinary traffic.

Though farming, cattle-breeding and other mines can be taken into account as other kinds of development, they are lacking in actuality of the present stage, so they are not considered here for the estimation of generated traffic volume

The traffic generated by the mine is compiled in Table 5-15 based on the traffic volume calculated in 2-4.

Table 5 - 15 Generated Traffic Volume from Mine

(Unit: vehicles/day)

	1980 ~ 82	1983 ~ 85	1986 ~ 88	1989 and forward
Atalaya Mine	(6)	(6)	(6)	–
Tintaya Mine	(12)	60	60	60
Coroccohuayco Mine	–	(2)	(14)	(14)
Quechua Mine	–	–	(8)	36
Subtotal	18	68	88	110
Commuting Trip	–	[6]	[8]	[10]
Living Trip	–	[2]	[2]	[4]
Business Trip	–	< 2>	< 4>	< 6>

Note: 1) Commuting trips are generated only between the mine and Yauri.
2) ( ); 12 t trucks, [ ]; buses, < >; cars, otherwise 20t trucks.

(6) Future traffic volume

The foregoing result are rearranged in Table 5-16. As uncertain developments such as inducing factors are barely included in these figures, there may be a marked tendency to underestimate especially concerning the section between Yauri and Sumbay on Route (a), and as for the other sections these values show the lowest level.

Consequently, as for future development of this region, considerable increase in traffic volume would be expected on both routs. In reference to the diverted traffic volume, the improvement of the route from Sicuani or Combapata to Yauri holds an important key, and if the improvement of this region proceeds, Route (b) will be the principal main route connecting Cuzco Department with Arequipa Department.

4-2 Road Development Plan

4-2-1 General Condition of Geology and Weather

Most of the sites for road development are located on a plateau 4,000 m above sea level in the Andes mountains, and mountains 4,700 m high extend midway between the sites. Except in the mountains district, the sites are mostly on the comparatively gentle hills or in the plain area.

Geologically, the mountains and valleys consist of tuffaceous rocks, and the hills and plains are formed from the strata of glacial deposits or from alluvia.

Rocks in the mountains are relatively soft in quality and can be fairly easily excavated. On the other hand, above the alluvia or the lake sediments in the plain areas covers the outer layer of humus soil, and the ground of the districts where this layer is thick is quite weak.

Concerning the weather, the rainy season is from December to April in the plateau area, but the annual precipitation is approximately 800 mm and not so much. The precipitation decreases in proportion to the distance from the littoral region, and there is no rainy season in the littoral region which is a desert area of little precipitation throughout the year.

The annual average temperature is 3 – 8°C in the plateau area, but it is characteristic of this region that the change of temperature in a day is extremely great. For example, the minimum temperature goes down to 10°C below zero, even when the maximum temperature is 20°C. However, though there is snowfall, snow seldom stays in this region and the surface freezing of roads does not matter for it melts within a short time. Table 5-17 shows the weather condition in the mine area.

4-2-2 Standard and Structure of Road

Both Routes (a) and (b) go partly through areas of steep topography, but most other areas are mainly of gentle topography. Therefore, there is no problem in adopting standard criteria for road design, even from the viewpoint of construction cost. But concerning a part of those sections where topography is steep and construction will become very expensive, a tentative plan of construction should be considered.

Based on these ideas, the standard of development for the roads will be as follows.

(1) Standard

Route (a) (Mine – Sumbay) : road of 3rd class
(Sumbay – Arequipa) . road of 2nd class
Route (b) . . . . . . road of 3rd class

(2) Design velocity

Plain area . . . . . . 80 km/h
Hilly area . . . . . . 60 km/h
Mountainous area . . . 40 km/h
Area of tentative plan . . . . 30 km/h

Table 5-16 Future Traffic Volume (All Kinds of Vehicles Included)

(Unit: vehicles/day)

Section	Classification	1977	1980	1985	1990	1995	2000
Ⓐ – 1	Transport Traffic Generated from the Mine	–	12	62	110	110	110
	Traffic Relevant to the Mine	–	–	10	20	20	20
	Ordinary Traffic	50	63	93	131	176	235
	Diverted Traffic	–11	–14	–20	–29	–39	–52
	Total	39	61	145	232	267	313
Ⓐ – 2	Transport Traffic Generated from the Mine	–	18	68	110	110	110
	Traffic Relevant to the Mine	–	–	4	10	10	10
	Ordinary Traffic	20	25	37	52	70	94
	Diverted Traffic	56	71	103	147	197	263
	Total	76	114	212	319	387	477
Ⓐ – 3	Transport Traffic Generated from the Mine	–	18	68	110	110	110
	Traffic Relevant to the Mine	–	–	4	10	10	10
	Ordinary Traffic	50	63	93	131	176	235
	Diverted Traffic	56	71	103	147	197	263
	Total	106	152	268	398	493	618
Ⓐ – 4	Transport Traffic Generated from the Mine	–	18	68	110	110	110
	Traffic Relevant to the Mine	–	–	4	10	10	10
	Ordinary Traffic	194	244	359	508	681	910
	Diverted Traffic	56	71	103	147	197	263
	Total	250	333	534	775	998	1,293
Ⓑ – 1	Transport Traffic Generated from the Mine	–	18	68	110	110	110
	Traffic Relevant to the Mine	–	–	4	10	10	10
	Ordinary Traffic	20	25	37	52	70	94
	Diverted Traffic	9	13	19	26	35	47
	Total	29	56	128	198	225	261

Table 5-17 Weather Conditions of Mine Area

Classification		Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Temperature (°C)	Mean Temperature	1975	7.6	8.8	8.9	8.5	6.1	4.1	2.6	4.4	7.5	6.8	8.1	8.5
		1976	8.0	8.1	8.8	6.6	5.0	3.2	4.0	5.0	6.4	7.1	7.1	9.0
		1977	8.9	7.5	8.9	7.0	5.1	2.9	4.2	4.5	–	–	–	–
	Monthly Maximum	1975	18.9	15.7	16.5	17.5	15.5	15.5	15.3	18.0	18.0	20.1	20.1	18.2
		1976	15.0	16.9	17.5	16.9	17.0	15.9	16.7	18.7	18.5	20.7	20.2	20.2
		1977	18.9	18.8	16.5	17.3	17.7	16.4	17.5	18.8	–	–	–	–
	Monthly Minimum	1975	−2.4	1.1	1.1	−4.3	−5.3	−10.2	−13.2	−10.7	−9.2	−8.8	−8.8	−0.2
		1976	0.3	−1.9	−3.2	−7.0	−8.6	−10.6	−11.5	−12.5	−6.4	−8.8	−7.1	−4.2
		1977	2.2	−2.8	−0.5	−7.0	−9.8	−12.2	−10.2	−12.0	–	–	–	–
Precipitation (mm)	Monthly Precipitation	1975	167	174	134	38	36	3	0	2	42	29	50	243
		1976	272	159	157	31	17	6	0	16	53	5	0	114
		1977	103	93	196	4	2	0	8	0	0	–	–	–
	Maximum per day	1975	22	22	19	16	8	0	0	0	35	11	12	34
		1976	29	20	27	17	5	4	0	9	9	4	0	29
		1977	18	18	35	4	2	0	8	0	0	–	–	–

Source: Observation Data at Coroccohuayco Mine

(3) Number of lane

- 2 lanes (one lane for the section of tentative plan, which is to be widened into two lanes in future).

(4) Pavement

- Gravel road (thickness of gravel layer = approximately 20 cm in average)

(5) Load for bridge design

- 20 ton truck

4-2-3 Road Construction Plan

Existing roads on both Routes (a) and (b) do not satisfy the criteria of geometrical structure of road in most of their sections, but for the most part improvement will be attained by improving existing roads. In this case, the conditions for the planned roads will be as in Figs. 5-10 and 11. Concerning this plan detailed investigations on the following points are necessary.

(1) Route (a)

As the section through the Apurimac valley requires expensive widening and improvement because of many massive rocks and steep topography around crossings, there may be no alternative to adopting tentative structure in part of it at first (Photo 5-1).

Photo 5 - 1 Present State of Road in Apurimac Valley

In the Angostura plain, a dam is scheduled to be constructed according to the Majes project, so it is necessary to plan a roundabout route which may be rather easily constructed.

By the way, judging from the investigation on the map, it is possible to plan, as a route avoiding these areas, the route which includes the joint road to the Condoroma dam constructed according to the Majes project and which joins to National Route 21 near Sibayo. But as this route requires the construction of a new road from the Condoroma dam to National Route 21 and in addition has long sections of steep inclination and of high altitude, it is by no means a good route. However, there is a prospect that the distance from the mine could become the shortest, further investigation may be necessary.

Fig. 5 - 10 List of Conditions of Road : Route (a)

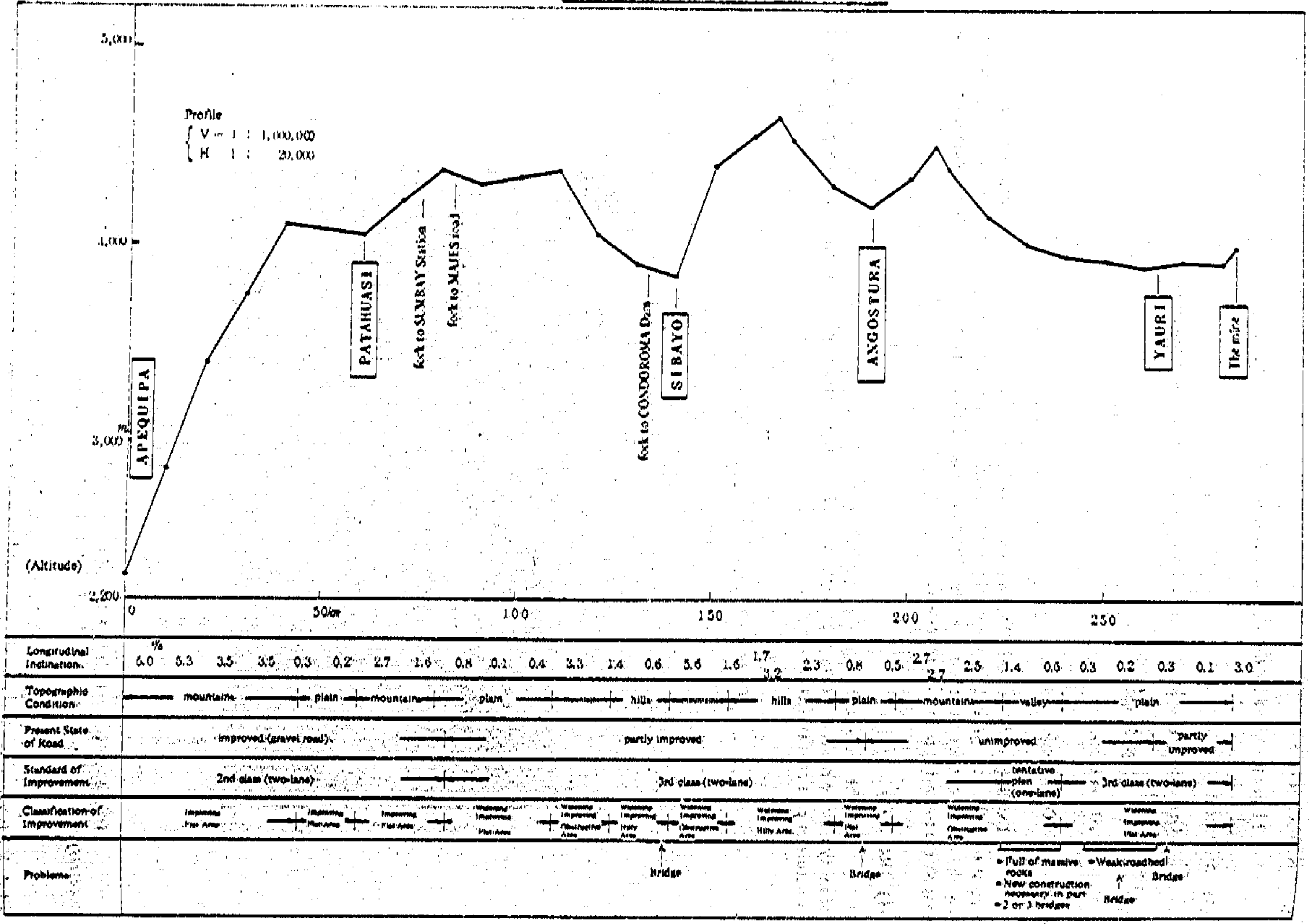
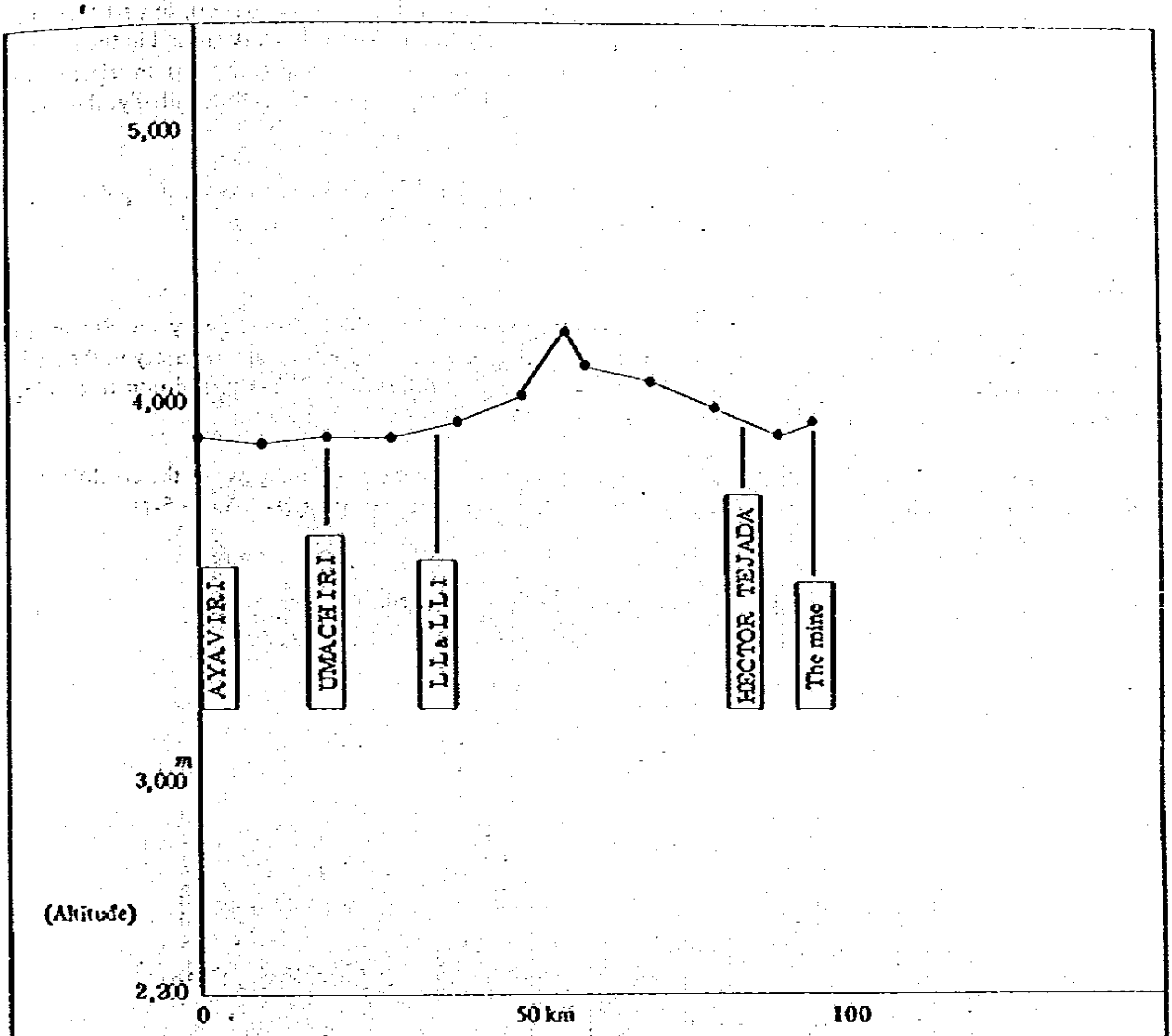


Fig. 5 - 11 List of Conditions of Road : Route (b)



Longitudinal Classification	0.2	0.2	0.1	0.5	0.8	4.0 / 5.0	0.1	0.8	0.8	2.5

Topographic Condition	Plain ┼ Mountain ┼ Plain →
Present State of Road	Partly Improved ┼ Unimproved →
Standard of Improvement	3rd Class (two-lane) →
Classification of Improvement	Improving Flat Area ┼ Widening Improving Hilly Area ┼ Widening Improving Mountainside Area / Widening Improving Hilly Area ┼ Widening Improving Flat Area →
Problems	Bridge, Bridge, Bridge, Improvement of Linear Alignment, Bridge

(2) Route (b)

Though there is hardly any section that requires especially detailed investigation, in part there are some sections where roundabout routes should be planned, owing to the extremely weak ground in the mountains area from the view point of geometrical structure. By the way, there is an alternative plan in reference to this route, which connects with the railroad at Chuquibambilla. But as it is the same route essentially, this route can be considered adequate.

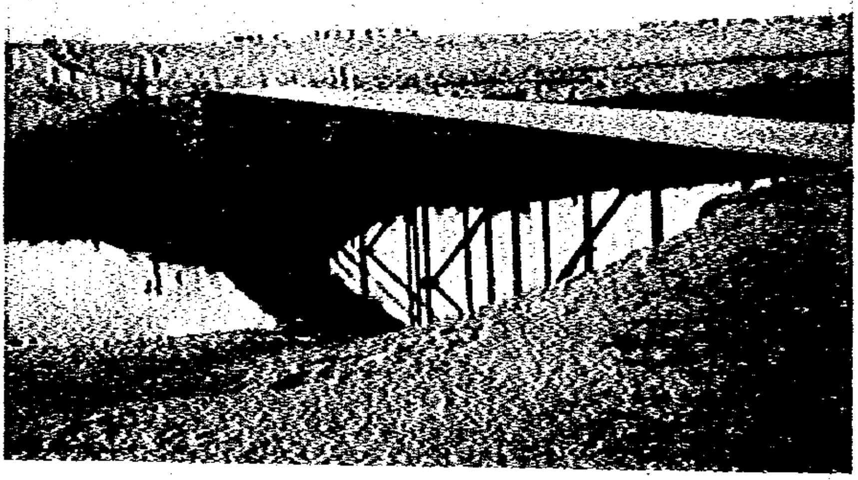
Fundamentally, these points are the problems. The following are the remarks on the points to be attended to in the future improvement plan, judging from the present conditions of existing roads.

(1) Bridges

All the existing bridges on both Routes (a) and (b) cannot bear the traffic of heavy vehicles and so need to be rebuilt. As there are many points without bridges at present, where they are necessary in the rainy season, the construction of new bridges on culverts is required in considerable number in addition to existing bridges.

While designing these bridges, an analysis of exact weather data or a good grasp of the conditions in the rainy season will be necessary for the determination of the cross section of the river. (Photo 5-2)

Photo 5 - 2 Light Bridge Made of Old Rails



(2) Drainage works

As drainage is barely necessary in the dry season, very few parts are fitted up with drainage works, and so there are many areas where roads are damanged by flooding in the rainy season. Drainage works are necessary in the rainy season, and gutters along the road shoulder in the section of cut or of low fill and crossing pipes under the points where streams cross are minimum requirements. (Photo 5-3)