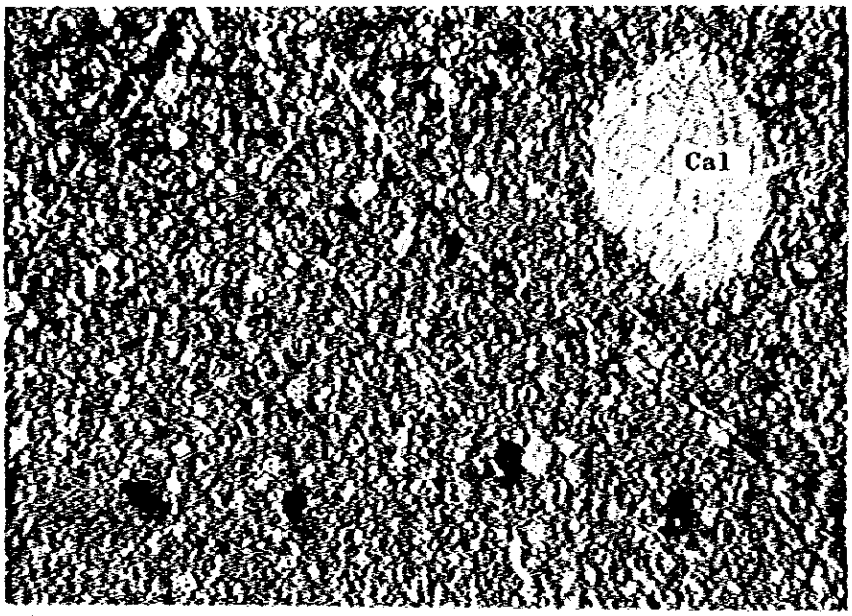
YF-6

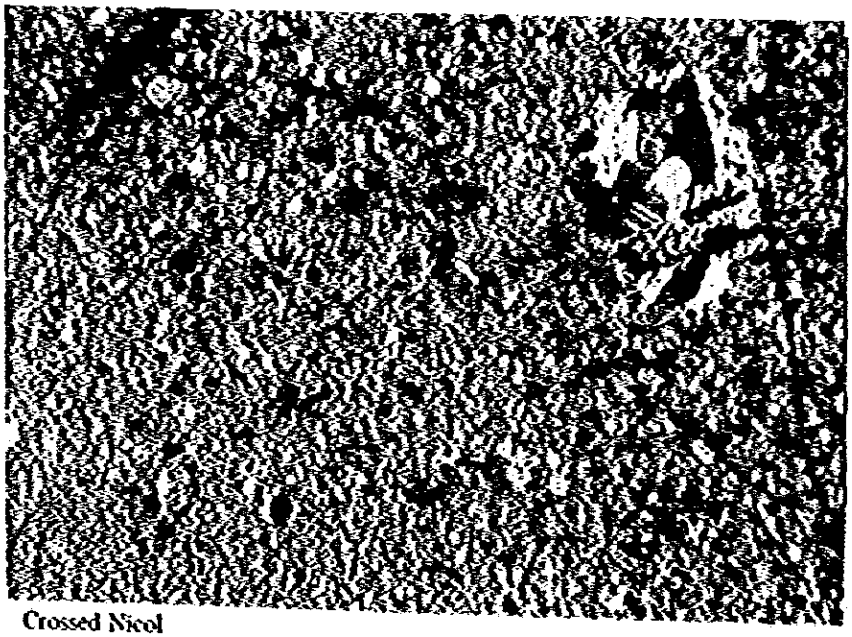


Limestone

Cal : Calcite

Open Nicol

0 0.5 mm



Limestone

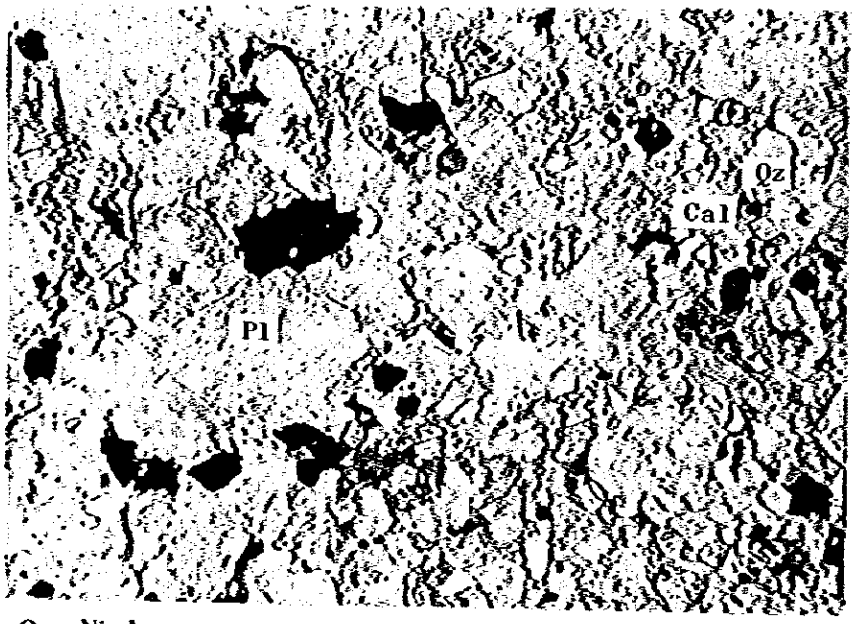
Crossed Nicol

0 0.5 mm

YF-6 Limestone

Macroscopically, this is dark grey, fine massive limestone (calcareous rock). Microscopically, it consists of medium – fine grained calcite and ferrous oxide. There is a little fine-grained plagioclase and quartz.

The calcite has two types of granularity. One is micro-grained (several microns) and anhedral. The other is medium – fine grained (0.3 mm ~ 0.1 mm), hypidiomorphic – anhedral. The outer shape appears to have been replaced by feldspar or mafic minerals.

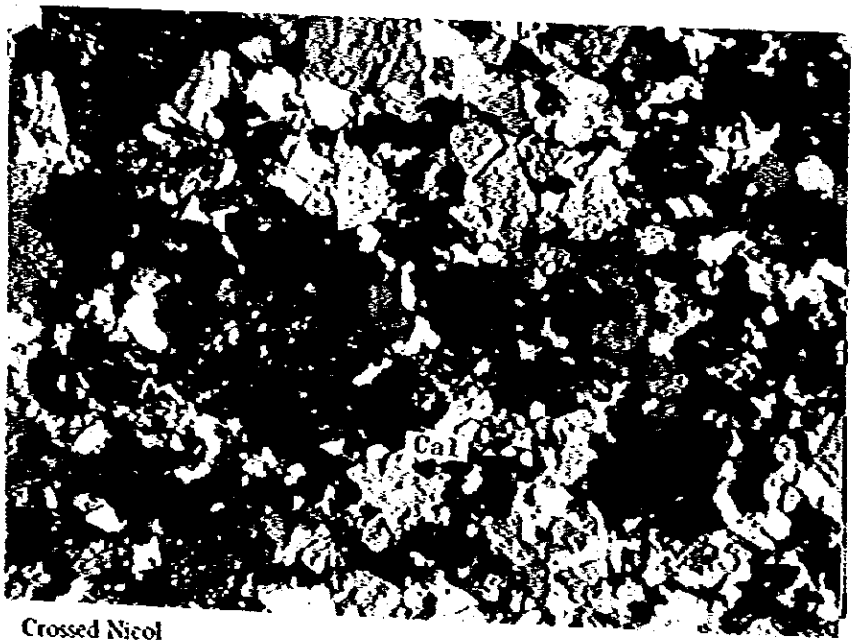


Lithic-tuff

Pl : Plagioclase
Qz : Quartz
Cal : Calcite

Open Nicol

0 0.5 mm



Lithic-tuff

Crossed Nicol

0 0.5 mm

N4-1 Lithic tuff

Macroscopically, this is a greyish red tuff containing rock fragments. It has banding and a stratified structure. Microscopically, there is a sorting texture. The structural minerals include large amounts of quartz, plagioclase, calcite, biotite and rock fragments. The rock is lithic crystalline tuff. There is little volcanic glass.

Quartz: 0.7 ~ 0.1 mm in size, anhedral.
Rounding is advanced on the whole, but part showed irregularities.

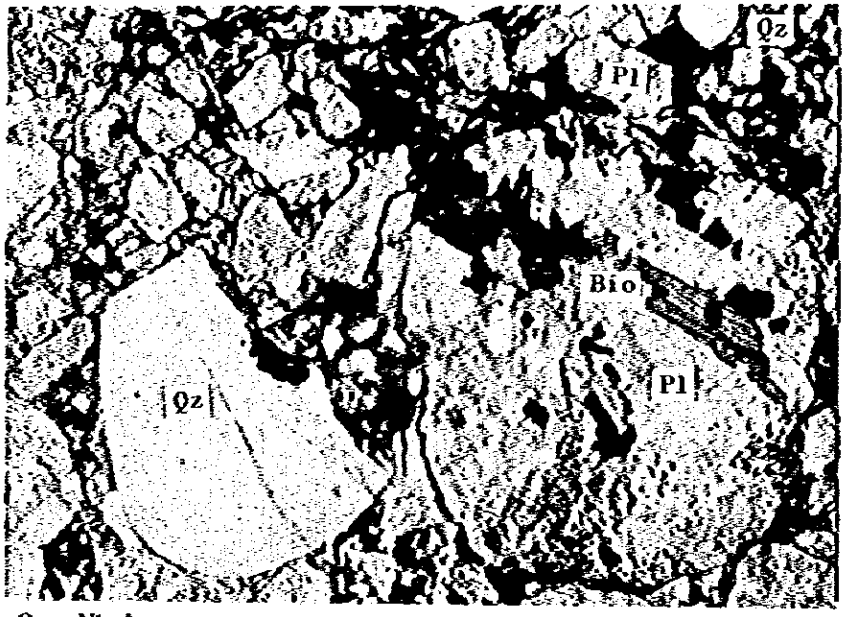
Plagioclase: 0.5 ~ 0.1 mm in size, idiomorphic – hypidiomorphic.
Much is tabular, but a lot has been crushed.
There are albite and Carlsbad twins and a zonal texture. There are inclusions of calcite inside the crystals and sericitization.

Calcite: 0.3 ~ 0.1 mm in size, anhedral.
Embedded between crystal granules.

Biotite: 0.3 mm in size, idiomorphic.
Altered blade shape. Small quantity.

Rock fragments: Average size of 0.5 x 0.3 mm.
Consists of breccia and a small amount of subrounded fragments. Most of the fragments are andesitic with a porphyritic texture. They consists mainly of plagioclase and calcite.

N8-01

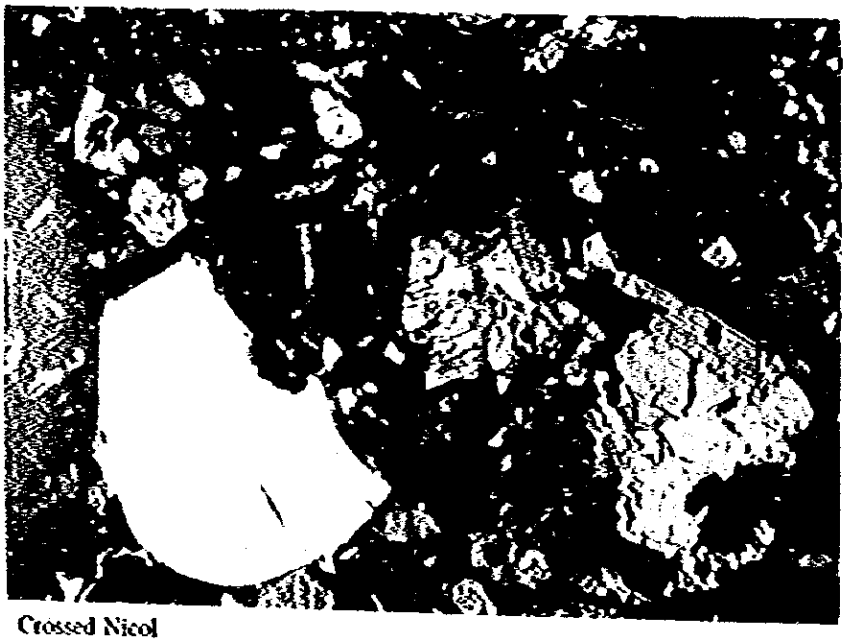


Open Nicol

Lithic-crystalline tuff

Bio : Biotite
Pl : Plagioclase
Qz : Quartz

0 0.5 mm



Crossed Nicol

Lithic-crystalline tuff

0 0.5 mm

N8-01 Lithic – crystalline tuff

Macroscopically, this is a dark red pumicious coarse tuff. Microscopically, there is a large amount of rock fragments. This rock consists of coarse quartz, plagioclase, biotite and calcite. It is a crystalline tuff. The matrix consists of a black amorphous material and fine-grained quartz and feldspar. There is little volcanic glass.

Plagioclase: 1.5 ~ 0.3 mm in size; idiomorphic.
Tabular but usually a lot of crushed material. There are albite and Carlsbad twins and a zonal texture. Some carbonatization and sericitization are seen.

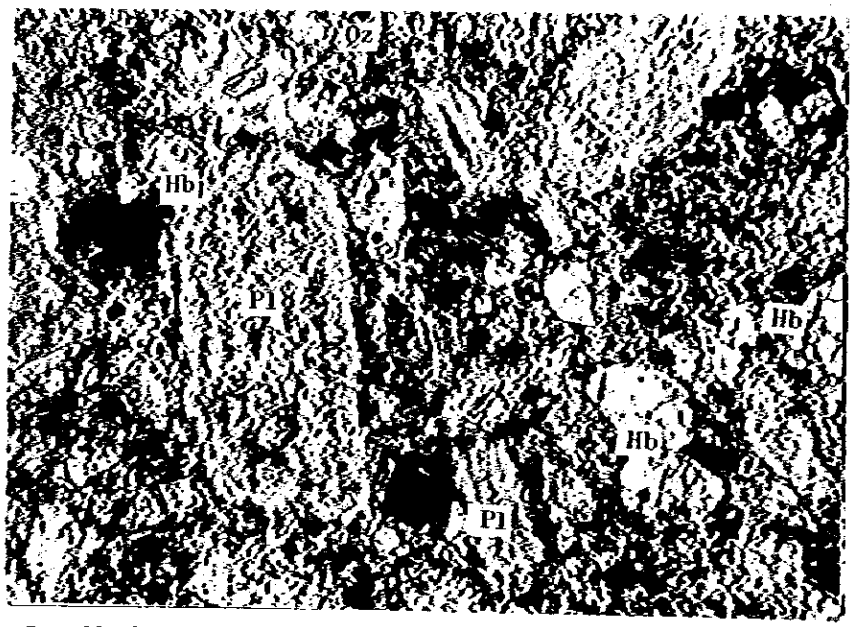
Quartz: 1.0 ~ 0.2 mm in size, anhedral.
Shape shows advanced subrounding.

Biotite: 0.5 ~ 0.2 mm in size, idiomorphic – hypidiomorphic.
Remarkable pleochroism and anisotroism.

Calcite: 0.3 mm in size, anhedral.
Embedded between crystals.

Rock fragments: 2.0 x 0.5 mm ~ 0.3 x 0.2 mm in size.
Breccia – subrounded; andecitic and dacitic.

N9-01

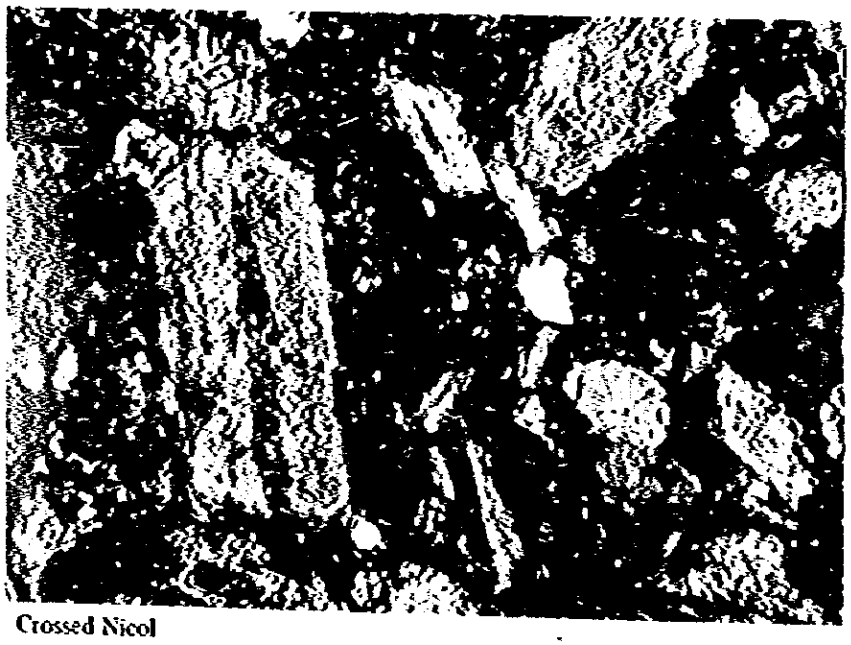


Hornblende andesite

Hb : Hornblende
Pl : Plagioclase
Qz : Quartz

Open Nicol

0 0.5 mm



Hornblende andesite

Crossed Nicol

0 0.5 mm

N9-01 Hornblende andesite

Macroscopically, this is a greyish, greenish, black andesite with a porphyritic texture. The feldspar has been altered and changed to white. Microscopically, the phenocrysts with a porphyritic texture consist of plagioclase, hornblende and clinopyroxine. The matrix consists of plagioclase, hornblende, clinopyroxine and quartz. In the sample as a whole, there is alteration (thermal alteration) and the matrix shows strong argillization and chloritization.

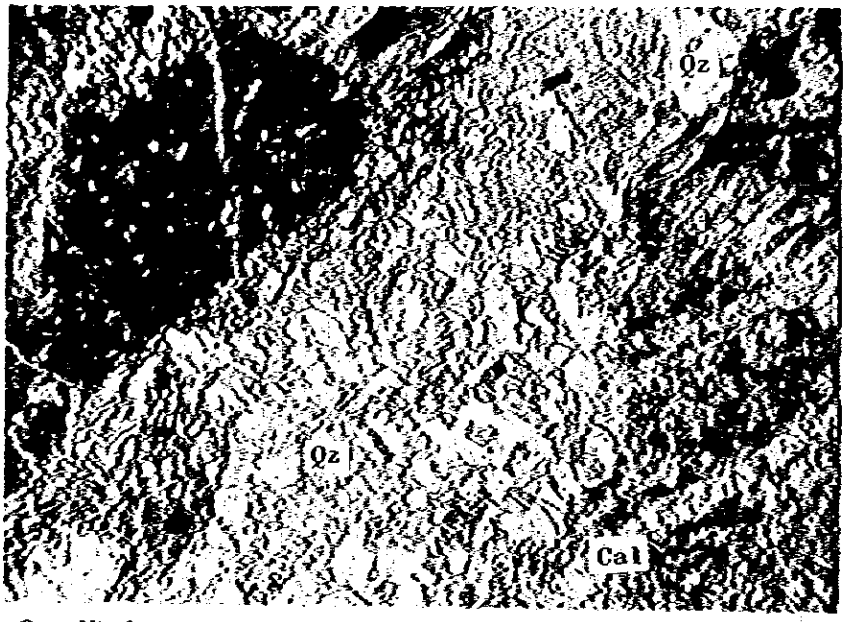
Phenocrysts

Plagioclase: 2.0 ~ 0.5 mm in size, idiomorphic – hypidiomorphic.
Albite and Carlsbad twins have developed.
There has been sericitization, chloritization and argillization. Contamination within the crystals is remarkable. Inclusions of some small-grained hornblende and calcite.

Hornblende: 1.0 ~ 0.3 mm in size, idiomorphic.
Orthophyric – tabular but a lot of crushed material seen. Also inclusions of plagioclase and clinopyroxine.

Clinopyroxine: 0.5 mm in size, hypidiomorphic.
Columnar – rectangular. Inclusions of ferrous oxide and partial replacement by chlorite.

N11-01

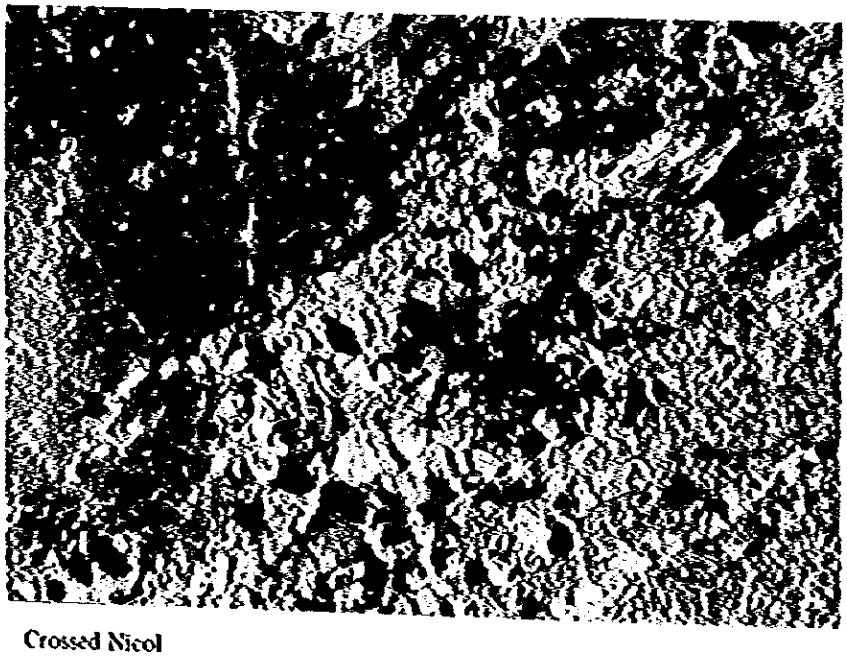


Limestone with calcite veinlet

Cal : Calcite
Qz : Quartz

Open Nicol

0 0.5 mm



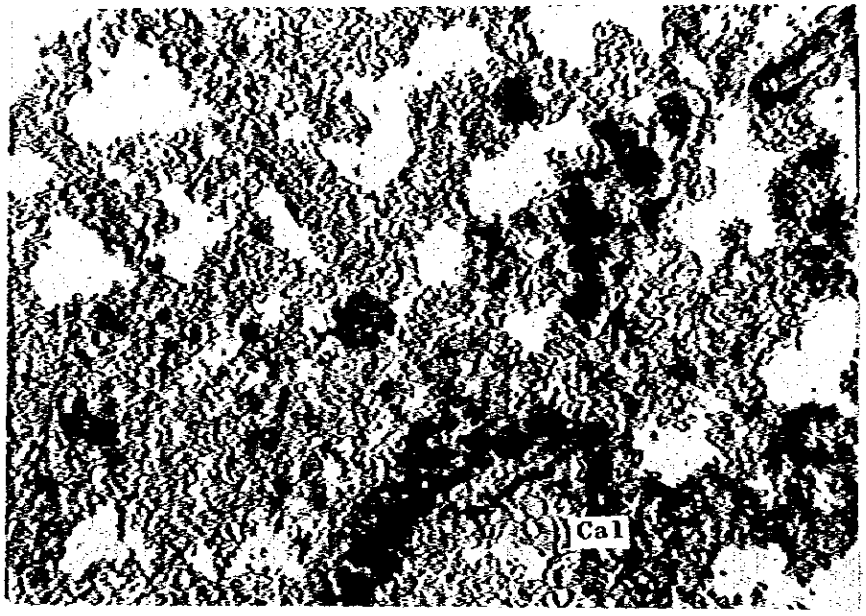
Limestone with calcite veinlet

Crossed Nicol

0 0.5 mm

N11-01 Limestone with calcite veinlets

Macroscopically, this is dark grey dense limestone with white calcite veinlets. Microscopically, it is many small veinlets consisting of fine to medium grained (1.0 ~ 0.2 mm) calcite in massive limestone consisting of fine – very-fine (0.1 mm – several microns) calcite. In addition to calcite, there is medium – fine-grained (0.3 ~ 0.05 mm), anhedral quartz.

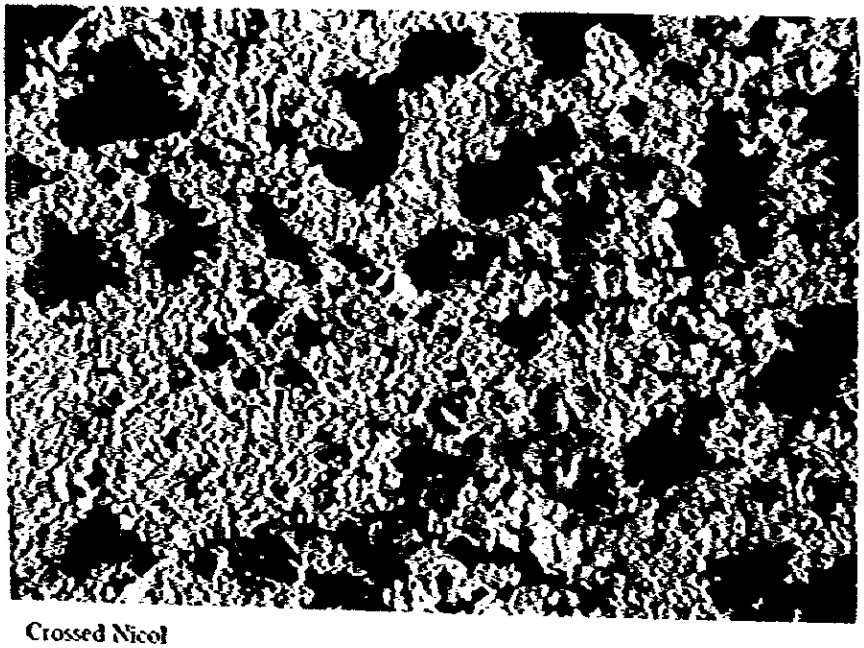


Limestone
(Carbonaceous rock)

Cal : Calcite

Open Nicol

0 0.5 mm



Limestone
(Carbonaceous rock)

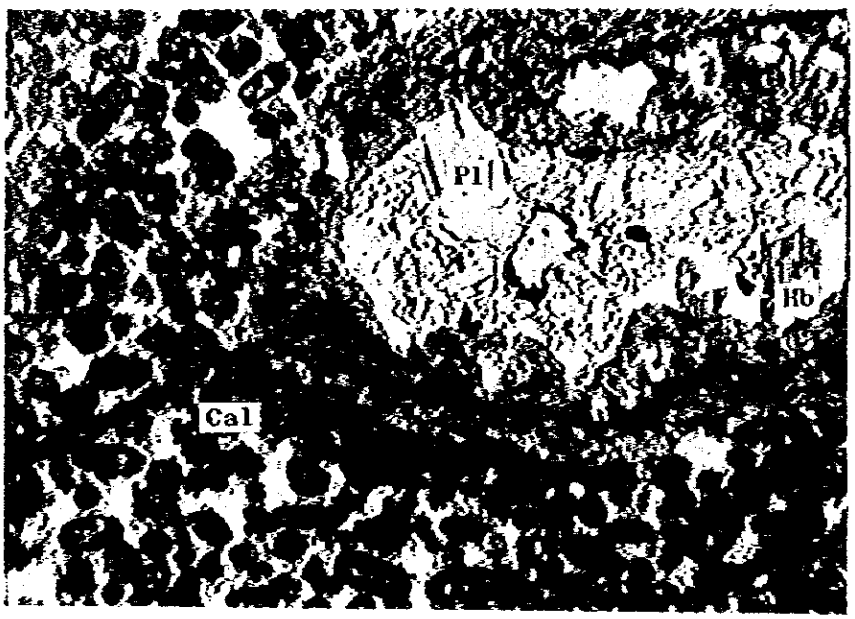
Crossed Nicol

0 0.5 mm

N11-02 Limestone (carbonaceous rock)

Macroscopically, this is greyish-white layered carbonaceous rock (carbonaceous sediment). Microscopically, it is fine-grained (several microns), anhedral calcite with many cavities. In addition to calcite, there are a few carbonates and ferrous oxide.

N12-01

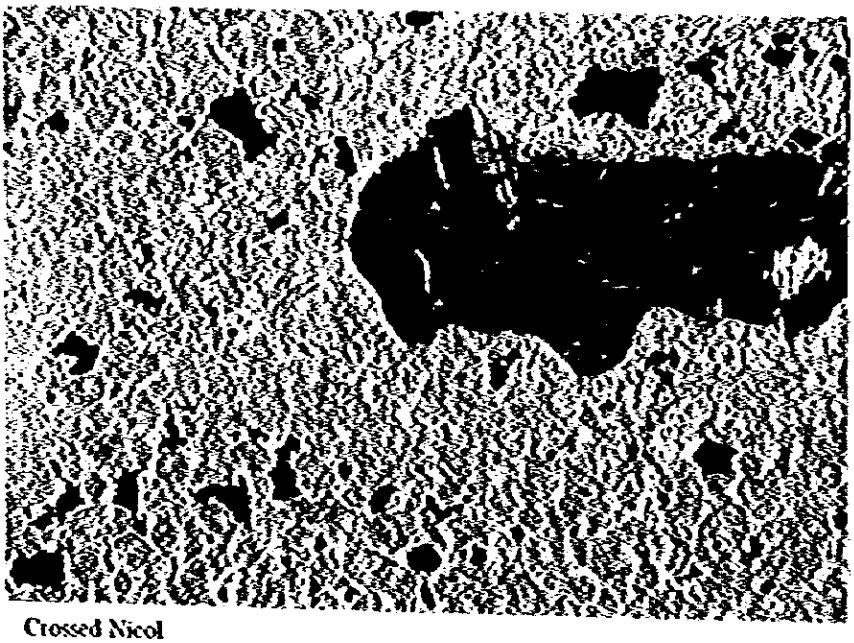


Oolitic limestone

Cal : Calcite
Hb : Hornblende
Pl : Plagioclase

Open Nicol

0 0.5 mm



Oolitic limestone

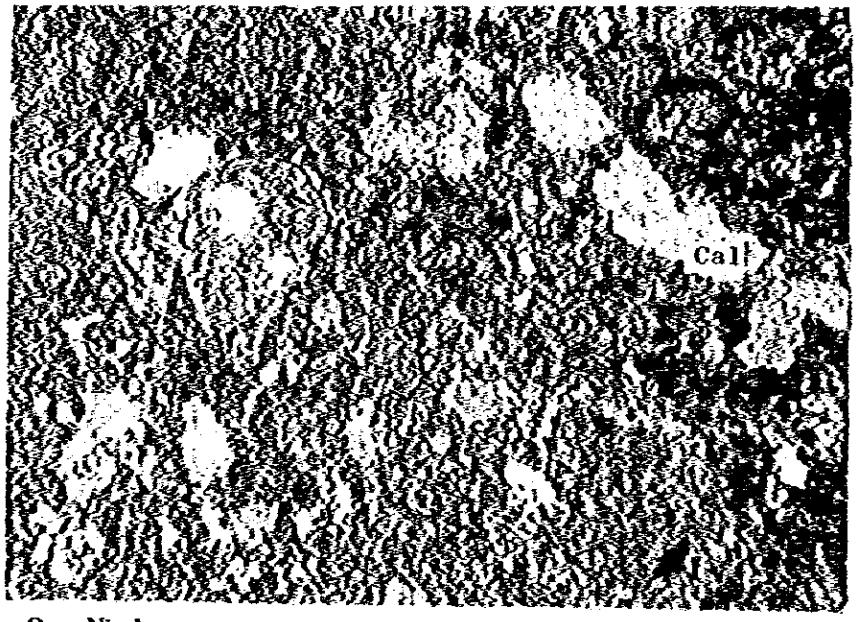
Crossed Nicol

0 0.5 mm

N12-01 Oolitic limestone

Macroscopically, this is a greyish white porous carbonaceous rock. Microscopically, it has an oolitic structure. The calcite is very fine -- fine-grained (several microns – 30 ~ 40 microns) and is anhedral. The length of the oolite is 0.5 ~ 0.1 mm. In this sample, there are fragments of porphyrite (2.0 x 0.5 ~ 0.3 x 0.1 mm) and fragments of plagioclase (0.5 x 0.1 mm ~ 0.1 x 0.1 mm). The fragments of porphyrite consist mainly of plagioclase (0.2 mm) with a small amount of hornblende (0.3 x 0.3 mm).

N12-02

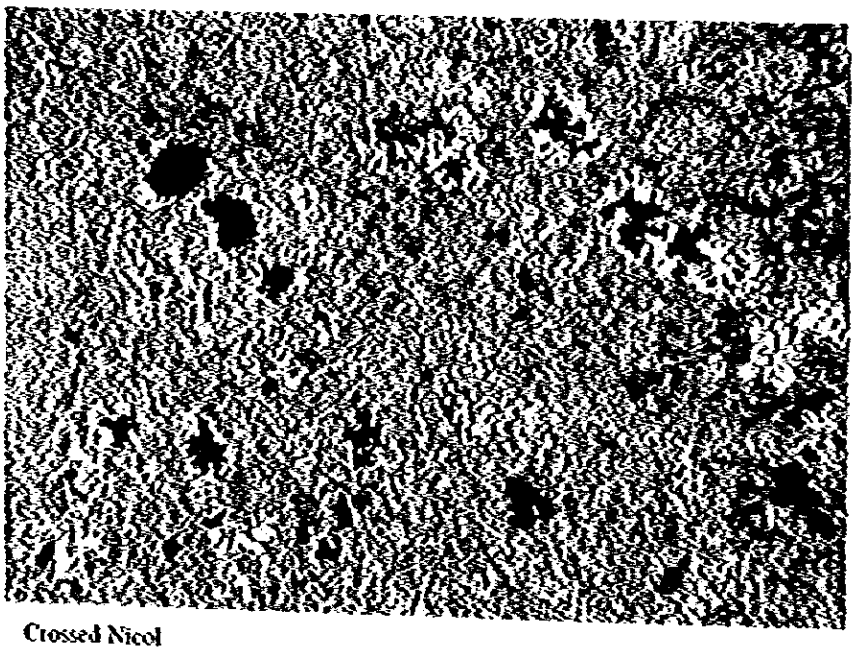


Oolitic limestone

Cal : Calcite

Open Nicol

0 0.5 mm



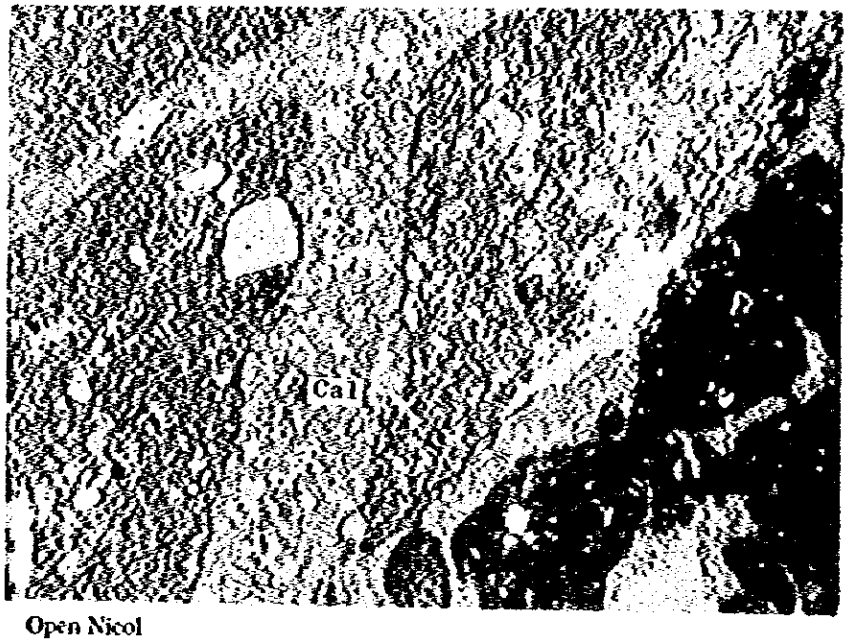
Oolitic limestone

Crossed Nicol

0 0.5 mm

N12-02 Oolitic limestone

Macroscopically, this is greyish white – milky white massive limestone. Microscopically, there are small amounts of oolite, but less than in sample N12-01. It consists mainly of very fined grained calcite, although there is also some recrystallized fine grained (0.1 mm – several microns) calcite with replacement by cavities (or feldspar or mafic minerals). In addition to the calcite, there is some fine-grained quartz, plagioclase and chlorite with irregular shapes.

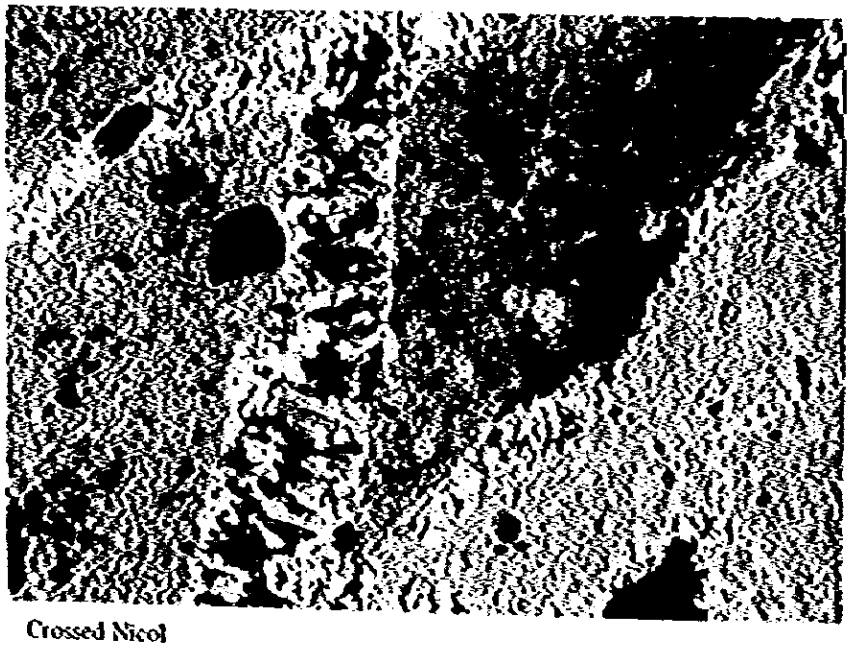


Oolitic limestone

Cal : Calcite

Open Nicol

0 0.5 mm



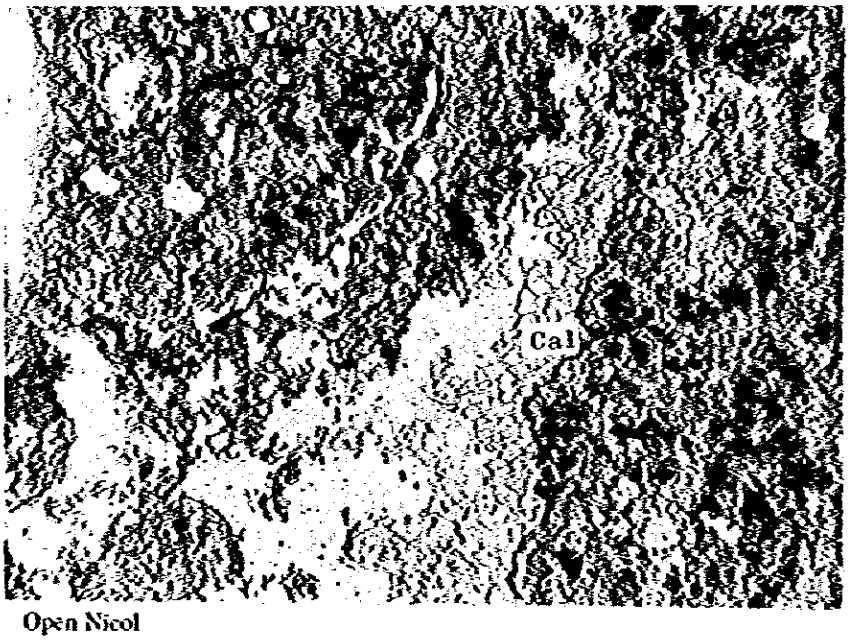
Oolitic limestone

Crossed Nicol

0 0.5 mm

N12-03 Oolitic limestone

Macroscopically, this is liver brown to milky white limestone consisting of oolite with a diameter of several mm. Microscopically, it has a coarse oolitic texture (length of 5.0 ~ 0.2 mm). The space between the oolite grains is filled with fine-grained (0.3 ~ 0.1 mm) calcite. Inside the oolite are some small fragments of feldspar and quartz and andesitic fragments.

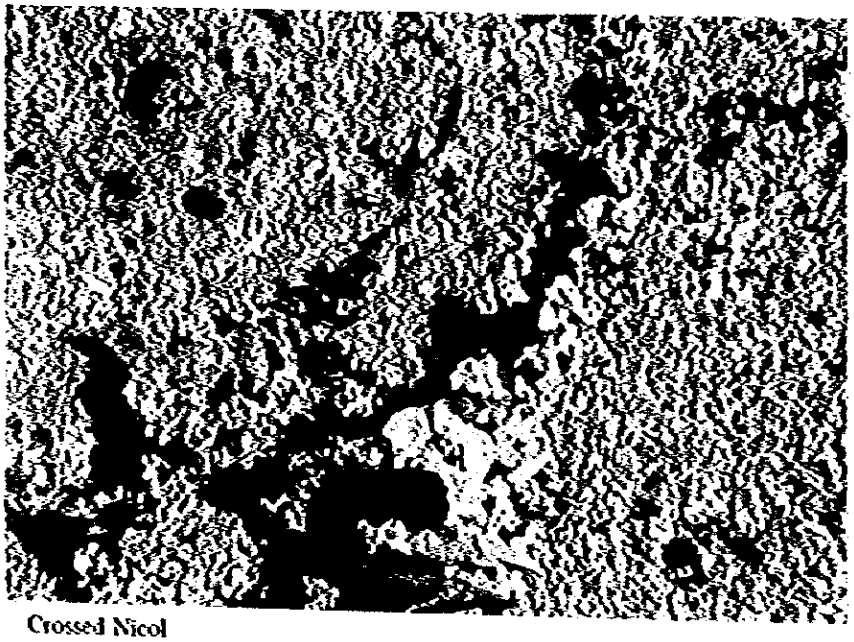


Oolitic limestone

Cal : Calcite

Open Nicol

0 0.5 mm



Oolitic limestone

Crossed Nicol

0 0.5 mm

N12-04 Oolitic limestone

Macroscopically, this is a greyish-white – dark grey banded limestone. Microscopically, it has a banded texture and no clear oolite. It is limestone consisting of very fine-grained calcite with many cavities. There are no impurities such as rock or feldspar fragments. It is the same as limestones N12-01 – N12-03 with respect to structural minerals and rock quality.

3-3 Geochemical Survey

3-3-1 Outline of the Survey

In planning for geothermal development, the chemical properties of the hot springs in the region are extremely important, and they are one of standards, especially in the initial period when there are few geothermal data. The amount of heat released in the region is calculated in relation to the amount of steam released by the hot springs. This serves as an index for estimating the scale of geothermal development. Therefore, a geochemical survey was undertaken concerning the hot springs and river water in the Macarara and Rio Jarma areas.

Recently, a method has been developed for estimating the hot water behavior in geothermal regions by analyzing volatile elements such as mercury and arsenic in the soil. This method was also used in this survey.

3-3-2 Hot Spring Water Survey

Hot springs were gushing out at one location in the Rio Jarma area and at several locations in the Quisicollo area, but none were found in the Macarara area. Table 7-5 shows the spring temperatures and chemical analysis values for these hot springs. Each spring had almost the same components, but the Rio Jarma spring was hotter than the Quisicollo spring.

Table 7 - 5 Chemical Composition of Rio Jarma Spring Water

(Unit: ppm)

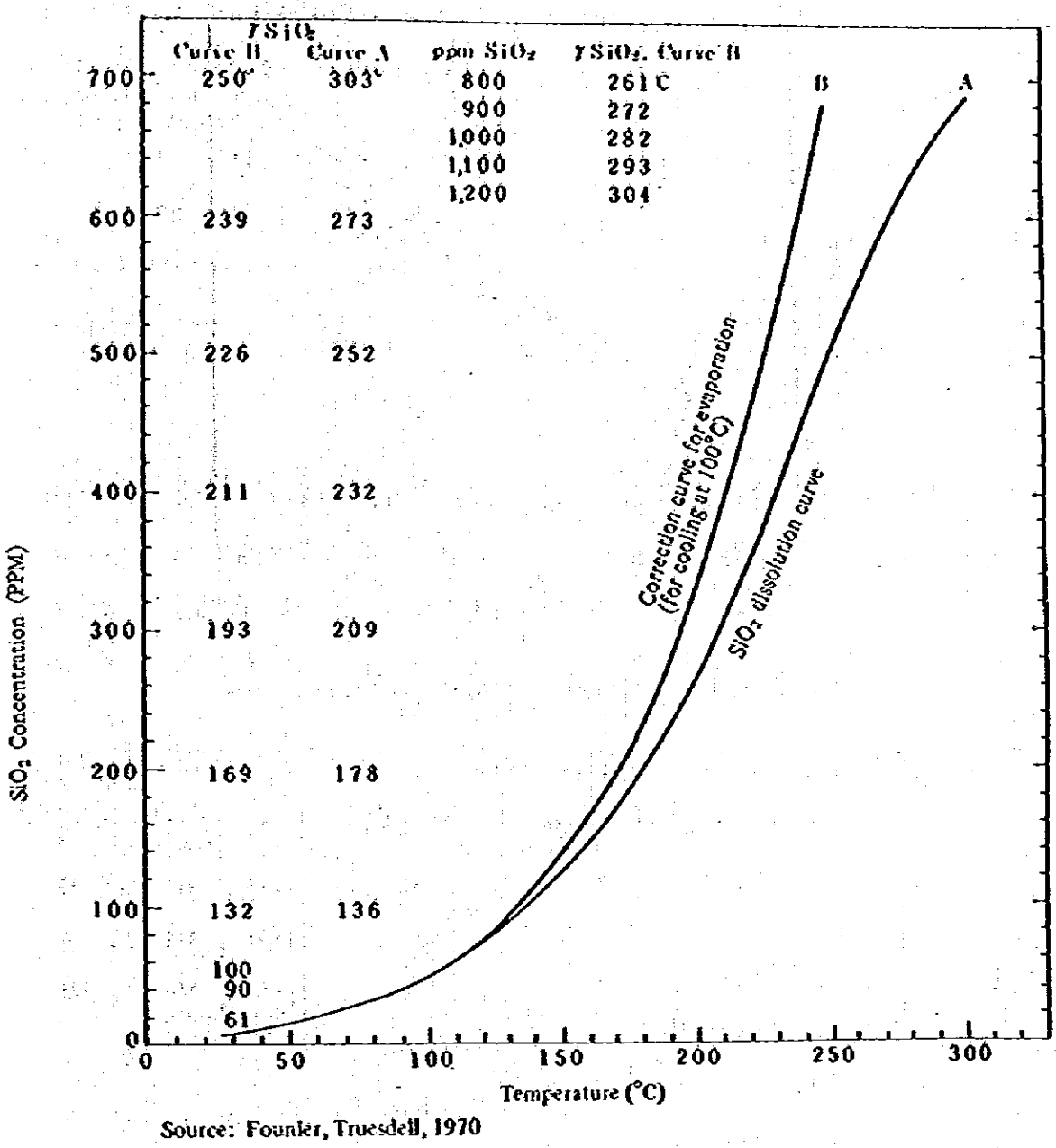
	Spring Temperature	pH	HCO_3	CO_2	Cl^-	SO_4^{--}	Na^+	K^+	Ca^{++}	Mg^{++}	SiO_2	Fe^{++}	Al^{+3}
Rio Jarma Spring	50.7	6.9	269	65.1	11,500	2,893	7,500	114	809	190	37	0.11	0.11
Qaisicollo Spring	52.7	6.9	241	50.2	9,000	2,400	5,680	87	826	124	36	0.46	0.15
Raya-Norte Spring	55.5	6.6	861	356	1,800	651	1,140	130	432	44	77	4.46	0.01

According to the underground temperature estimation method proposed by Fournier (Figs. 7-13 and 7-14), the underground temperature was calculated as shown in Table 7-6. These values were lower than those in other geothermal areas, and lower than those in the La Raya area surveyed previously. Therefore, these areas are not necessarily suitable for geothermal development.

However, these regions show complex underground hydraulics such as a higher value in the upstream river water than in the downstream water as will be described in the next section. The effects of dilution should be considered and a quick evaluation is not possible.

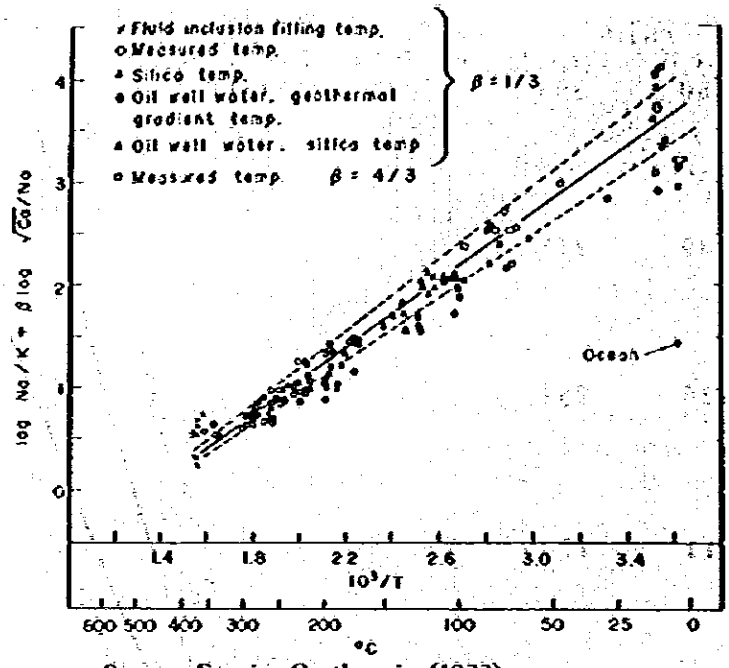
The amount of hot spring water gushing out in the Rio Jarma area is discussed in section 3-3-3.

Fig. 7 - 13 Temperature According to SiO_2 Concentration in Hot Water



Source: Founier, Truesdell, 1970

Fig. 7 - 14 Temperature According to Alkali Ratio In Hot Water



Source: Founier, Geothermics (1977)

Table 7 - 6 Temperatures Estimated by Chemical Thermometers

	Na – K thermometer						SiO_2 thermometer
	Na/K	log Na/K	$\beta\sqrt{Ca+Mg}/Na$	$\log \beta\sqrt{Ca+Mg}/Na$	y*	Estimated temperature °C	Estimated temperature °C
Rio Jarma Spring	113.2	2.05	0.50	−0.30	1.95	116	89
Quiscollo Spring	110.7	2.04	0.65	−0.19	1.93	114	87
Raya-Norte Spring	14.87	1.17	2.26	0.35	1.64	150	121

* $y = \log \frac{Na}{K} + \beta \log \left(\frac{\sqrt{Ca+Mg}}{Na}\right)$

$10^3/T = 0.65y + 1.3 \qquad T: °K$

Where β : $\log \frac{\sqrt{Ca+Mg}}{Na} > 0 \Longrightarrow 4/3$

$\log \frac{\sqrt{Ca+Mg}}{Na} < 0 \Longrightarrow 1/3$

(According to Fournier)

3-3-3 Heat Release Survey

The process of heat release in a geothermal region normally involves the following steps:

(1) Gushing out of hot spring water
(2) Release of steam and gas
(3) Heat conduction by rocks (ground surface)
(4) Evaporation from water surface

In these areas, there was no release of steam or gas and most of the heat release came from hot spring water gushing out from spring (1) in the Rio Jarma area and evaporation from the water surface including the wet land surface in springs (3) and (4) in the Macarara area.

For rough calculations of the heat release in these areas, simple calculations of the river water temperature, amount of water and chemical components were performed. The results were as shown in Table 7-7.

Table 7 - 7 River Water in Survey Region

Sample No.	Collection date	Water temperature	Flow rate	pH	Electrical Conductivity	Na^{+}	K^{+}	Ca^{++}	Mg^{++}	Fe
W – 1	10/11	22°C	22 ton/minute	7.6	12,000	2,350	37.5	315	67.5	0.22
W – 2	Calculated value	18.8	16.7	–	–	2,060	–	–	–	–
W – 3	10/11	16	1.1	7.8	380	59	1.3	28.5	3.8	0.05
W – 4	"	19	15.6	7.8	9,700	2,200	40.0	270	55	0.13
W – 5	"	13	1.9	7.8	330	47.5	1.0	31.5	2.5	0.45
W – 6	"	13	0.2	7.6	2,300	510	7.2	55	7.7	<0.05
W – 7	"	12	0.8	7.8	315	34.5	0.73	38	3.5	0.05
W – 8	"	15	1.6	7.8	1,000	150	2.6	43	5.0	<0.05
W – 9	"	17	2.9	7.7	355	65	1.3	27.5	3.0	0.07
W – 10	"	16	0.8	7.8	405	53	1.3	29.5	4.5	<0.05
W – 11	10/12	28	31.4	7.5	13,500	3,650	75.0	500	82.5	0.12
W – 12	"	18	12.7	8.0	1,100	2,200	40.0	290	60.0	0.10
W – 13	"	13	5.4	7.8	900	145	3.0	50	8.5	<0.05
W – 14	10/5	–	–	7.6	175	11.5	0.4	28.5	2.0	<0.05
W – 15	10/4	–	–	8.8	145	7.5	0.9	20.5	8.0	<0.05

Note: W-2 was calculated as (W-3) + (W-4) to obtain the river water value upstream from the Rio Jarma spring

(1) Rio Jarma area

Hot springs gushed out along the river in this area as shown in Table 7-5. The amount of water gushing out in this area was calculated as follows from the river water temperature and chemical composition upstream and downstream in the spring area.

$$G_o = G_2 \times \frac{t_2 - t_1}{t_o - t_1} \quad \cdots\cdots\cdots \quad (1)$$

or

$$G_o = G_2 \times \frac{Na^+_2 - Na^+_1}{Na^+_o - Na^+_1} \quad \cdots\cdots \quad (2)$$

G_o : total water gushing out of hot springs

G_2 : downstream river water

t_o : hot spring temperature

t_1 : upstream river water temperature

t_2 : downstream river water temperature

Na^+_o : Na concentration in hot spring

Na^+_1 : upstream river Na concentration

Na^+_2 : downstream river Na concentration

From (1) : $G_o = 0.37\ m^3/sec \times \frac{22.0 - 19.0}{52.0 - 19.0} = 0.034\ m^3/sec$

From (2) : $G_o = 0.37\ m^3/sec \times \frac{2.350 - 2.060}{7.500 - 2.060} = 0.020\ m^3/sec$

The difference between the two is rather large, but the order is the same and if the non-uniformity of water temperature and quality at the time of sampling is taken into consideration, these values can be used as rough estimates.

Therefore, the amount of heat released in this area, Q, can be calculated as follows of the spring temperature θ_o is 52°C and the standard underground temperature θ is 10°C:

$$Q = (\theta_o - \theta) \times G_o\ kg/sec \times c \times \rho \quad (c: \text{specific heat}, \rho: \text{density})$$
$$= (52-10)°C \times (20-34)\ kg/sec \times 1.0\ Kcal/kg°C$$
$$= (0.84 - 1.4) \times 10^3\ Kcal/sec$$
$$= (5.0 - 8.4) \times 10^3\ cal/min$$

This value is about one tenth of that obtained for the surveyed Quisicollo area.

(2) Macarara area

There were no erupting hot springs found in this area. However, values were obtained from the river and hot water conditions in this area (Table 7-7) which indicated that the area was influenced by hot springs such as W-6 and W-5. This is a wet, high area with a daytime humidity of 10 ~ 20%, a night humidity of 80 ~ 90% and an air pressure of 600 mb. Therefore, there is a very large amount of heat release due to evaporation of water. The days on which measurements were performed differed and the measurements were not precise, but the fact that there was more river water at the most upstream point W-11 than downstream probably shows not only that the underground water system in the area is complex but also that there is a high evaporation factor.

Therefore, it is difficult to determine the heat release in this area quantitatively, but from the results of the soil analysis, etc. described later, it can be assumed that the heat released geothermally in this area is at a rather high level.

3-3-4 Analysis of Trace Component of the Soil

In geothermal regions, volatile elements such as mercury and arsenic tend to accumulate in the upper ground layers (including the ground surface). Therefore, soil sampling was performed in almost right angles to the south-north fault matching the ground temperature measurement line in the Macarara area and mercury and arsenic were analyzed. The sampling sites are shown in Fig. 7-9.

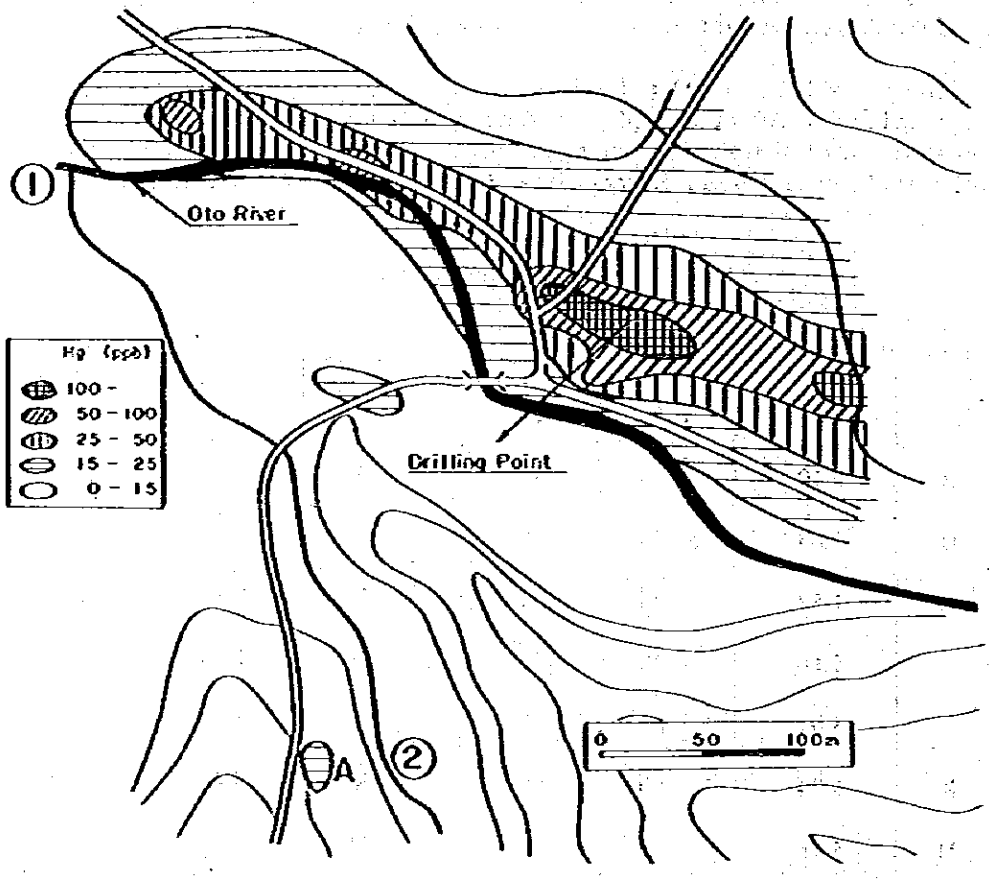
Samples of 100 g to 200 g of soil were collected under an 80 mesh screen from points 30 ~ 40 cm below the ground surface. After the samples were dried at 105°C for four hours, mercury was analyzed by atomic absorption spectrochemical analysis by means of $SnCl_2$ reduction and vaporization and arsenic was analyzed by photoelectric photometry using mercury diethyldithiocarbaminate. The results are shown in Table 7-8.

Table 7 - 8 Mercury and Arsenic in the Soil

Sample	H_2O (–) %	Hg ppb	As ppm	Sample	H_2O (–) %	Hg ppb	As ppm
21 – A	5.10	45	17	25 – A	2.38	5,490	41
C	3.63	3,660	156	C	10.22	56	13
E	1.57	24	41	E	7.38	144	16
G	5.16	90	778	G	7.06	107	17
I	3.02	25	47	I	5.42	167	17
K	5.74	50	32	K	4.48	45	10
M	5.98	72	16	M	3.74	153	12
23 – A	5.94	94	11	0 – E	5.52	257	32
C	4.46	61	19				
E	8.34	47	89				
G	8.25	33	61				
I	1.79	31	72				
K	4.02	49	13				
M	6.38	40	17				

These values are about the same as those obtained in Hachimantai, a typical geothermal area in Japan (Hg: 40 ~ 4,000 ppb). With the developed area at Oguni in Kyushu as a reference (Fig. 7-15), it can be assumed that there is a geothermal area along the A and C lines in the south-north direction and along line No. 25 in the east-west direction.

Fig. 7 - 15 Hg Anomalies in Ota Village, Minami-Oguni-Machi, Kumamoto Pref., Japan



For reference, an analysis was made at the main surveying point (Quisicollo area), but the mercury values were higher there.

3-4 Ground Temperature Survey

3-4-1 Ground Temperature Survey

The most direct method of determining the distribution of underground heat sources is a ground temperature survey. To find out the distribution of the ground heat accumulation strata several hundred meters underground, it is recommended to make the temperature measurement borings deeper but borings of 100 m, 30 m, 10 m and 1 m are proposed as survey methods. The 100 m boring is used for estimation of the heat source model and the 30 m boring is the boundary point at which there is no longer any dependence on surface conditons.

The 1 m deep ground temperature survey depends considerably on ground surface conditions, but it is convenient and is widely used for determining one criterion.

This survey consisted of a rough survey to determine the overall trends in the Quisicollo, Macarara and Rio Jarma areas and measurements of ground temperature at a depth of 1 m at grid-type measuring points in the Macarara area.

3-4-2 Survey Period and Measuring Points

(1) Rough survey

October 4 ~ 7, 1978 — 36 points

(2) Detailed survey

October 8 ~ 11 — 76 points

The measuring points were arranged in a grid pattern with gaps of 100 m. The points matched the soil sampling points.

3-4-3 Measuring Method

The ground temperature measuring method at a depth of 1 m involved pounding a hexagonal chisel 14 mm in diameter and 120 cm long into the ground with a hammer to make a temperature measuring hole 1 m deep. Then, a rod-shaped thermister thermometer was inserted into the hole. To avoid the effects of frictional heat when the hole was made, the measurements were made after a few minutes when the heat sensitive part of the thermometer had reached a sufficient ground temperature.

3-4-4 Survey Results

The survey results are shown in Tables 7-9 and 10. As can be seen in the tables, the detailed survey in the Macarara area gave low temperatures because most of the measuring points were in areas of low wetness, which is not desirable.

Fig. 7-16 gives a rough outline of the isotherms of the area obtained from Tables 7-9 and 10.

Since the topography in the Rio Jarma area is rugged, a detailed survey was impossible but the area shows the same high ground temperature distribution as in the Quisicollo area.

Because of the low level of wetness of the land in the Macarara area, good results could not be obtained, but if the results of soil analysis, the distribution of alterations, etc. are taken into consideration, it can be assumed that the heat increases along the underground fault and this area remains a potential area for geothermal development.

3-5 Compilation of Geothermal Surveys

Various surveys were conducted in the Rio Jarma, Macarara and Quisicollo areas. The results are summarized with respect to the possibility of geothermal development in these areas in the following sections.

3-5-1 Geological Structure

In these areas, there is wide ranging sedimentation of mesozoic cretaceous Ayabacas limestone strata. After elevation, erosion and sedimentation, there was sedimentation of a Puoo clastic rock on these strata.

Thereafter, severe crustal disturbances occurred and a south-north main structure, followed by an east-west sub-structure, were formed.

There was repeated volcanic activity along the main structure in the tertiary eocene period and Tacaza volcanic rock accumulated. The activity of the structural lines continued after the end of the volcanic activity and the east side settled. In the tertiary pliocene period, the Yauri lake was formed and there was sedimentation of the Yauri lacustrine deposits.

The geothermal showings were remarkable at the intersections of the main and sub-structure lines and it appears that there is a Fisher type geothermal structure.

Table 7 - 9 Ground Temperature Measurements (A)

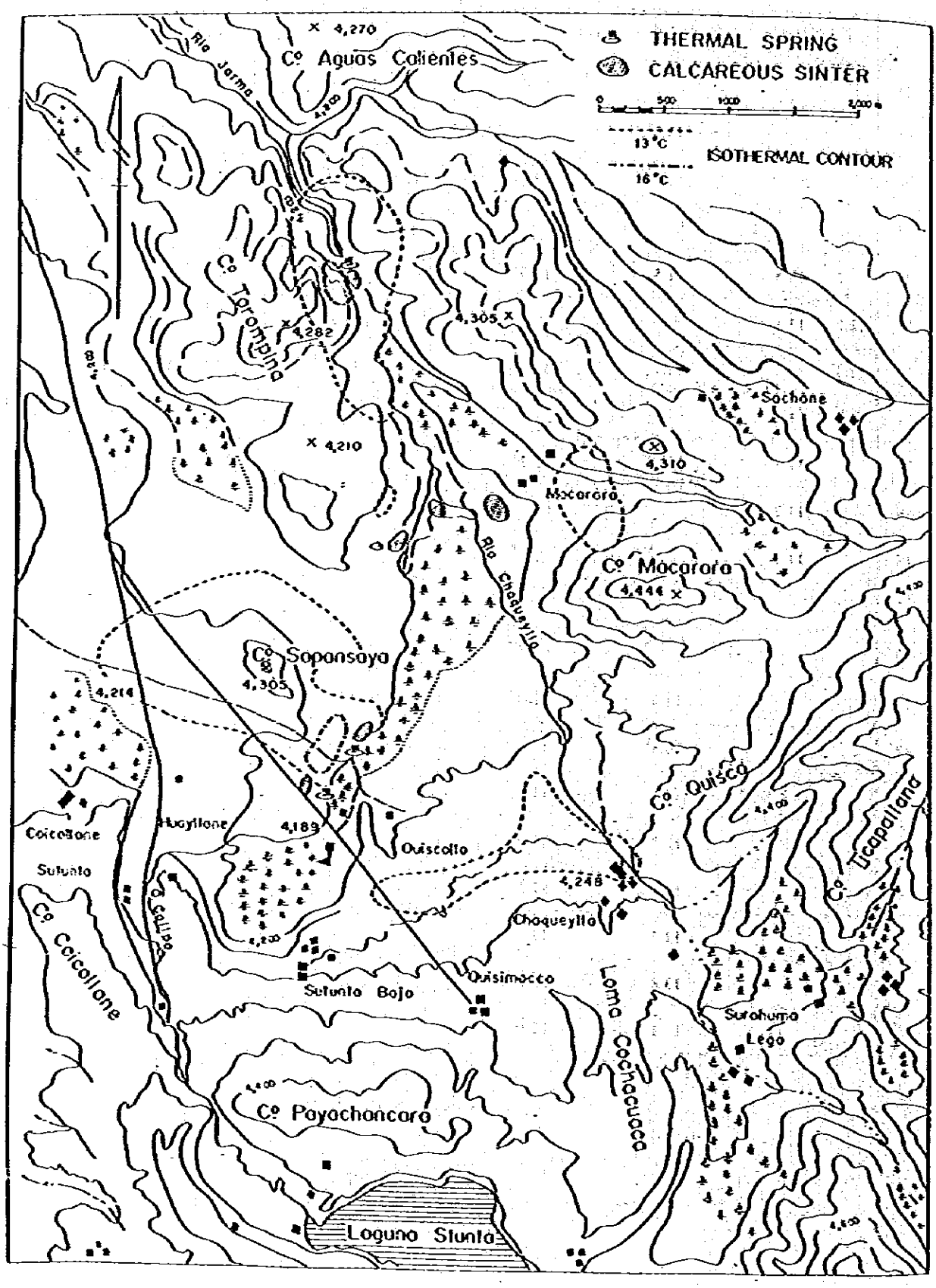
No.	Temperature	Location
1	13.6	About 1 km along road from St. pt.
2	13.0	1 km from 1
3	11.5	2 km from 1
4	12.0	1 km from 1 in Quisimoco direction
5	13.0	1 km from 4
6	11.5	Quisimoco
7	12.7	1 km north from St. pt.
8	13.0	2 ,,
9	10.5	Beside sinter, wet
10	–	
11	13.1	Chaqueylla church side
12	13.1	About 800 m from church to Sapansaya
13	11.9	About 800 m more from 12
14	12.8	About 700 m from 13 to Macarara
15	10.8	60 cm many rocks, Center of pampas
16	10.0	Center of pampas
17	11.2	800 m from 16
18	13.2	500 m north of Sapansaya
19	12.7	About 600 m from 18 Sapansaya
20	10.0	West sinter north bank
21	12.0	300 m to mountains from 20
22	11.0	Water from 30 cm down, large sinter center
23	10.5	No note, wet, as above
24	16.5	[check 50 m below, 12.7°C] From Macarara 800 m hillside
25	10.2	Macarara town, South side
26	12.7	26A 10.2 Chaqueylla river on bluff
27	12.7	Chaqueylla river east
28	13.5	1 km north from 20, Highland beside river bank
29	13.5	300 m to north from 28
30	14.8	North spring south 100 m on bluff
31	18.0	North spring bluff 50m
32	13.0	North spring downstream 100 m
33	13.5	33 opposite bank
34	14.8	North spring opposite bank
35	12.5	Macarara town, North side
36	11.0	North Macarara area on bluff near river
37	11.2	North Macarara area on bluff near river

Note: St. pt. 21.5 (B) O - E point

Table 7 - 10 Land Temperature Measurements in Macarara Region (B)

	Z	A	B	C	D	E	F	G	H	I	J	K	L	M
28						10.4								
27				13.2			12.5							
26				10.0[W]		12.7	12.8	12.5		11.8	12.3	14.0	10.5[W]	
25									11.5			12.7	12.2	
24		10.5		8.5		10.0			10.2[W]		12.4	10.2	10.5	11.0
23	12.2	11.8							11.3	10.3		13.5	11.3	12.7
22	12.3			11.7		11.5			11.8[W]		12.5	11.8	12.3	11.5
21	11.7	11.3									10.4	9.3	12.8	11.8
20		11.8		11.0[W]		9.2[W]					10.8	9.7	10.3	12.7
19		11.2												
18		11.5		[W]		9.2[W]								
17														
16			12.3	[W]		8.8[W]								
14				12.0		10.0[W]								
12				10.8[W]		13.0								
10				14.3		11.5								
8				12.7		13.0								
6				12.3		12.4								
4				12.3		12.1								
2				13.8		13.3		(Quisicollo region)						
0				12.1		22.6								

Fig. 7 - 16 Location Map of Geothermal Showings, Quisicollo Area, Southern Cuzco, Peru



3-5-2 Geochemical Survey

The underground temperature estimated from the chemical composition of hot springs in the area was not very high. However, in the case of the amount of heat released, the Quisicollo area was found to be at thermal level IV and the Rio Jarma area at thermal level III from the amount of active hot springs. The Macarara area was not clear but if it is taken into consideration that the area is a dried highland, it can be expected that the amount of heat released by water evaporation will be higher than the values given above. This area can also be considered as a potential zone of geothermal development from the values for mercury and arsenic in the soil.

3-5-3 Ground Temperature Surveys

The ground temperature survey carried out in the Macarara area did not give the results expected because of the low land wetness in the area. However, the presence of high temperature areas was confirmed at points along the structural lines in rough surveys which included the Quisicollo and Rio Jarma areas. The thermal structure in these areas is assumed to be based on a fractured zone along the fault.

3-5-4 Summary

A summary of these survey results indicates that the Quisicollo, Macarara and Rio Jarma areas form the same geothermal region based on structural lines and the same heat source. Among these areas, the Quisicollo area is the most promising. The amount of heat released in the Rio Jarma area is about one tenth of that in the Quisicollo area. The heat release in the Macarara area is not clear, but it is possible that it about the same as that in the Rio Jarma area.

It has been reported that in the areas which have already undergone geothermal development, the ratio of the amount of geothermal intake and the amount of natural heat release are 4 ~ 5-fold in Wairakei (New Zealand), 10-fold in Ralderello (Italy), more than 180-fold in Geyser (USA) and 25-fold in Matsukawa (Japan).

The possible geothermal intake in these areas should be about 22×10^7 Kcal/h if it is five times the natural heat released (75×10^7 cal/min.). A power generation of 300 MW/h can be anticipated as the geothermal capacity. The details will have to be obtained from the results of future surveys.

4. Plan for a Geothermal Power Generation Plant

4-1 Construction Site and Scale

It is also mentioned in the surveys of the Electric Power Sector that it would be very economical if there was a geothermal source near the mines to serve as an electric power source for the mining city development.

The Rio Jarma and Macarara areas which were the subjects of these geothermal surveys are about 30 km from the mines, as is the Quisicollo area and on the basis of the heat release, power generation of 30 MW or more can be expected. If it can be confirmed that there are high temperature geothermal fluids, it is highly possible that these areas could be the site of a geothermal power plant.

Geothermal fluid with a slightly higher temperature can be expected in the La Raya area than in the Quisicollo area but the La Raya area is about 80 km over mountains away from the mines and it can be considered as a secondary potential area for about 10 ~ 15 MW.

With respect to the scale of the power plant, it is estimated that the power requirements of the mines and the surrounding cities will be about 30 MW, and a scale of 30 MW is anticipated for the first stage of the plan.

4-2 Outline of the Construction

Based on the hypothesis that 300 tons/hour can be obtained from steam of 5 kg/cm² from a geothermal well in the area near the mines, the facilities of a geothermal 30 MW power plant will be roughly as follows.

(1) Production wells

Six wells with a depth of about 1,000 m and a diameter at the bottom of 8.5 inches.

The amount of steam from the production wells will differ in accordance with the area and place, but a standard production well in Japan has been used for reference (maximum of 120 tons/hour, minimum of 30 tons/hour, average of 50 tons/hour).

(2) Reduction wells

Two to six wells

It is also assumed that hot water will be available as a geothermal fluid in these areas. In existing geothermal power plants, the ratio of steam to hot water is often about 1:4-5 at 5 kg/cm². Therefore, for power generation of 30 MW, 1,200 ~ 1,500 tons/hour of hot water will be produced. This hot water can be used in agriculture and other applications. However, from the standpoint of conservation of water resources in geothermal areas, it is necessary that a circulation system be formed so that part or all of the hot water flows underground. For this plan, future surveys will be necessary but it is now assumed that there will be six reduction wells. An example of the completion of the production and reduction wells is shown in Fig. 7-17.

(3) Well outlet arrangement and steam transport piping

The facilities for collection of the steam from the geothermal wells and its transport to the power plant as shown in Fig. 7-18 will be necessary.

There are multi-stage flush systems for separation of steam and hot water, but an ordinary single-stage system is shown here.

(4) Turbine

Type:	Single-cylinder, single-flow type condenser turbine
Number:	2
Rated output:	15,000 kW (power generation end)
Steam conditions:	Output – 4.5 kg/cm² abs. (before main steam stop valve) Temperature – 147.4°C (moisture content: 1%)
Exhaust pressure:	100 mmHg abs.
Steam input:	150 t/h (per turbine)
Speed of rotation:	3,600 rpm

(5) Condenser

Type:	Barometric jet condenser
Number:	2
Capacity:	14.5 t/h (per condenser)
Internal pressure:	100 mmHg abs.
Cooling water temperature:	25°C
Amount of cooling water:	3,100 t/h (per condenser)
Gas extractor:	two-group, 2-stage steam spray type ejector

(6) Generator

Type:	Horizontal, rotating field, air cooled, total enclosed, 3-phase synchronized generator
Number:	2

Ratings:		No. of phases	3
		No. of poles	2
		Output	18,750 kVA
		Voltage	6,600 V
		Frequency	60 Hz
		Speed of rotation	3,600 rpm
		Power factor	0.8
		Short-circuit ratio	over 0.55
Cooling system:		stator winding	cooling by air
Excitation system:		static excitation system	

(7) Main transformer

Type:		outdoor-type	oil-injection self-cooling type
Number:		2	
Ratings:	Capacity	primary	18,750 kVA
		secondary	18,750 kVA
	Frequency	60 Hz	
	No. of phases	3 phases	
	Voltage	primary	6,600 V
		secondary	66 kV

(8) Power lines

Line distance	30 ~ 40 Km
Power	30 MW
Voltage	66 kV

Fig. 7-19 is an overall flow diagram of the power plant. For reference, Photos 7-1 and 7-2 show a general view and the turbine of a thermal power plant of about the same scale as the planned plant (37,500 kW Cerro Prieto geothermal power plant in Mexico).

Fig. 7 - 17 Example of Geothermal Well

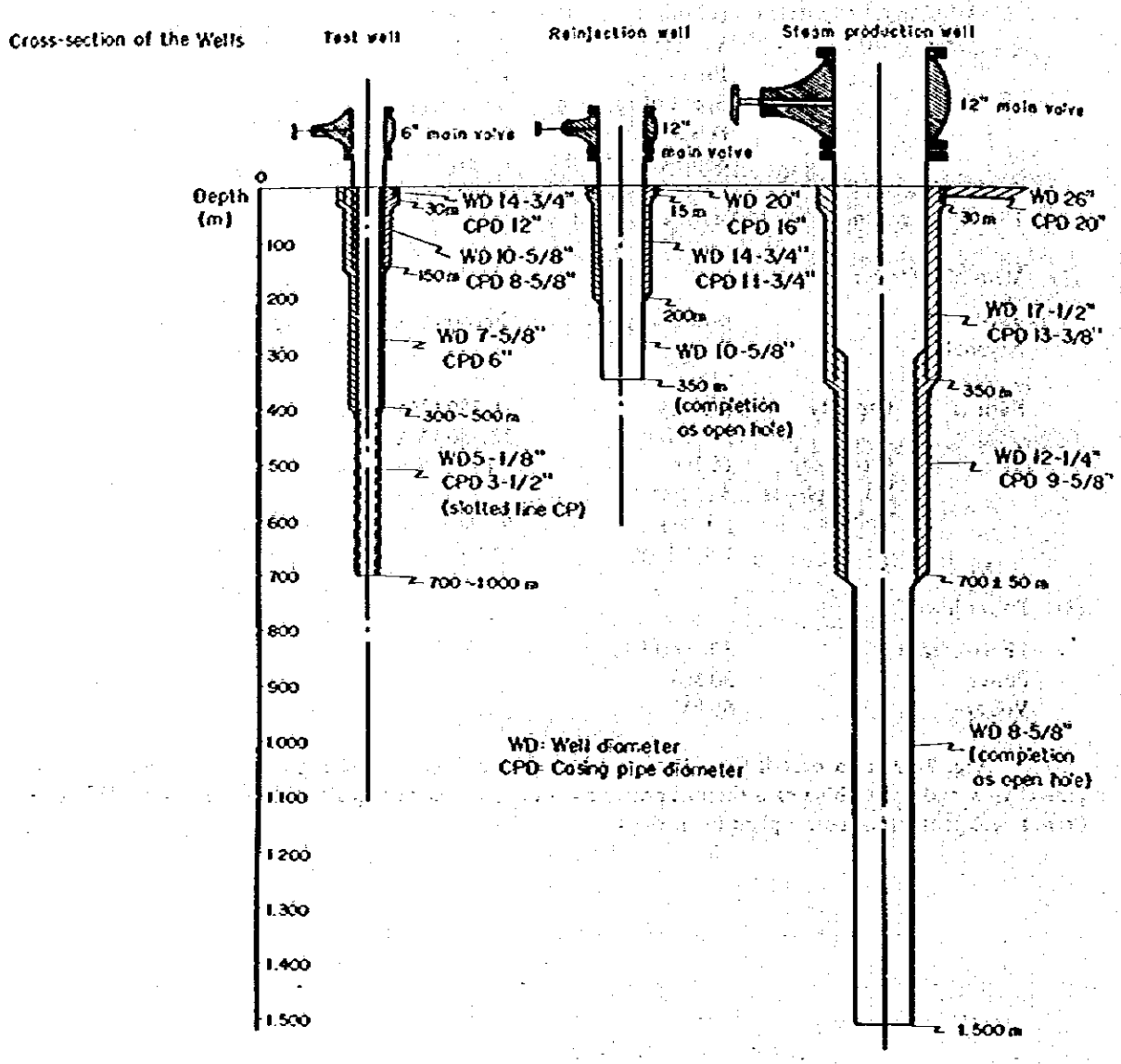


Fig. 7 - 18 Geothermal Well Facilities

(Unit: mm)

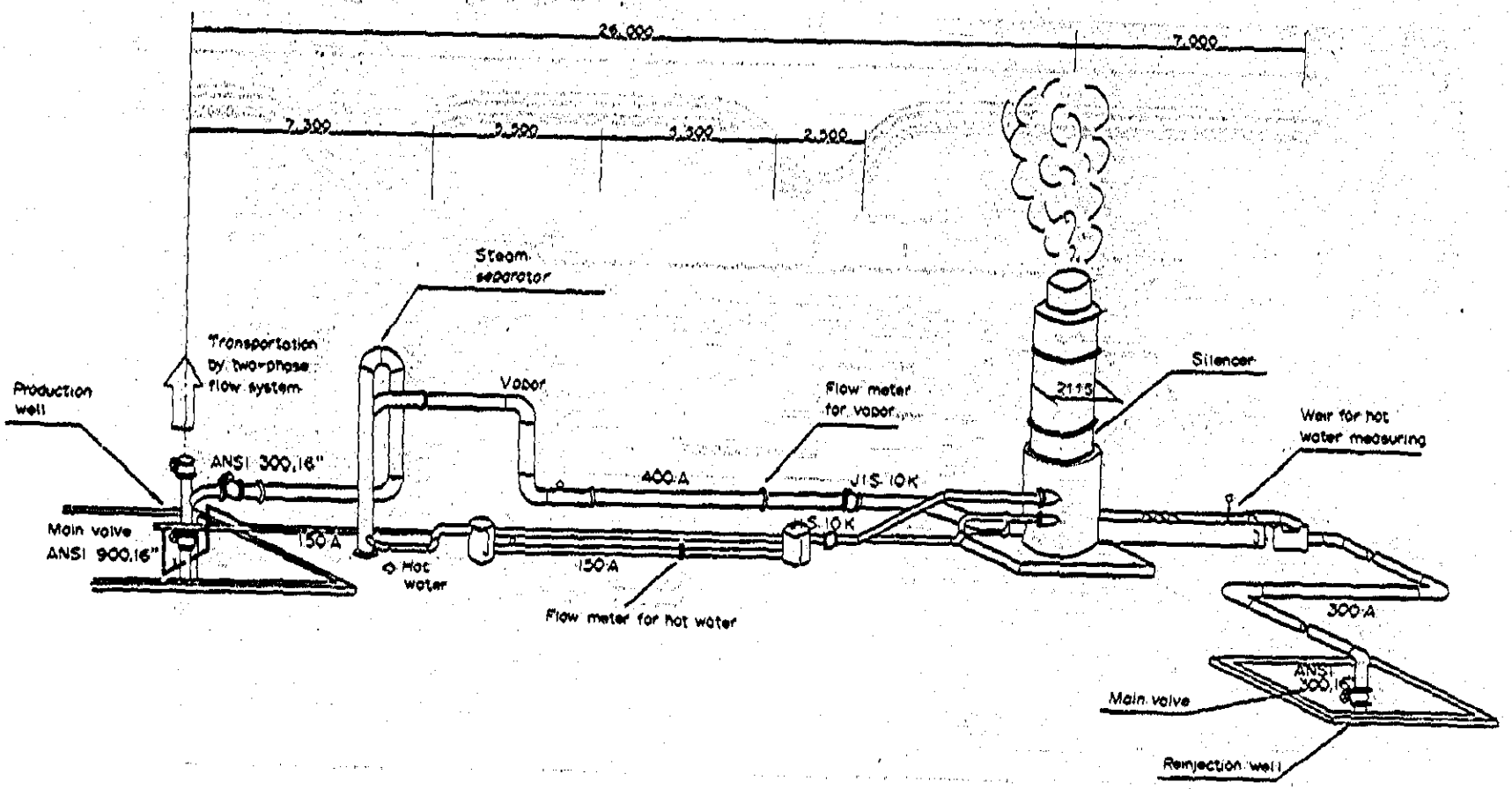
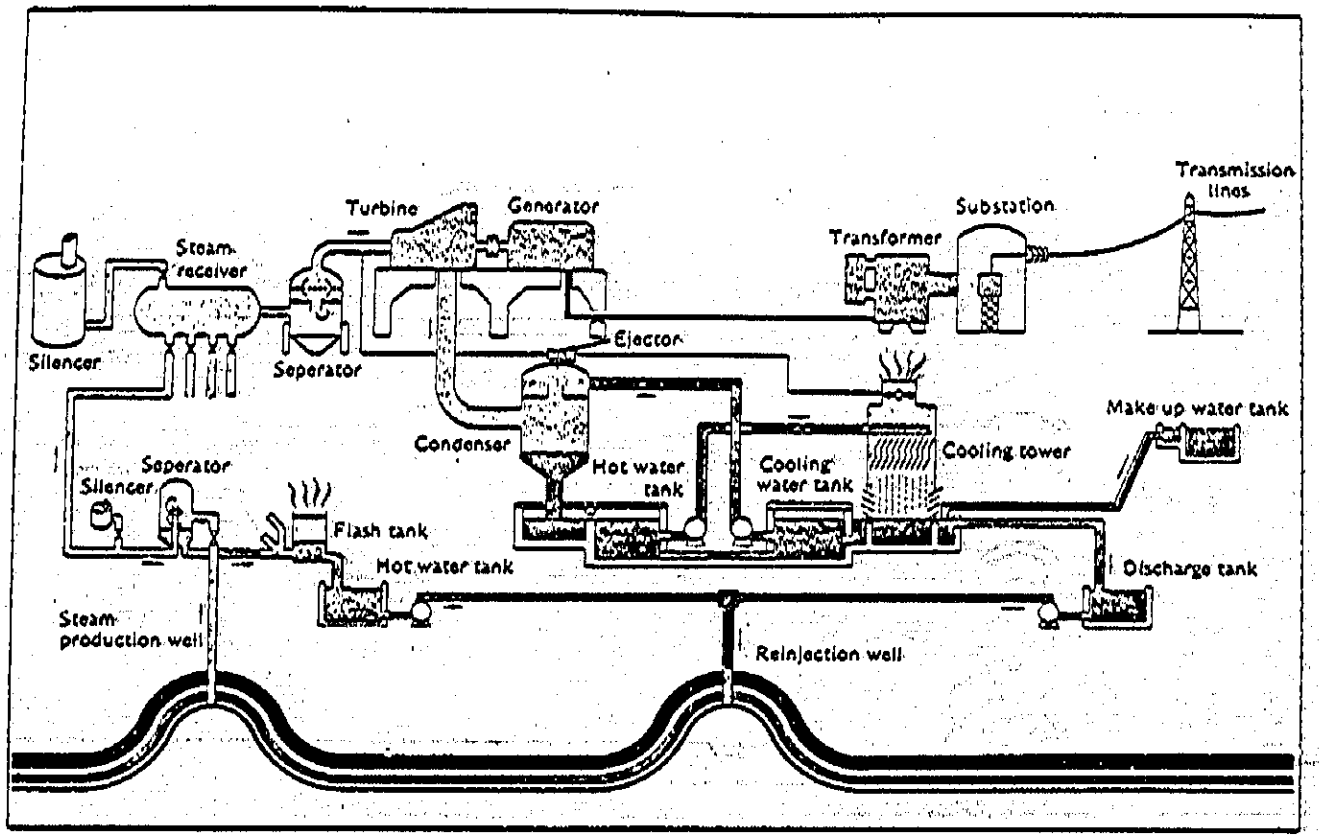


Fig. 7 - 19 Typical Flow Chart of Geothermal Power Plant



Source: Geothermal Energy Resea

Photo 7 - 1 Cerro Prieto Power Plant (37.5 MW)

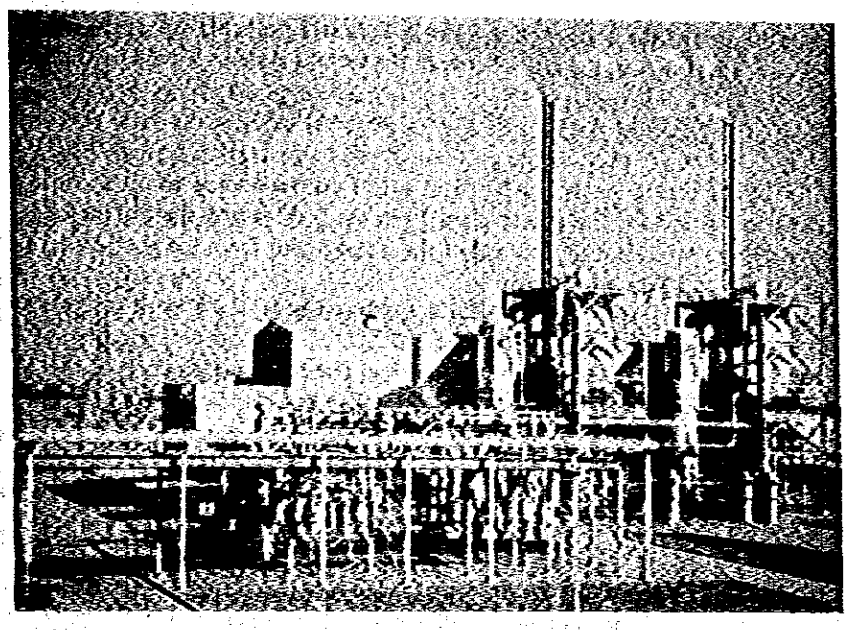
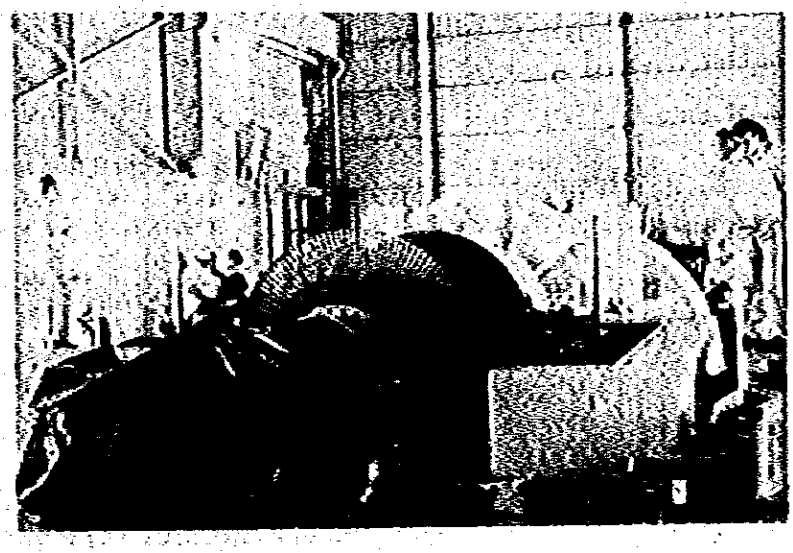


Photo 7 - 2 Cerro Prieto Power Plant Turbine



4-3 Construction Costs of the Goethermal Power Plant

Table 7-11 shows comparative costs of construction of various types of power plants. These figures are based on prices in Japan and the construction costs in Peru will probably differ considerably since the construction date is not decided. However, the ratios between the various systems should be the same.

In Table 7-11, geothermal power generation system (A) takes in the total cost from the geothermal probes to completion of the power plant, while geothermal power generation system (B) shows the case where geothermal steam for power generation is purchased at prices corresponding to oil thermal power. Therefore, the construction costs in (B) are for the power plant from the turbine and the difference in the construction costs between (A) and (B) are equivalent to the costs of the steam piping from the geothermal wells to the plant.

The construction costs of the power plant are reduced because of merit of scale when the construction unit is large, but there is no merit of scale for the geothermal well and piping costs and the costs actually increase once the length of the piping exceeds a certain value. The construction costs of the 30 MW power plant in this plan should be about 1,250 dollars/kW if Table 7-11 is taken as a standard.

Table 7 - 11 Comparative Table of Various Types of Power Generation Systems

As of 17 March, 1975

Type of power plant	Output (kW)	Start of construction	Proposed date of start-up	Unit construction price (1,000US$/kW)	Unit power generation price (US$/kWh)	Utilization rate %
Geothermal A	50,000	1975 - 4	1977 - 6	1.15	0.03	80
Geothermal B (Steam purchase type)	50,000	1975 - 7	1977 - 12	0.69	0.04	80
Hydroelectric A (Dam type)	6,000	1975 - 7	1978 - 8	2.92	0.08	60
Hydroelectric B (Conduit type)	10,000	1975 - 10	1978 - 3	2.05	0.06	54
Thermal power A (Coal)	350,000	1975 - 7	1978 - 6	0.79	0.06	70
Thermal power B (LNG)	600,000	1975 - 12	1978 - 10	0.57	0.05	70
Thermal power C (Heavy oil and crude oil)	500,000	1975 - 8	1977 - 11	0.61	0.04	70
Nuclear power A	550,000	1977 - 9	1982 - 3	0.86	0.04	70
Nuclear power B	890,000	1977 - 2	1981 - 7	0.93	0.03	70

5. Geothermal power Utilization Plans Other than Power Generation

5-1 Facilities for Agricultural Utilization

Examples of facilities for agricultural utilization of geothermal fluids are given in Chapter 2. Plans of agricultural utilization in these areas are currently limited to the La Raya and Quisicollo areas where geothermal surveys have indicated that there are hot springs.

As the geothermal surveys progress and the stage of planning of the geothermal power plant is reached, the amount of hot water produced in conjunction with the production of steam for power generation will become clear. If these areas are of the steam predominant type as in the case of Geyser, there will be almost no hot water production, but if they are the hot-water type as in Wairakei, hot water equivalent to four to five times the amount of steam (1,200 ~ 1,500 tons/hour for a 30 MW power plant) will be produced. When there are large hot water requirements in such cases, it is possible that hot water will be transported over long distances, but in these areas, the population is small and there seem to be no concentrated heat requirements. Therefore, agricultural facilities will probably be constructed in the vicinity of the geothermal power plant to utilize the hot water.

The economy of heating glass or plastic greenhouses with geothermal hot water can not be determined since the economy of heating agricultural facilities by an oil boiler in the area is not clear. The advantages of agricultural facilities using geothermal heat over those using oil are discussed below.

The air temperatures in these areas show comparatively small seasonal differences, but there are big differences between the daytime and night temperatures and heating is necessary at night throughout the year. In the daytime, the average annual temperature is 14°C, but there is sunlight and the heating time during the day is assumed to be half throughout the year.

The amount of heat required per square meter depends on the outside air temperature, but on the basis of an experiment[1] performed in Akita prefecture, the heat requirement will be as follows for an agricultural facility of one hectare in these areas when 130 Kcal/m^2 per hour is utilized:

$$130\ \text{Kcal/m}^2\text{h} \times 10^4\ \text{m}^2\text{/ha} \times 18\ \text{h/day} \times 365\ \text{days} \times 0.6\ \text{(annual utilization rate)}$$
$$= 5.1 \times 10^9\ \text{Kcal.ha.year}$$

If this heat is supplied, the following amount of oil is required:

$$5.1 \times 10^9\ \text{Kcal/ha.year} \div [8{,}770\ \text{Kcal/l} \times 0.8\ \text{(boiler efficiency)}] = 0.73 \times 10^5\ \text{l/year}$$

If the oil price is 0.16 dollar per liter, the annual cost would be about 120,000 dollars.

If the amount of hot water supply during the maximum load and at a utilization temperature of 30°C of the equipment for hot water supply required as a heat source is three times that given above:

$$130\ \text{Kcal/m}^2\text{h} \times 10^4\ \text{m}^2\text{/ha} \div 30 \times 10^3\ \text{Kcal/t} \times 3 = 130\ \text{t/h}$$

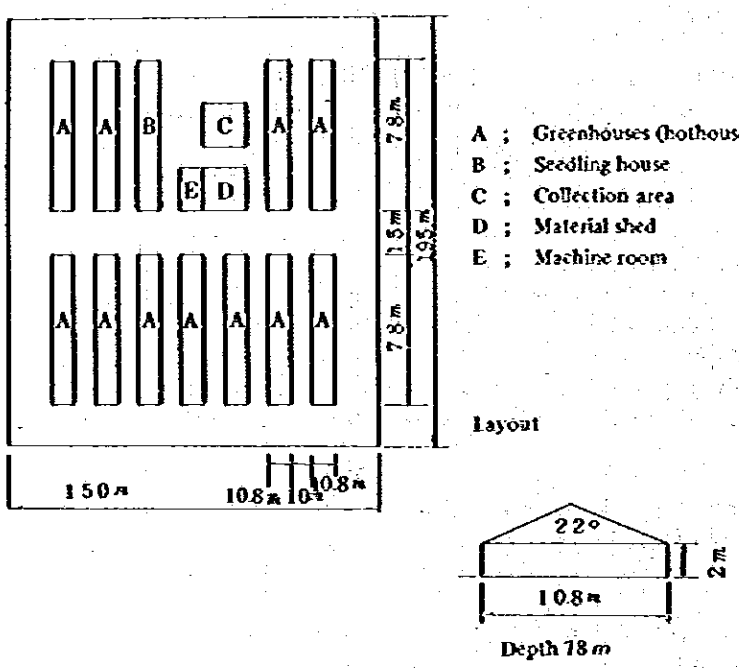
If 1,200 ~ 1,500 tons of hot water per hour is obtained from a 30 MW geothermal power plant, an agricultural facility of 10 ~ 20 hectares is possible.

The effects of geothermal utilization were calculated on the basis of agricultural facilities using oil, but the agricultural facilities require a high level of agricultural technology and experience and it is essential to make thorough investigations and preparations.

---

1) Terrestial Heat Vol. 13, 191 ~ 200 (1976)

Fig. 7 - 20 Example of Greenhouse Facilities



5-2 Utilization for Heating and Other Applications

As in the case of agricultural utilization, home heating is also discussed in comparison with oil. In ordinary housing, heat loss from the walls and roof is small when compared with that from greenhouses, but the effects of sunlight are small and the amount of heat required for heating is about the same as that needed for agricultural facilities. In Japan, 100 Kcal/m^2 per hour is required for heating homes in Hokkaido, and when the hot water supply is added, 125 Kcal/m^2 per hour is used.

If the area per house is 100 m^2 and there are four persons per house, the amount of heat required to heating for a population of 1,000 is as follows:

$$125\ \text{Kcal/m}^2\text{h} \times 100\ \text{m}^2\text{/house} \div 4\ \text{persons/house} \times 1{,}000\ \text{persons} = 3.1 \times 10^6\ \text{Kcal/h}$$

If this amount of heat is supplied by hot water, the following amount of hot water will be required for an effective utilized heat value for hot water of 3×10^4 Kcal per ton (utilization temperature: 30°C):

$$3.1 \times 10^6\ \text{Kcal/h} \div (3 \times 10^4\ \text{Kcal/t}) = 103\ \text{t/h}$$

If the required heating time per year is 3,000 hours, 3.1×10^6 Kcal $\times$ 3,000 h $= 9.3 \times 10^9$ Kcal of heat is required annually. This is equivalent to 1.32×10^6 l of oil which would cost about 200,000 dollars a year.

If the amount of hot water produced in a geothermal power plant is 1,200 ~ 1,500 tons per hour, heating will be possible for about 12,000 to 1,500 persons in these areas at a hot water utilization temperature of 30°C. It is evident that heating facilities should be planned within the range of 40 million x (1.2 – 1.5) per year.

6. Recommendations for Further Detailed Studies

6-1 Geothermal Surveys

The results of these geothermal surveys in the Quisicollo and surrounding areas indicated geothermal showings along the south-north main fault and also remarkable showings at the point of intersection with the east-west subfault. It was assumed that 30 MW of power can be obtained from the heat released. The following surveys will be required to confirm this.

(1) Geological survey

The Macarara and Rio Jama areas which were surveyed this time lie to the north of the Quisicollo area which shows the largest heat release. Next, a geological survey should be conducted in the south along the main south-north structural line from Quisicollo. A geological survey will also be necessary on the west side along the east-west sub-structural line in the Macarara area to determine the areas with high ground temperatures.

(2) Electrical probes

It will be possible to understand the distribution of underground hot water by probing areas underground with a low specific resistance. These survey areas are flat, spacius grasslands which are very appropriate for electrical probes (plumb method).

(3) Gravity probes

To determine the deep underground structure, it is recommended to conduct gravity probes. It is possible to estimate the flow behavior of hot water and detect the presence of underground fractured zones and faults from abnormalities in the gravity gradient.

(4) Boring of probe holes

Temperature measurement borings 30 m deep are at the borderline at which the ground temperature can be measured with no effects from ground surface conditions. Therefore, it is important to make such 30 m borings for ground temperature measurement.

If the underground structure is clarified by electrical and gravity probes, geothermal fluids can be confirmed by survey wells about 500 m deep and the initial geothermal development plan can be prepared from these results.

(5) Others

While the above surveys are carried out, chemical probes, various types of other surveys, etc. will be conducted in parallel, but a thorough investigation of water utilization in the Quisicollo area will also be necessary.

6-2 Ground Heat Utilization Survey

As the geothermal surveys progress, ground heat utilization surveys will have to be performed. The problem of utilization in the daily lives of citizens can not be solved unless there is a reception system.

In this survey, the economy must first be investigated and governmental policy problems concerning agricultural utilization, heating utilization, etc. must be included.

This survey should progress on the basis of actual proof in coordination with the progress of the geothermal surveys. For example, in La Raya, IVITA and other organizations should conduct tests on heating, agricultural facilities, etc. utilizing hot springs and if the results are favorable, sufficient publicity should be undertaken.

CHAPTER 8

AGRICULTURAL DEVELOPMENT

CHAPTER 8 AGRICULTURAL DEVELOPMENT

1. Agriculture in Peru and the Main Features in the Project Area

1-1 General Description of the Area

Geographically, Peru can be divided into (i) Costa (the coastal region), (ii) Sierra (Andes mountains) and (iii) Selva (the jungle region), with each one developing an agricultural activity reflecting the region's ecological characteristics. In the coastal region, is located the most important farming area of Peru, yielding 45% of the agricultural production of the country, mainly vegetables and fruits. In the plateau area the climate is typically dry, and the agriculture developed therein is mainly composed of the culture of the potato and cereals. However, the most important economical activity in the rural area of the plateau is the cattle breeding based upon the naturally grown pasture (pasto natural). The Selva jungles belong to the tropical area, and are located in the east side of the Andes Mountains. This area comprises altitudes up to 2,500 meters above the sea level, and yields typically tropical products like banana, cocoa, etc.

The total area of Peru is 127,867,000 ha, and the land use patterns may be summarized as follows:

- Arable area: 12,659,000 ha
- Forests and area utilizable as pastures: 40,663,000 ha
- Area utilizable exclusively as pasture for cattle breeding: 31,114,000 ha
- Other areas, not suited for agricultural use: 42,561,000 ha.

The arable area presently in use are some plateaus in the mountainous region and the coastal strip with mild climate. According to data in 1975, the area actually used for agricultural purposes is 2,617,000 ha., or approximately 21% of the arable area and just 2% of the country's total area. Of this arable area, 1,130,000 ha, accounting for 43.2%, is irrigated. The proposed Project Area is located in the southern extremity of the Department of Cuzco, as shown in Fig. 8-1, and is a typically dry agricultural region, of the plateau of the Andes Mountains, having altitudes exceeding 3,850 meters above the sea level.

The Province (Provincia) of Espinar, which is the Proposed Project Area, is situated in the southern extremity of the Department of Cuzco, rising 3,800 through 4,300 meters above the sea level in the plateaus of the Andes Mountains. Occupying an area of 4,418 m^2, this province is divided into 5 administrative areas, and the political center of Espinar is its capital town Yauri. Fig. 8-2 shows administrative division of the Department of Cuzco and Province of Espinar.

The distances from Yauri to the important neighboring cities are 103 km to Sicuani, of the neighboring province of Canchis, 244 km to Cuzco, capital city of the Department of the same name, 78 km southward to Condoroma, and 256 km to Arequipa, of the homonym Department of Arequipa. The distance from Yauri to Lima, capital city of Peru is 1,170 km via Cuzco and 1,295 km via Arequipa. Yauri and Lima are connected by means of highways, and the trip can be done by conventional means of communication like bus and automobiles.

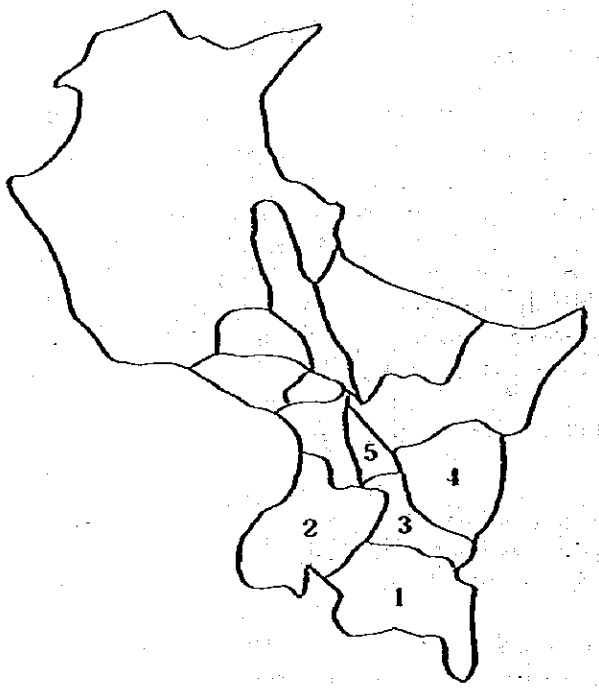
There is a railway between Cuzco, Sicuani and Arequipa, but the region around Yauri is not served by this facility. The most important economic activity in the Province of Espinar is actually the cattle breeding, based upon the naturally grown pasture (pasto natural) existing in the Area.

According to the population census of 1972, the peasants account for 61.4% of the whole working population in the Department of Cuzco, while in the Province of Espinar that ratio is surprisingly low at 28.4%.

Actually, besides the agriculture only the Atalaya Copper Mine can be mentioned as a modern industry in the Project Area. There are the traditional commerce and the cottage industry, to serve the population of the Area, and in most of the cases these economic activities are run as a side job, in parallel with the agriculture and the cattle breeding.

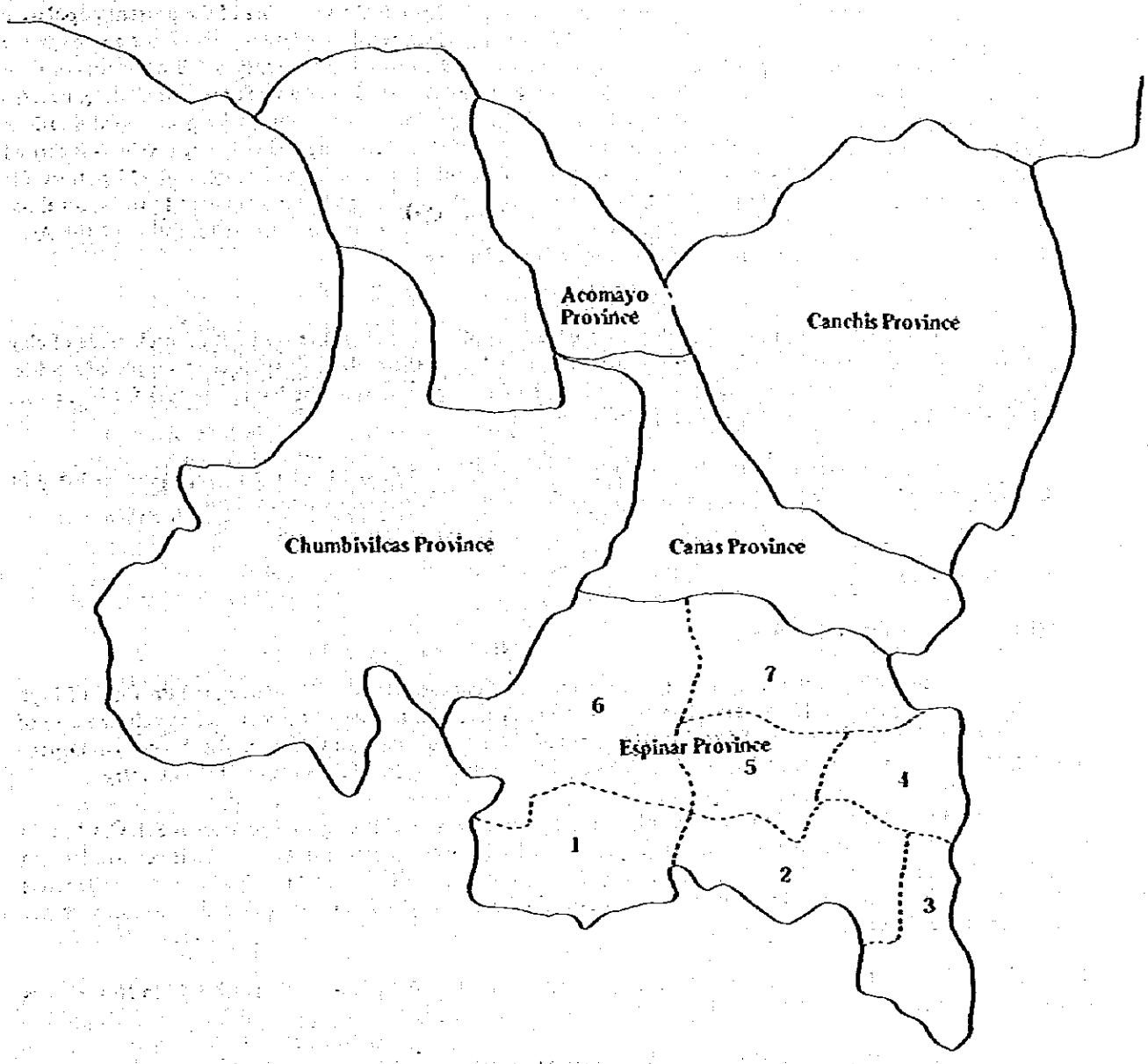
In view of the above it is supposed that while the population engaged exclusively in the agriculture may be small in proportion more than 75% of the whole working population of the Project Area is engaged in the agriculture either as a main or a subsidiary job.

Fig. 8 - 1 Department of Cuzco



No.	Province	Capital
1	Espinar	Yauri
2	Chumbivilcas	Santo Tomas
3	Canas	Yanaoca
4	Canchis	Sicuani
5	Acomayo	Acomayo

Fig. 8 - 2 Administrative Division of the Department of Cuzco and the Province of Espinar



Espinar	No.	Center of the Administrative Area
Suyckutambo	1	Suyckutambo
Ocoruro	2	Ocoruro
Condoroma	3	Condoroma
Pallpata	4	Héctor Tejada
Espinar	5	Yauri
Coporaque	6	Coporaque
Pichigua	7	Santa Lucia Pichigua

Throughout this vast area are distributed the farming families. Since the most important economic activity of the Area is the cattle breeding, the peasant families are required to have vast areas for cattle raising. Thus, the characteristic of the demographic distribution in this region is the scattering of the peasant population throughout a vast area, grouped in hamlets of several families. This scattered population gather once a week in the local market (feria) aming to purchase their daily necessaries and to turn into currency small quantities of their farming and cattle breeding activities. In these local markets (feria) opened once a week are sold all daily necessities, including clothes, medicine, foodstuff, etc., and at the same time gather traders who purchase the various products of the area. In most of the cases, the transportation of these incoming and outgoing products is carried out on the horseback and by means of bicycles. The rural population often manufacture unglazed pottery for daily use and sell them as a side job aiming to obtain additional earnings. The llamas are used to transport those products to the market and also to bring back the maize, which is the most important foodstuff of the Area, barley, wheat, etc., obtained as a result of the barter described above.

In the Province of Espinar, the houses where the peasant families live are built of brick made of clay blocks dried under the sunlight, which are manufactured by peasants themselves. There is no supply of electric power at all. The illumination is carried out by means of candles and kerosene lamps. As fuel for home use, besides kerosene there is the dry dung of the cattle.

As can be seen from the description presented above, the daily life of the peasant families living in this Area is based upon the income provenient mainly from cattle breeding, is extremely poor.

1-2 Agriculture

1-2-1 Climate of the Project Area

With regard to the temperature and the rainfall, a comparison is made between the Province of Espinar, which is a typically cold and dry plateau, with other agricultural regions of the vicinity, namely the area of Sicuani, located in the Province of Canchis, Huanchac in the area surrounding Cuzco, in the homonym Department, and Arequipa, in the coastal area, where is located the most important farming area of the country.

As can be seen in Table 8-1, in the area of Espinar, the annual average temperature is 8.1°C, while in Sicuani, where the altitude is 3,550 meters above the sea level the temperature is 11.1°C. In Huanchac located 3,399 meters above the sea level the annual average temperature is 12.8°C, and in Arequipa located 2,350 meters above the sea level the temperature is 13.2°C. These data indicate that the average temperature increases with the decrease of the altitude above the sea level.

While in Espinar the maximum average temperature is 15.6°C, in Sicuani is 19.2°C, in Huanchac is 19.9°C, and in Arequipa is 22.4°C.

On the other hand, the minimum average temperature, which is the most important factor in the agriculture, becomes below 0°C in the cultivation season (December – April) in the area of Espinar, while in the other areas that value exceeds 4.9°C.

The annual rainfall and the temperature are presented in Tables 8-2 and 3.

The maximum rainfall of 859.9mm occurs in Espinar, which has the maximum altitude above the sea level. Sicuani is placed next with 706mm, Huanchac with 685.6 mm, and Arequipa with 92.2mm in this order. As can be seen from these figures, Arequipa has very little rainfall.

The rainfall and the annual average humidity are mutually related. In Espinar the average annual humidity is 63.3%, in Sicuani 55.7%, in Huanchac 55.3%, and in Arequipa is 54.9%.

As can be seen from the weather conditions described above, in Arequipa, provided with irrigation facilities, is possible the farming throughout the year and in addition, in Sicuani and in Huanchac is expected that the introduction of irrigation facilities will improve the agricultural productivity in the dry season.

With Espinar has more rainfall than other areas, the rainwater is drained toward the lowlying grounds due to the area being located in higher altitude than others, and having topography with many steep slopes. In addition, the main vegetation in the area is the natural pasture which has very little water-holding capacity. Another important factor which makes the development of agriculture in Espinar very difficult is its annual minimum temperature becoming below 0°C.

1-2-2 Geological Characteristics of the Project Area

(1) Topographical conditions

The main topographical features of the Project Area are the mountains and the plateaus, and small areas of alluvial fans.

In the mountainous areas the slopes are relatively steep, and generally the slope from the plateaus to the summit of the mountains is of the order of 10° through 20°. In view of the areas high altitude, this Area is supposed to have suffered a strong glacierization in the 4th glacial period. In the area surrounding the Lake Sutunta, located in the southern extremity of the Project Area are observed remarkable formations characterizing the galcial period, like moraines, glacial lakes, etc. It is supposed that most of the plateaus are benches or terraces located along those glaciers. These benches or terraces are distributed along the Salado river and its tributary waters in 3 through 5 steps. These benches or terraces are mostly composed of layers of gravels. The surface of these benches or terraces is almost flat, presenting a slope of less than 3%. These flat plateaus are very widely distributed, and the ratio between mountainous areas and plateaus is approximately 7:3.

The occurrence of alluvial fans is very rare, and they are observed in the transition between the mountainous areas and the plateaus.

The alluvial fans have favorable drainage conditions compared with the plateaus, and in many cases they are utilized for farming purposes.

(2) Soil conditions

The soil of the Project Area can be roughly classified into transported type and disintegrated type. The transported type soil occurs in the mountainous area and in part of the plateaus, and is the result of the weatherization of the rock bed throughout a long period and the accumulation of the material obtained in the same place, resulting in soil. This type of soil occurs mainly in the slopes of the mountains, and the soil layer has a thickness of approximately 50 cm through 1 meter. As a depth of the order of 20 cm through 30 cm below the surface the soil begins to present contents of gravel, and then it shifts to the rock bed as the depth from the surface increases.

The occurrence of soil of transported type is observed where terraces and alluvial fans have been highly developed. This type of soil is a result of the alluvial effect of the rivers, and the main materials which generate it are the fluvial gravel and clay.

In the Project Area a wide distribution of benches and terraces is observed, and thus, there is a wide formation of soil of the gravel type. In the most generally found cross sectional configuration of the soil, the humus is found in the first 3 cm through 5 cm below the surface, and in the next 10 cm through 30 cm is found the transition layer.

The soil layer is assumed to have a thickness of the order of 30 cm through 1 meter, but in view of the large content of gravel, in some places occurrence of gravel is observed even at the surface.

In the present survey soil samples of higher terraces (samples No.1 and No.2) and of lower terraces (sample No.3) were collected and analyzed. The results of the analysis are presented in Table 8-4.

1-2-3 Land Use and Land-ownership

Table 8-5 presents data of the land utilization in the whole Department of Cuzco, the Province of Espinar (the Project Area), and the Province of Canchis located in the southern region of the Department of Cuzco.

Table 8 - 1 Temperature

(Unit: °C)

Area	Altitude m	Classification	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Average
YAURI	3,915	MAX	15.3	14.8	15.1	15.8	16.1	15.7	15.3	15.1	15.5	16.2	16.6	16.1	15.6
		MIN	−1.5	−1.1	−1.6	−4.8	−8.1	−11.6	−11.6	−10.3	−6.0	−5.5	−4.2	−1.6	−5.7
		MEDIO	9.2	9.1	9.0	8.9	7.7	6.4	6.5	6.6	7.3	8.2	8.9	9.1	8.1
SICUANI	3,550	MAX	18.0	18.2	18.9	19.3	19.2	18.5	18.3	19.2	20.1	20.2	20.8	19.2	19.2
		MIN	5.8	6.1	5.5	3.9	0.5	−1.6	−1.8	−0.1	3.2	4.4	4.9	5.6	3.0
		MEDIO	11.9	12.0	12.1	12.2	11.3	10.0	9.5	10.9	12.5	13.5	13.7	12.5	11.1
HUANCHAC	3,399	MAX	18.8	18.7	19.6	20.2	20.3	19.8	19.6	19.6	20.2	21.3	21.0	19.6	19.9
		MIN	6.4	6.5	6.1	4.7	1.8	−0.1	−0.3	1.2	3.3	5.2	5.9	6.2	3.9
		MEDIO	13.0	13.0	13.3	13.2	12.5	11.5	10.9	11.8	12.7	13.9	14.0	13.3	12.8
AREQUIPA	2,350	MAX	21.9	21.7	22.4	22.7	22.8	22.4	22.5	22.6	22.7	22.8	22.6	22.0	22.4
		MIN	8.4	8.5	8.2	5.3	2.9	2.0	1.9	2.2	3.9	3.8	4.5	6.3	4.8
		MEDIO	14.5	14.4	14.5	13.6	12.3	11.3	11.3	11.9	13.0	13.3	13.6	14.1	13.2

Source: Estación Meteorológica

Table 8-2 Rainfall (Unit: mm)

Area	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total	Period
YAURI	189.5	198.3	134.3	59.8	6.8	6.4	5.5	20.1	29.2	67.3	44.2	98.5	859.9	1967 ~ 1977
SICUANI	140.0	136.9	134.9	49.2	6.6	1.8	6.3	13.4	19.2	35.0	57.8	104.9	706.0	1967 ~ 1977
HUANCHAC	143.4	149.1	93.2	59.7	7.2	2.7	0.6	11.9	20.9	30.0	56.3	110.6	685.6	1958 ~ 1970
AREQUIPA	27.2	36.9	20.3	0.6	0.0	0.02	0.01	2.2	0.4	0.4	0.1	4.1	92.23	1968 ~ 1977

Source: Estación Meteorológica

Table 8-3 Humidity (Unit: %)

Area	Altitude	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Average	Period
YAURI	3.915 m	67.3	69.0	68.5	66.2	62.5	63.2	63.0	62.0	58.9	59.2	58.1	61.1	63.3	1967 ~ 1976
SICUANI	3.550	67.5	69.7	67.2	60.3	52.3	45.3	45.6	47.5	48.2	49.4	53.7	61.3	55.7	1967 ~ 1976
HUANCHAC	3.399	61.5	62.4	60.8	62.3	53.4	50.6	50.6	50.2	51.7	49.7	53.3	57.5	55.3	1968 ~ 1977
AREQUIPA	2.350	69.8	71.8	70.1	58.7	50.9	47.8	41.3	40.4	49.2	48.8	52.7	57.2	54.9	1968 ~ 1977

Source: Estación Meteorológica

Table 8-4 Analysis Results of Soil Samples

Item / Sample No.	PH	KCl	Y_1	CC	(me) Ca	(me) Mg	(me) K	(me) Na	(%) C	(%) N	Soil Texture (%)				Clay Minerals						
											Large Gravel	Fine Gravel	Silt	Clay	Caolin	Serpentine	Mica	Vermiculite	Montmorillonite	Chlorite	Others
1	4.9	3.9	2.0	9.9	2.7	0.6	0.6	0.1	1.29	0.144	37.2	26.4	17.5	18.9	++	–	+	+	+	±	+
2	4.9	3.9	1.7	14.7	6.8	2.1	0.4	0.2	1.94	0.180	27.0	23.2	23.7	26.1	++	±	±	±	+	±	+
3	5.4	4.3	0.4	22.0	16.2	2.1	2.1	3.0	1.68	0.139	22.8	24.1	27.2	26.0	+	+	+	+	±	±	+

Table 8 - 5 State of Cultivation of the Land

Area	Espinar Province			Canchis Province			Cuzco Province		
Classification	Irrigated	No-Irrigated	Total	Irrigated	No Irrigated	Total	Irrigated	No Irrigated	Total
	ha	ha	ha	ha	ha	ha	ha	ha	ha
Farming Land	(366.50)	(5,162.44)	(5,528.94)	(4,050.73)	(6,093.81)	(10,144.54)	(32,874.26)	(171,297.78)	(204,172.04)
Seasonal Cultivation	8.53	2,013.08	2,021.61	3,551.54	2,707.76	6,259.30	25,639.90	59,211.42	84,851.32
Permanent Cultivation				0.08		0.08	2,591.88	37,182.09	39,773.97
Pasture Cultivated Farming Land		0.25	0.25	59.07	4.19	63.26	662.82	617.69	1,280.51
Reforestation Area	4.28	2,077.54	2,081.82	338.53	894.77	1,233.30	2,013.81	21,281.16	23,294.97
Idle Farming Land	353.69	1,071.57	1,425.26	101.51	2,487.09	2,588.60	1,965.85	53,005.42	54,971.27
Land Utilized for Cattle Breeding		(324,915.53)	(324,915.53)		(203,455.34)	(203,455.34)		(1,480,883.99)	(1,480,883.99)
Cultivation of Natural Pasture		2,609.26	2,609.26		1,519.22	1,519.22		18,376.44	18,376.44
Natural Grown Pasture Land		322,306.27	322,306.27		201,936.12	201,936.12		1,462,507.55	1,462,507.55
Forests		(2,784.13)	(2,784.13)	(4.15)	(2,884.99)	(2,889.14)	(44.21)	(259,704.92)	(259,749.13)
Reforestation Area		1.20	1.20	4.15	7.77	11.92	44.21	1,119.29	1,163.50
Natural Forests Jungles		2,782.93	2,782.93		2,877.22	2,877.22		258,585.63	258,585.63
Others		14,697.58	14,698.58		6,644.99	6,644.99		188,538.37	188,538.37
Total	366.50	347,560.68	347,927.18	4,054.88	219,079.13	223,134.01	32,918.47	2,100,425.06	2,133,343.53

Source: II Censo Nacional Agropecuario Año, 1972

In the Department of Cuzco as a whole, the total arable area accounts for approximately 10% of its territory. Of this total arable land, 45% is utilized for seasonal cultivation, 19% for permanent cultivation, and 38% is used for reforestation or is in idle state.

In the same Department of Cuzco, just 5% of the territory of the Province of Canchis is used for farming purposes, and in the Province of Espinar that ratio is still more lower, reaching just 3%. The seasonal cultivation accounts for only 7% and 2% the total arable land in the Provinces of Canchis and Espinar respectively. These figures show clearly that the altitude and natural conditions limit the kind of crops that can be grown in these areas.

It is assumed that in the Project Area just areas with altitudes ranging from 2,000 meters through 3,000 meters are suited for farming purposes. Land cultivated with permanent crop correspond to 1.9% of the Department of Cuzco as a whole, but in the Provinces of Espinar and Canchis there is practically no cultivation of this type. Also in the case of permanent crops, the weather (humidity and rainfall) is the most important factor limiting the effective utilization of the land.

The most important crops composing the permanent cultivation are coffee, cocoa, coca and citrus, and are located in the lowlands of the Department of Cuzco, which belong to the tropical and temperate zones.

The reforested areas and idle arable areas of the Provinces of Espinar and Canchis contribute respectively with 4% of the whole Department of Cuzco. However, in the Province of Espinar the idle arable area is high in percentage of the total of that province (63.4%, while in Canchis that ratio is 37.7%), due to the fact that the agriculture developed therein is a typically dry farming. Irrigated farming is observed in some very restricted areas, but in general the agriculture in this Area is predominantly rain-fed .

In the Department of Cuzco, pasture land accounts for 69% of the total arable area. The Province of Canchis contributes with 14% of the total pasture land of the Department of Cuzco, while the Province of Espinar contributes with 22%. These figures show the increase of the percentage of pasture land proportional to the increase of the altitude. In these pasture lands the naturally grown pasture (pasto natural) occupies the overwhelming majority, in the cattle breeding activity, as pasture lands are not suited for uses other than the cattle breeding. There is no cases of the introduction of improved pasture.

The forests occupy 13% of the territory of the Department of Cuzco, and most of them are natural forests growing in the lowlands. The flora is changed with the altitude, becoming finally composed exclusively of eucalyptus. Reforestation is seen in a very few limited areas in the high altitudes of the Province of Canchis. In general the forests grow naturally in the places where water is available.

In the Department of Cuzco, 16% of the total arable areas are irrigated by means of taking water from the rivers and supplying it between ridges. In the Provice of Canchis 40% of the farming area is irrigated, while in the Province of Espinar the irrigated area is only 7%.

The reason for the substationally higher percentage in the Province of Canchis is as follows. In that province composed mostly of dry highlands, the most important farming areas are located in positions favorable for irrigation, with water easily taken from rivers flowing in valleys of basins. This favorable location makes it possible to construct water collecting facilities with low costs.

In the Province of Espinar, where the major economic activity is the cattle breeding,the introduction of new irrigation facilities would require huge investments, and thus, the irrigation is restricted to very small areas where water is easily available.

In the Province of Espinar, 91% of the arable land is utilized as pasture for cattle breeding, while in the Province of Canchis that ratio is 93%. These high percentages show that with the increase of the altitude the plantation of general crops is limited, resulting into the increasing importance of the cattle breeding.

The data presented in Tables 8-6, 7 and 8 show the state of the land holding in the Department of Cuzco, where 99.6% of the farmers are landed. In that Department, 65% of the arable area belong to those landed farmers.

In the Province of Canchis 99.8% of the farmers are landed, and 95.5% of the farming land belong to those farmers. In the Province of Espinar 99.6% of the farmers are landed, and 79.7% of the farming land belong to those farmers. In the Department of Cuzco, the Comunidad Compecina, organizations for collective production reorganized under the Dirección General de Reforma in 1970, and totalling 208 in number in the Department, hold 28.5% of the whole farming land. In the Province of Canchis there are 13 of such organizations, possessing 4% of the farming land, while in the Provice of Espinar the number of such organizations is 18, possessing 20.2% of the farming land. Besides the Comunidad Compecina mentioned above, there are also few cooperative associations and organizations carrying out collective work.

The size of land holding is as follows: 50% of the farmers possess 1 ha or less, and 37% posses 1 ha through 5 ha in the Department of Cuzco.

In the Province of Canchis, this tendency is more pronounced, where 74% possess less than 1 ha, and 21% possess 1 ha through 5 ha, i.e., 95% possess 5 ha or less. In the Province of Espinar, 41% holds less than 1 ha, and 22% possess 1 ha through 5 ha, i.e., 63% possess 5 ha or less. However, in this Province 15% of the farmers possess relatively larger areas, sized 10 ha through 50 ha.

The rural population, the absolute majority of which holds areas less than 25 ha, is composed mostly of former tenant farmers who used to work under a landlord prior to the agrarian reform. After the agrarian reform, they were converted into landed peasants, acquiring their own farming land.

However, since the subsistence is quite difficult relying exclusively upon their small sized land, the farming activity is left to the wives and children, and in most of the cases the adult man works as a daily or seasonal laborer in the surrounding areas or in other Department, in order to obtain additional income.

Most of these peasants are organized as members of the Comunidad Campecina, but the effectiveness of those organizations in improvement of the agricultural productivity and of profitability is limited.

The average sizes of the land holding by the farmers are: 17 ha, 15 ha, and 51 ha, in the Department of Cuzco, the Provinces of Canchis and Espinar respectively.

1-2-4 Plantation of the Crops

In the Province of Espinar, the year can be divided into the dry season and the rainy season, with the dry season lasting from May through November, and the rainy season lasting from December to April.

In the coastal strip with mild climate, the production is possible througout the year, independent of the rainy or dry seasons, in every area provided with irrigation facilities. However, in Alpine areas like the Province of Espinar, the temperatures become below 0°C during the dry season, and even in the rainy season the temperature remains below 0°C until early November. Thus, the agricultural activity is concentrated in a very limited period during the rainy season, under very severe natural conditions.

Table 8-9 shows the cultivation schedule prevailing in the Province of Espinar during a farming season. The seed sowing of potato, the main agricultural product of the Area, is carried out during the months of September and October, and the harvesting during May and June. As evidenced by these data, the period of cultivation is abnormally long, lasting approximately 8 months. This period is 3 months longer than that required by the normal cultivation of potato. This long period required for the cultivation of potato in this Area can be attributed to the cultivated breed, in addition to the severe climatic conditions. In this region the harvesting is performed at the beginning of the cold dry season.

As can be seen from the table, the cultivation schedule is composed of the following sequence of jobs: Plowing, Seed sowing, Weeding, Insect extermination. However, the extermination of insects is not actually carried out. The cultivation is performed very roughly, with just a single cultivation throughout the year.

Table 8 - 6 Classification of the Land Possession in the Prorince of Espinar

Classification	Common Farmer		Local Collective Organization		Others		Not Declared		Total	
	Number of Peasant Families	Possessed Area	Number of Peasant Families	Possessed Area	Number of Peasant Families	Possessed Area	Number of Peasant Families	Possessed Area	Number of Peasant Families	Possessed Area
		ha		ha		ha		ha		ha
Less than 1 ha.	2,763	618.93					3	1.05	2,766	619.98
1 ~ 5	1,511	3,458.93							1,511	3,458.93
5 ~ 10	586	3,891.47	1	9.00					587	3,900.47
10 ~ 50	1,016	21,557.05			2	47.50	1	35.00	1,019	21,639.55
50 ~ 100	344	22,665.02							344	22,665.02
100 ~ 500	423	86,726.26	3	900.00	1	100.00			427	87,726.26
More than 500 ha.	128	138,516.97	14	69,400.00					142	207,916.97
Total	6,771	277,434.63	18	70,309.00	3	147.50	4	36.05	6,796	347,927.18

Source: II Censo Nacional Agropecuario, 1972 INE.

Table 8 - 7 Classification of the Land Possession in the Province of Canchis

Classification	Common Farmer		Cooperative Association		Local Collective Organization		Sociedad de personas		Others		Not Declared		Total	
	Number of Peasant Families	Possessed Area	Number of Peasant Families	Possessed Area	Number of Peasant Families	Possessed Area	Number of Peasant Families	Possessed Area	Number of Peasant Families	Possessed Area	Number of Peasant Families	Possessed Area	Number of Peasant Families	Possessed Area
		ha												
Less than 1 ha.	11,326	4,092.02											11,326	4,092.02
1 ~ 5	3,219	6,107.51							4	10.92			3,223	6,118.43
5 ~ 10	229	1,521.08							1	5.00			230	1,526.08
10 ~ 50	175	3,544.67	1	23.00	1	40.00			2	31.74			179	3,639.41
50 ~ 100	50	2,919.50	2	157.36									52	3,076.86
100 ~ 500	156	32,140.00			5	1,058.24	1	100.00			1	101.00	163	33,399.24
More than 500 ha.	94	162,702.92			7	8,029.05	1	550.00					102	171,281.97
Total	15,249	213,027.70	3	180.36	13	9,127.29	2	650.00	7	47.66	1	101.00	15,275	223,434.01

Source: ■ Censo Nacional Agropecuario, 1972

Table 8 - 8 Classification of the Land Possession in the Department of Cuzco

Classification	Common Farmer		Cooperative Association		Local Collective Organization		Sociedad de personas		Others		Not Declared		Total	
	Number of Peasant Families	Possessed Area	Number of Peasant Families	Possessed Area	Number of Peasant Families	Possessed Area	Number of Peasant Families	Possessed Area	Number of Peasant Families	Possessed Area	Number of Peasant Families	Possessed Area	Number of Peasant Families	Possessed Area
Less than 1 ha.	61,749	26,212.53					4	0.65	12	6.77	9	1.80	61,749	26,221.75
1 ~ 5	45,258	93,859.60	4	15.18			3	8.05	37	82.60	5	10.02	45,307	93,915.45
5 ~ 10	6,862	45,382.91	4	22.68	15	112.24	2	14.05	13	77.20	1	6.00	6,897	45,615.13
10 ~ 50	6,422	130,869.66	15	326.56	33	881.21	7	148.78	28	596.35	3	95.00	6,508	132,908.56
50 ~ 100	925	60,096.74	5	370.36	21	1,462.13	6	387.00	8	549.99			965	62,866.22
100 ~ 500	1,197	240,812.44	12	3,372.57	60	15,326.95	4	771.59	13	3,963.50	2	316.00	1,288	264,563.05
More than 500 ha.	448	783,917.02	16	98,148.65	79	589,246.46	6	8,648.00	14	27,232.64			563	1,507,192.77
Total	122,844	1,381,141.90	56	102,256.20	208	607,028.99	32	9,978.57	125	32,509.05	34	428.82	123,299	2,133,343.53

Source: ■ Censo Nacional Agropecuario, 1972

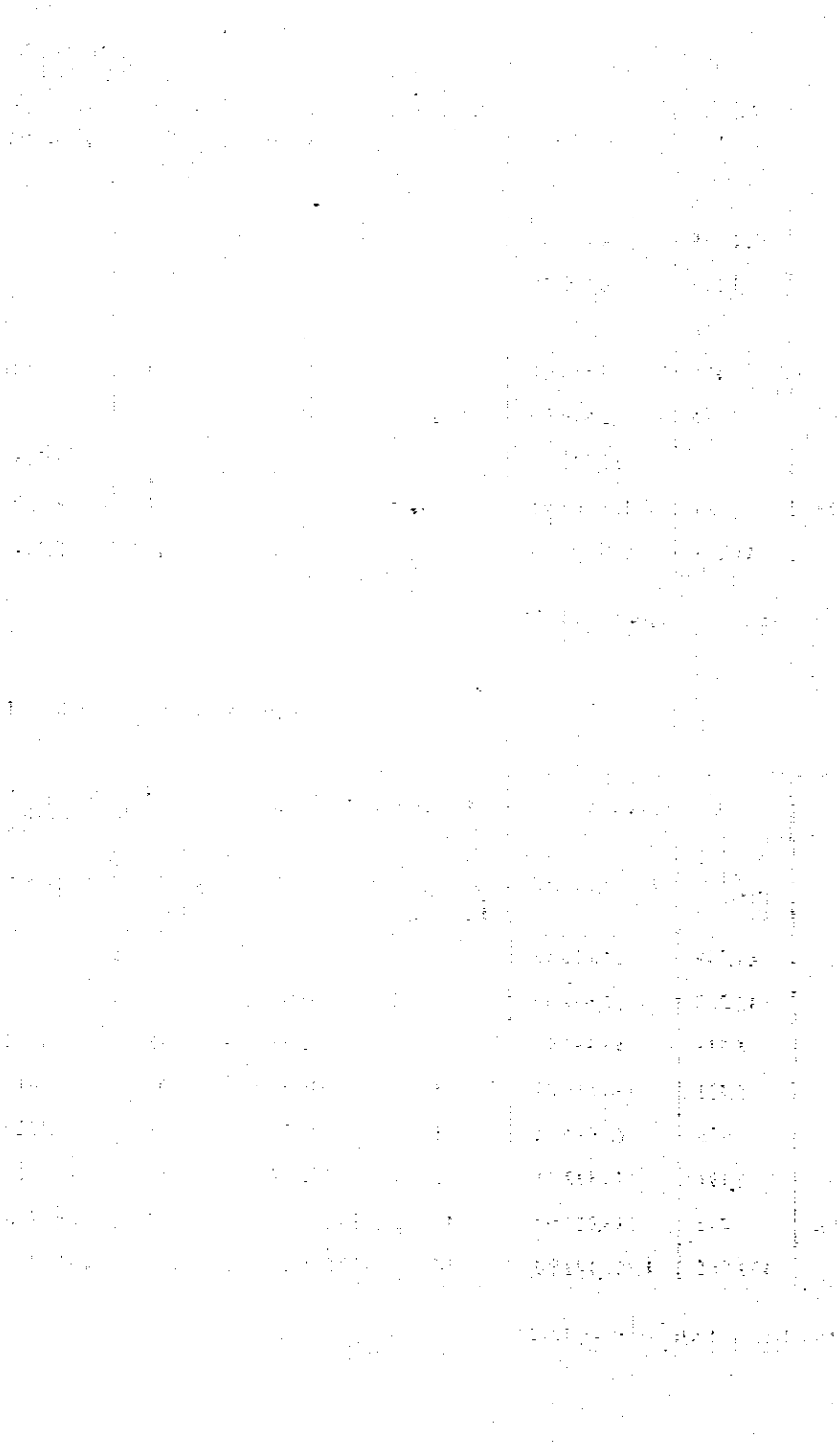


Table 8 - 9 Cultivation Schedule in the Province of Espinar

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Potato	D, A	AF			C	C			S	S		
Quinua	D, AF			C					S			
Cañihua	D, AF		C						S			
Barley	D, AF		C	C						S	S	
Oats	D, AF		C	C						S	S	

Note: 1) The cultivated potato is known as "papa amarga", and is a variety prior to artificial breed improvement.

2) S → Seed showing
D → Weeding
A → Intermediate Plowing
AF → Extermination of Insects
C → Harvesting

Source: Agencia de Produccion Espinar

1-2-5 Farming Practices

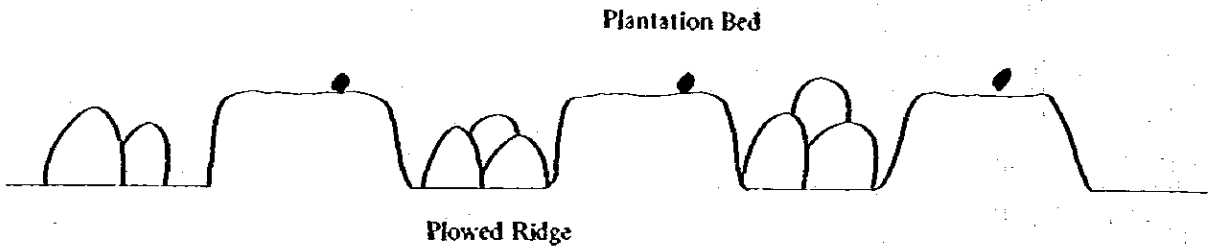
In the Project Area the farming is practiced under the severe conditions imposed by the dry and cold highland. Especially in the southern region, the altitude exceeds 3,800 meters, and the cultivation period is very restricted by factors like freezing, etc. On the other hand, in the valleys along the rivers in the Province of Canchis, with altitudes below 3,800 meters, the heavy rains during the rainy season cause heavy damages in the crops.

The level of the farming technology depending almost exclusively on human hands is extremely low, and the productivity of both land and labor is generally low.

In carrying out farming, bulls occupy 48% of the total, human labor 51.6%, and farm-machinery accounts for a very low percentage of only 0.4%. The utilization of bull is restricted to the plowing activity, and practically all the remaining jobs are carried out by human labor. The very low percentage of utilization of farm-machinery is due to the following causes: (i) the cultivation is mostly done in slope areas where mechanization is difficult to introduce; (ii) the cultivated area is small in size, and hence mechanization is extremely difficult; and (iii) the purchase of farm-machinery is difficult for low-income farmers. In the Province of Espinar the plowing of the soil is performed usually by utilizing domestic animals, but actually more than 80% of this job is carried out by human labor.

When the plowing is made with bulls, the whole surface of the ground is plowed, but when human hands are used with the help of hoes, only the soil of the ridges between the strips are plowed where the seeds are planted, as shown in Fig. 8-3. After the plowing, additives like ash, barnyard manure, etc., are spread on the planting strips, which are not plowed, and then the seed potatoes are laid on those strips. After that the planting strips are covered with the plowed earth of the ridges between the planting bed. This latter operation is carried out with human hands, without the help of instruments like hoes, etc.

Fig. 8 - 3 Plowing by Means of Human Hands



Potatoes are generally planted in gentle slopes, where the drainage of the rain waters is relatively easy. When they are planted in flat land, it is necessary to construct drainages to prevent the seed potatoes from having rotted due to the stagnant water after the rain. The sowing practices have two characteristics, i.e., the beds where the seed potatoes are planted are not plowed, and the earth of the plowed ridges used to cover the seed potatoes laid on the planting beds is not crushed. These practices have apparently a negative effect upon the growth of roots of the planted seed potatoes. In addition, seeding techniques like the cutting of the seed potatoes into pieces for their more effective utilization are not know, thus lowering furthermore the productivity.

The additional operations like intermediate plowing, weeding, etc., performed during the growing of the crops are also performed by human labor. However, the intermediate care performed in this Area is limited to cutting the stalks of the potatoes approximately 2 through 3 weeks before the harvesting, i.e., before the withring of the stalks. However,during this period the potatoes are still growing, owing to the accumulation of the nutrients still processed by the stalks. Thus, the premature cutting of the stalks results into the reduction of the yield of the crop.

In the farming practiced in the Province of Espinar no agricultural chemicals are used at all, and the cultivated area is shifted every year in order to prevent the damages due to diseases and insects,and especially the damage in the potatoes.

The cultivation of cañihua is performed mainly by means of human hands. Similar to the case of potatoes, just a part of the land for cultivation is plowed. The beds where the seeds are planted are plowed in strips, and the plantation is performed without crushing the plowed lumps of earth. The harvested crops are transportated by domestic animals like horses, donkeys, and llamas. Table 8-10 shows the status of the utilization of fertilizers and agricultural chemicals in the Department of Cuzco. As can be seen from the figures, the quantities actually used per cultivated area are very limited. Fertilizers and agricultural chemicals are used mostly in the low lying lands. In the valleys in the southern Provinces of Canchis and Chumbivilcas, these agricultural inputs are used in very small scale in the cultivation of improved varieties of potato and maize. In these provinces and in the Province of Espinar the use of barnyard manure from the dung of cattle, and also the use of other organic matters, is restricted to few cases of dry farming.

The agricultural chemicals are also used in very limited areas in the southern low lying lands, in the cultivation of maize and greens, as in the case of fertilizers. In the Province of Espinar, there is practically no use of agricultural chemicals.

While each farmer holds relatively large areas, only a small portion of the land is cultivated to meet their own consumption. As it is very easy to convert the area where natural pasture is densely grown into farm land, shifting farming is practiced every year, in cycles of 6 through 7 years, instead of planting the same crops in the same area in successive years, and requiring no use of agricultural chemicals.

Only 10% of the main cultivation areas use improved varieties mainly of potatoes, barley, oat, etc. every year. In the other areas a part of the harvested crops of local varieties is selected and used as seed. Especially in the Province of Espinar, no improved varieties of potatoes and quinua are put into practice at all.

Table 8-11 shows the cultivated area during the agricultural season of 1977 – 1978 in the southern region of the Department of Cuzco and the quantities of the harvested crops. It is evident from the table that the cold climate restricts the kind of main crops in the Province of Espinar as compared to the Provinces of Canchis, Canas, Acomayo and Chumbivilcas where altitudes are below 3,500 meters above the sea level.

The most important crops cultivated in the four Provinces mentioned above are potatoes, cereals like barley, wheat, oat, maize, etc., broad bean, quinua (see Note 1), oca, olluco, afalfa and small quantities of greens like onions and fruits.

On the other hand, with altitudes exceeding 3,800 meters above the sea level, the cultivated crops the Province of Espinar in produce potatoes and small quantities of cañihua (a variety of quinua, suited for cultivation in cold highlands) and extremely limited quantities of barley. However, the barley cultivated in this region does not bear grains in view of the climatic conditions, and in most of the cases it is harvested while green, and used as fodder of domestic animals.

The cultivation of potatoes is limited to low lying lands, and the cultivated variety is the so-called "papa amarga," a type of unimproved breed, suited for cold climate regions but with a slightly bitter taste. In the Province of Espinar, as a result of the incentive for cultivation of improved breeds promoted several years ago, the productivity per area was improved remarkably, being materialized harvests of the order of 10 tons per hectare. However, Table 8-12 indicates that the 1978 production costs per kilogram of improved varieties of potatoes are 9.78 Soles for the papa color variety, and 7.82 Soles for the papa blanca variety, respectively. On the other hand, according to the data presented in Table 8-13, the production cost per kilogram of the papa amarga is 3.80 Soles, being therefore far cheaper compared with improved varieties, requiring furthermore less intensified cultivation techniques.

While the cultivation of improved varieties makes possible better productivity per unit area, the severe natural conditions, like frost and freezing occurring during February tend to reduce the harvest of the year to zero in the worst case. Since the farmers of this area do not have the sufficient fund to cope with such natural calamities, they usualy cultivate the traditional papa amarga in order to prevent the possible risks.

After harvest papa amarga is processed into a sort of dry potato called "chuño," which is used as preserves. There are two types of chuño, i.e., white chuño and black chuño.

To make white chuño, the harvested potatoes in bags are put into water for 1 through 2 weeks, in order to eliminate the bitter taste, and then dried by spreading them in the open air. Instead of exposing the potatoes directly to the sunlight, they are dewatered and dried by freezing repeatedly during the nights. The final product is obtained by stamping the potatoes underfoot in order to peel them.

Unlike white chuño, the preparation of black chuño does not put potatoes in water, and the drying is performed by repeating the freezing and dewatering night and day in the open air, and as a result a bitter taste still remains.

In the Province of Espinar, most of these crops are intended from home use, and only when surplus quantities exist or cash is needed they are sold. Thsu, from the first step they are not produced for market.

The comparison of the productivity of potato shows that in the Province of Espinar the productivity per hectare is 2.25 kilograms, while productivities in other Provinces, are more than double that value. In the farming season of 1978, having very little irrigation facilities, the agricultural productivity in the Province of Espinar was extremely low, even taking into consideration of this year's low rainfall.

Note (1)

Native plant of Peru and shouthern Bolivia, presently cultivated in the plateaus of the Andes Mountains, from Colombia to Northern Argentina. It has high nutritive value, and is composed of 12.3% of water, 13.9% of proteins, 3.5% of fats, 5% of fibers, 61% of nitrogen free extracts, and 4.3% of ash. It is presently drawing the attention of the world as one of the most promising crops in the future.

Table 8 - 10 Quantity of Fertilizers Used in the Department of Cuzco

Name		Quantity (t)	1977 ~ 1978 Unit Price per Ton
Ammonite	(35.5% N)	4,293	15,800
Superphosphate of Lime	(46% P_2)	1,867	17,200
Potassium Chloride	(62% K_2O)	717	12,600
Mixed Fertilizers	(9–18–9)	40	10,600
Guano de islas	(Nitrite)	1,003	10,400
Total		7,920	–

Source: ORDESO

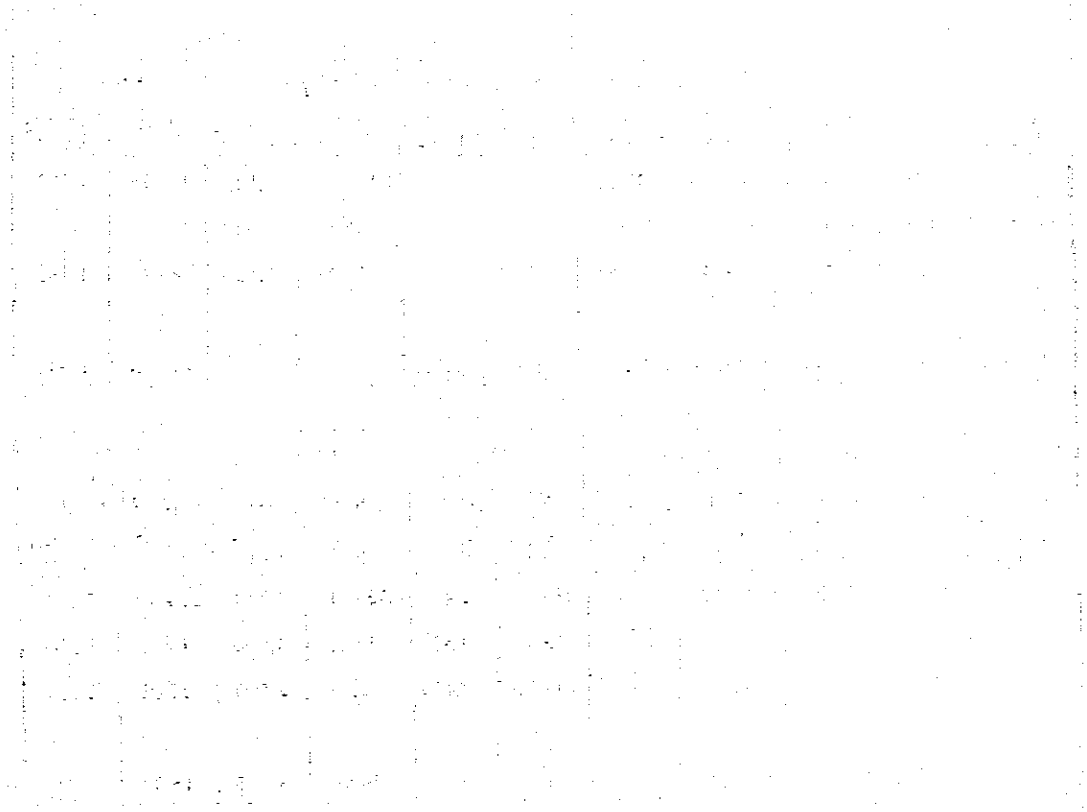


Table 8 - 11 Agricultural Production in 1977 – 78

Crops / Name of Province	Cherry		Apple		Peach		Eucalyptus		Barley				Maize				Cactus Fruit		Wheat			
	Not Irrigated		Not Irrigated		Not Irrigated		Not Irrigated		Irrigated		Not Irrigated		Irrigated		Not Irrigated		Not Irrigated		Irrigated		Not Irrigated	
	Area ha	Quantity kg/ha	Area ha	Quantity kg/ha	Area ha	Quantity kg/ha	Area ha	No.of Trees kg/ha	Area ha	Quantity kg/ha	Area ha	Quantity kg/ha	Area ha	Quantity kg/ha	Area ha	Quantity kg/ha	Area ha	Quantity kg/ha	Area ha	Quantity kg/ha	Area ha	Quantity kg/ha
Canchis							797.50	876,700	298.05	1,230	702.99	1,117	1,579.99	1,370	130,89	1,296			1,140.53	1,583	376.26	1,232
Canas							90.00	130,000	8.01	1,374	320.64	1,200	125.26	1,500					25.92	1,300		
Acomayo	3	14,000			13	12,000	294.48	146,410	4.00	700	663.00	959	635.75	1,160	26.50	957			80.25	1,420	47.25	1,380
Espinar																						
Chumbivilcas	48.26	14,000	6.12	5,000	11.65	1,033	5.54	5,792			549.32	1,200	97.28	1,000	1,119.02	1,360	52.81	7,000			442.16	1,000

	Cañihua		Quinua		Broad Bean				Onion		Alfalfa		Green Peas		Tarhui		Oca		Olluco		Izaño	
	Not Irrigated		Not Irrigated		Irrigated		Not Irrigated		Irrigated		Irrigated		Not Irrigated		Not Irrigated		Not Irrigated		Not Irrigated		Not Irrigated	
	Area ha	Quantity kg/ha	Area ha	Quantity kg/ha	Area ha	Quantity kg/ha	Area ha	Quantity kg/ha	Area ha	Quantity kg/ha	Area ha	Quantity kg/ha	Area ha	Quantity kg/ha	Area ha	Quantity kg/ha	Area ha	Quantity kg/ha	Area ha	Quantity kg/ha	Area ha	Quantity kg/ha
Canchis			115.50	1,268	949.91	1,723	267.61	1,543	58.50	13,521	11.00	14,000	145.78	1,212	58.42	1,047	289.37	5,479	325.96	2,541	265.89	3,602
Canas			39.40	700	18.78	1,600	210.55	1,500					3.50	1,200			15.50	3,500	32.23	4,000	10.00	3,500
Acomayo			38.00	600	80.00	1,220	74.87	1,200					31.50	680	12.75		33.70	2,433	69.75	2,600	32.08	2,100
Espinar	625.00	883																				
Chumbivilcas			15.60	1,200			101.40	1,620					18.00	1,600	7.00	1,200	42.00	3,500	54.00	3,000	16.00	3,500

	Potato				Oat		Total		Total
	Irrigated		Not Irrigated		Irrigated		Irrigated	Not Irrigated	
	Area ha	Quantity kg/ha	Area ha	Quantity kg/ha	Area ha	Quantity kg/ha	Area ha	Area ha	Area ha
Canchis	910.65	6,208	1,064.43	5,634	243.00	12,441	5,221.64	4,540.60	9,762.24
Canas	10.14	7,000	1,039.64	7,200	7.44	17,000	195.55	1,632.06	1,827.61
Acomayo	23.50	4,000	904.75	4,167			823.50	2,244.60	3,068.10
Espinar			1,455.91	2,250			0	1,529.75	1,529.75
Chumbivilcas			2,666.44	6,000	46.00	12,000	143.28	6,155.32	6,298.60

Source: Division de Estadistica Sicuani
Agencia de Produccion Sicuani

Table 8 - 12 Production Cost per Hectare of Improved Breed of Potato

Cultivated Variety : Papa Color

Cultivated Area : Sourthern Mountainous Region

Technical Level : Average

Classification	Unit	Required Quantity	Unit Cost	Required Cost
			S/=Soles	
1. Direct Cost				
Tractor	Hours	18	500	9,000
Labour	Man. Day	156	92	14,352
Seed	kg	1,500	18	27,000
Chemical Fertilizer	kg	1,000		9,739
Organic Fertilizer	kg	5,000	0.40	2,000
Agricultural Chemicals	kg-lts	67		8,074
Transportation Cost				2,000
Sprayer Rent	Hour	10	50	500
Other Presidential Ordinance	156 x 68.33			10,660
Contingency (10% of Direct Cost)				7,200
Social Security Law	52.48% of the Labour Cost			7,532
Sub Total				98,057
2. Indirect Cost				
Administrative Cost (8% of the Direct Cost)				7,845
Economic Cost				11,440
Sub Total				19,285
Total				117,342
Havested Quantity per Hectare				12,000 kg
Production Cost per kg of Potatoes				9.78 Soles
Cultivated Variety				
Papa Blanca				
Production Cost				117,342
Harvested Quantity per Hectare				15,000 kg
Production Cost per kg				7.82 Soles

Source: Ministerio de Alimentacion del Cuzco

Table 8 - 13 Production Cost per Hectare of Papa Amarga

Classification	Unit	Required Quantity	Unit Cost	Required Cost
1. Speed	kg	1,000	10 Soles	10,000
2. Labour				
Tillage	Man/day	40	92	3,680
Seeding	"	30	92	2,760
Stalk Cutting, Harvesting	"	40	92	3,680
Transportation				1,000
Total				21,120
Harvested Quantity per Hectare				5,500 kg
Production Cost per Kg				3.84 Soles

Source: Agencia de Produccion Espinar

1-2-6 Distribution of the Agricultural Products

As shown in Table 8-14, major agricultural products in the Department of Cuzco are produced from northern and southern Provinces having altitudes below 3,500 meters above the sea level, other than the Province of Espinar. Since the potato, the most important crop of the Province of Espinar, is produced for home consumption, the quantity sold in the market is very negligible. On the other hand, the Province of Espinar depends upon other areas for the supply of agricultural products like vegetables, etc.

In contrast, the city of Cuzco, the largest consumer market in the Department of Cuzco, depends the supply of vegetables upon regions like Urubamba and Quillabamba of the Department of Cuzco, which is an important vegetable producing area, and cereals are supplied from the southern and northern regions of the Department of Cuzco.

Most of the agricultural products consumed in the Province of Espinar come from Arequipa. Part of those products, like onions, haricot beans, oca and olluco are transported from Sicuani, of the Province of Canchis.

In the Department of Arequipa vegetables can be harvested 2 through 3 times a year, while in the Province of Canchis only a single cropping is possible, even with the adoption of the irrigation. The land productivity of Arequipa is higher, and in addition, the farming techniques are also more efficient than those adopted in the Province of Canchis, thus making the production costs in the Department of Arequipa substantially lower than the others. The Department of Arequipa is therefore in a better position to supply agricultural products to the project area, in spite of the higher transportation costs.

1-3 Livestock

1-3-1 Present Status

The domestic animals found in Peru are the cattle, sheep, pig, chicken and goat, the alpaca and llama, living only in the cold mountainous regions, and the cuye, a small rodent, the raising of which is recently steadily increasing due to the decrease of the number of cattles, which are the major source of animal proteins in Peru.

Table 8 - 14 Areas and Quantities Cultivated in 1976

	Cuzco Department		Puno Department		Arequipa Department	
	Cultivated Area (ha)	Harvested Quantity (kg/ha)	Cultivated Area	Harvested Quantity	Cultivated Area	Harvested Quantity
Rice	620	1,116	145	160	5,920	44,814
Maize	14,400	24,650	2,900	3,470	6,365	14,644
Fresh Corn	250	2,470	250	925	560	3,900
Oat	5,215	5,575	250	138	1,520	3,501
Barley	9,500	11,400	17,440	10,812	3,015	5,742
Quinua	700	635	12,000	6,364	90	72
Canihua	30	42	4,540	2,043		
Olluco	2,800	10,360	480	1,536	80	384
Potato	22,600	124,430	45,600	209,310	3,050	38,430
Yuca	2,200	30,800	500	4,500	103	1,082
Oca	1,500	5,400	1,250	4,500	30	138
Fresh Broad Bean	520	2,360	20	40	570	3,650
Orange	763	12,293	1,000	13,000	25	148
Banana	1,270	19,050	760	9,120	40	520
Tomato	115	1,248	5	20	265	4,010
Col	130	2,065	5	33	110	1,300
Zappallo	5	80	30	290	250	2,920
Onion	210	2,861	140	1,340	2,030	65,156
Carrot	80	1,040	5	50	100	2,000
Alfalfa	400	18,000			31,000	1,579,500
Improved Pasture	12,100	472,500				
Achiote	1,100	660				
Cacao	1,700	915	450	248		
Coffee	13,500	10,125	3,039	1,823		
Yuca	5,130	4,104				
Tea	3,310	9,924				
Decocted Tea	430	1,591	450	1,440		
Peanut Oil	400	572				
Dried Broad Bean	2,550	3,427	3,760	3,012	600	990
Avena Forrajera			7,070	67,340		
Cebada Forrajera			11,060	71,920		
Olive					1,598	6,392
Garlic					1,250	8,049
Frijol (Haricot Bean)					5,055	6,140
Maiz Chala					1,100	41,800
Cotton					940	1,504
Sugar Cane					810	119,799

Source: Ministerio de Agricultura y Alimentacion

In Lima, capital city of Peru, which has the largest urban population of the country, the sale of beef is prohibited from the 1st to the 15th days of every month. The cuye, which grows up within a short period, has therefore been adopted as a substitute to compensate the shortage of beef.

The pasture is indispensable for the breeding of cattle, sheep, goats, alpaca and llama. In Peru the pasture lands occupy 71,777,000 hectares, or 56% of the country's total land.

Most of the pasture lands are occupied by the naturally grown pasture (pasto natural) of the cold highlands, and the stock raising is performed upon those natural pastures in the Departments of Cajamarca, Ayacucho, Abancay, Puno and Cuzco, located in very high altitudes in Peru.

While the raising of cattle is more advantageous in the coastal region as compared with the cold regions, because of the better land productivity, large scale livestock requires large areas, and from the economic point of view, other suitable products like vegetables and fruits, are more advantageous. On the other hand, the breeding of small scale domestic animals is carried out very intensively in those regions.

1-3-2 The Livestock Raising

In the Province of Espinar, most of the natural pasture, which occupies 93% of the land utilized for cattle breeding, belongs to the Graminaceous. In that province the livestock is mostly based on those pastures but there are also areas provided with pastures of the "crawing" type.

Following are descriptions on pastures growing in the highland areas, according to data of the La Raya Livestock Experimental Station (Note 2).

As listed in Table 8-15, the natural pastures growing in the highland areas comprise 28 varieties, including the Alopecreo Bracteata N of the Graminaceous, which generally meets the taste of domestic animals.

Besides the Alchemillo, Pinnato and Pilger (Graminaceous family), there are 7 varieties which generally meet the taste of the domestic animals.

There are other natural pastures which do not meet perfectly the taste of the domestic animals, occupying 95% of the highland pasture lands, and as a matter of fact they are also used in the livestock.

Summarized in Table 8-16 is the status of the livestock raising practiced in the 5 Provinces of the southern region of the Department of Cuzco in 1977 – 78. In the various Provinces in the highland area, the sheep and cattle bred in large numbers in addition to alpacas and llamas, which are peculiar to highlands, account for the major items of domestic animals. Besides, chickens, pigs, horses, cuyes and goats are bred in small quantities.

In the Province of Espinar, there are approximately 27,000 sheep, a considerably large in number compared with the other 4 Provinces, due to the following causes:

1. The sheep raising is perfectly possible in cold highland areas;
2. Both wool and meat obtained from the sheep have high economic value;
3. Since sheep are more prolific than other domestic animals, they propagated in the Project Area; and
4. The spinning of the wool and the manufacturing of clothing for their home use is an important side-job to supplement the income of the petty farmers of the Province of Espinar.

The llamas and alpacas, belong to the camel family, are ruminants like cattles, and they can be raised even with low quality fodder. In the Province of Espinar, llams are the second largest in number next to sheep, and are grown mostly in high altitudes of the order or 4,100 meters above the sea level. In altitudes exceeding that level, more alpacas can be seen than any other domestic animal.

Note (2)

The La Raya Livestock Experimental Station is located at an altitude of 4,200 meters above the sea level, and has the same conditions of Espinar. It extends over the Province of Canchis (in the southern region of the Department of Cuzco) and the Department of Puno. Its administration is under the responsibility of the Department of Puno. It is an experimental livestock farm specialized in highland domestic animals like alpacas and llamas.

The meat of llama is sold in the market, dried or salted. The llama wool is cheaper than the alpaca wool, but is an important source of earning for the peasants. The llamas are also utilized for transportation of agricultural products of the area. In the cases of barter, which is a very common form of trade in this area the llamas are also utilized as means of long distance transportation.

In the Province of Espinar the alpacas are the third largest in number after sheep and llamas. From the economic point of view, the alpacas are important because their wool is sold at high prices not only in the domestic market, but also in the international market. Besides the wool, some types of alpaca fur are sold at very high prices as material for manufacturing of carpeting, and the alpaca meat is also sold in the market dried or salted, like the llama meat. The alpaca meat is recently drawing the attention of the consumers in the domestic market, because of its low content of colesterol.

However, the number of alpacas is declining in the recent years. In 1978, the quantity of alpacas in Peru was only 2,500,000 heads, and their protection is being advocated.

Fortunately in the Project Area the alpacas are not currently being slaughtered in large quantities, and it is expected that they will become an important source of earnings for the peasants.

The quantity of cattle in the Province of Espinar is almost equal to that of alpacas. Espinar has the second largest cattle population next to the Province of Chumbivilcas, and are intended for production of meat, and compose the most important item of earnings from the livestock industry in the Project Area. Besides those for meat production, a small number of cows are bred for dairy purposes. Part of the milk is used for own consumption by the peasants, but it is mostly utilized in the manufacturing of home made cheese, named "queso", also for home consumption because the milk is obtained in small quantities. The number of cattles in the Province of Espinar, i.e., 31,600 heads, is small in view of the available area of pasture lands, as well as of the types of pastures existing in the Area.

Table 8 - 15 Melidos Sudamericanos -- La Raya

ESPECIES DESEABLES

NOMBRE TECNICO	NOMBRE VULGAR	FAMILIA
Alopecurus bracteata, N	_____	Gramineae
Agrostis tolucensis	_____	"
Bromus lanatus, HBK	Cebadilla	"
Bromus unioloides, HBK	Cebadilla	"
Calamagrostis antoniana, G	Crespillo	"
Calamagrostis eminens	_____	"
Calamagrostis heterophylla	Huaylla ichu	"
Calamagrostis vicunarum, (wedd)	Pilger Crespillo	"
Calamagrostis SP.	_____	"
Carex SP.	_____	Ciperaceae
Distichia muscoides	Kuncuna	Juncaceae
Eliocharis albibracteata	Quemillo	Ciporaceae
Festuca dolichophylla, Presl	Chillihua	Gramineae
Hipochoeris SP.	Pili	Compositae
Hordeum muticum, Presl	Cola de ratón	Gramineae
Juncus andicola	_____	Juncaceae
Luzula Peruviana	Uma sutu	Juncacoae
Muhlembergia ligularis	Grama	Gramineae
Paspalum Pigmeau, Hack	Sara sara	"
Poa annua	_____	"
Poa candamoand, Pilger	_____	"
Poa gimnanta, Pilger	_____	Gramineae
Poa SP.	_____	"
Polipogon elongatus, HBK.	_____	"
Polipogon interruptus	_____	"
Stipa brachyphylla, Hitchc.	_____	"
Stipa ichu, Ruíz Pavón	Icho	"
Stipa mexicana, Hitchc.	_____	"
Stipa obtusa, Nees et Mey	Iisña	"

ESPECIES POCO DESEABLES

Alchemilla Pinnata, Ruíz Pavón	Sillo Sillo	Rosaceae
Distchlis húmilis, R.	_____	Gramineae
Muhlembergia fastigiata, Presl.	Grama	Gramineae
Muhlembergia Peruviana	Coja ñapa	Gramineae
Scirpus rígidus	Totorilla	Ciperaceae
Scirpus totora	Totora	Ciperaceae
Sisyrinchium andícola	Azul Papelillo	Lileaceae
Trifolium amábile	Layo	Leguminosa

ESPECIES INDESEABLES

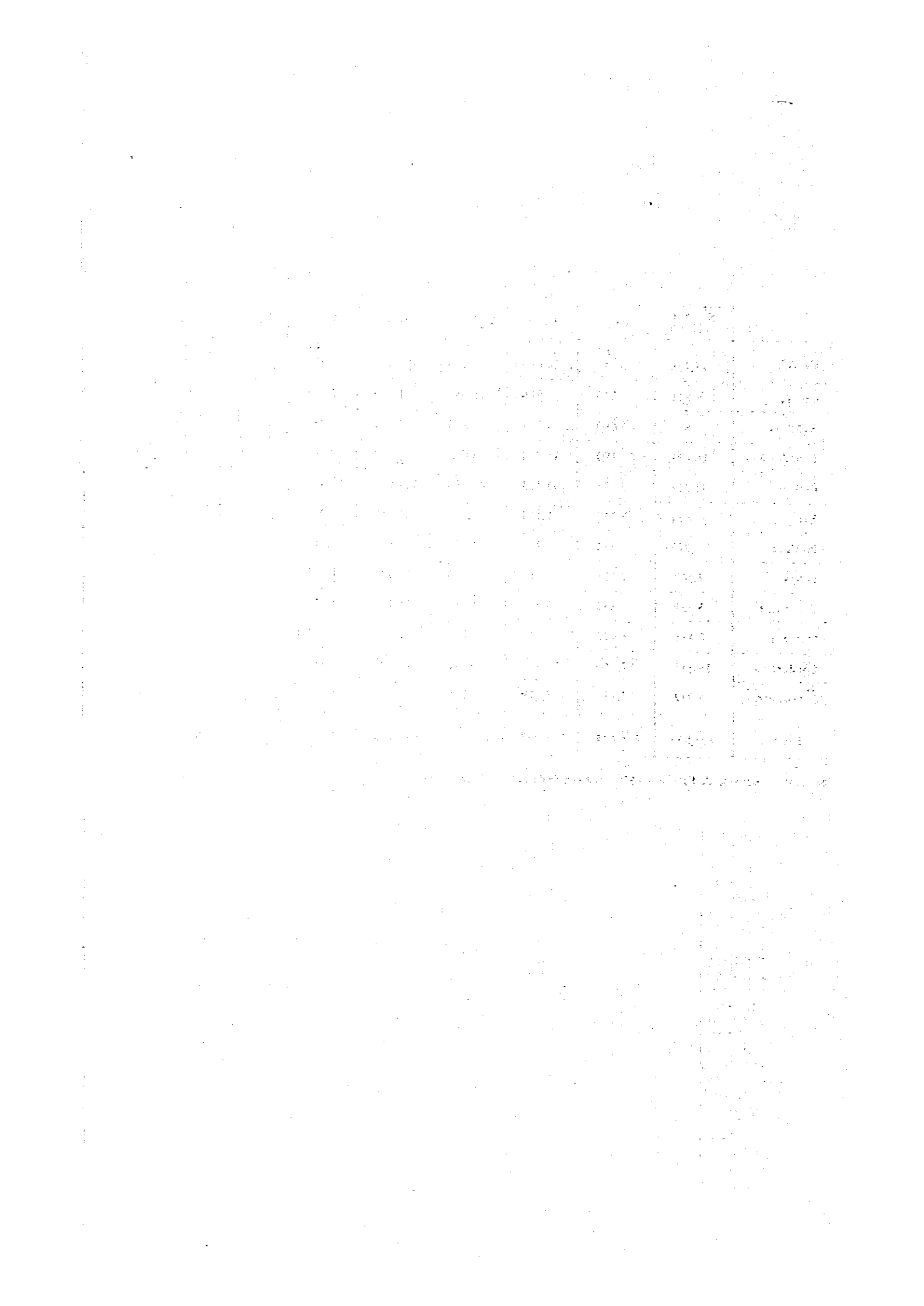
Azorella compácta, Hodge.	Puna yarita	Umbelifera
Astragalus garbancillo, Cay.	Garbancillo	Leguminosa
Aciachne Pulvinata	Paco paco	Gramineae
Adesmia spinosísima	_____	Leguminosa
Capsella bursa Pastoris	Bolsa de pastor	Crucifera
Ephedra americana	Pinco pinco	Gimnosperma
Erodium cicutarum, Kelst.	Alfilerillo	Geraniaceae
Festuca orthophylla, Presl.	Iro icho	Gramineae
Gentiana Prostata, Haenk.	_____	Gentianeceae
Gentiana SP.	_____	Gentianaceae
Geranium sessiliflorum, Cay	Ojotilla	Geraniaceae
Gnaphalium SP.	_____	Compsitae
Hipochoeris taraxacoides	Pili (flor amarilla)	Compositae
Lepiquenea SP.	Salvia	Labiada
Lepidium chichicara	_____	Crusifera
Liabum bullatum	Mula pilli	Compositae
Lupinus clorolepis	Tarwi	Leguminosa
Margiricarpus pinnatus, K.	Kanlla	Rosaceae
Malvastrum campastris	Malva sivestre	Malvaceae
Oenothera SP.	Yahuar choneco	Oenotheraceae
Opuntia flocosa	Waracco	Cactaceae
Plantago menticela	Chaqui saccavrana	Plantagianae
Solanum acaule	_____	Solanaceae
Urtica ori	Ortiga	Urticaceae

Source: La Raya, Livestock Experiment Station

Table 8 - 16 Production and Number of Heads in the Southern Region

	Alpaca			Llama			Goat			Cuyés		Sheep			Pig		Cattle			Horse	Chicken	
	Number of Heads	Meat	Wool	Number of Heads	Meat	Wool	Number of Heads	Meat	Milk	Number of Heads	Meat	Number of Heads	Meat	Wool	Number of Heads	Meat	Number of Heads	Meat	Milk	Number of Heads	Number of Heads	Meat
		kg	kg		kg	kg		kg			kg		kg	kg		kg		kg				kg
Canchis	77,426	270,548	84,960	25,414	105,331	17,439	40	99	0	20,657	3,035	95,222	171,390	50,249	839	21,780	20,753	326,060	566,325	18,663	20,816	14,660
Canas	1,841	5,320	986	15,046	74,540	3,028				6,420	1,252	142,745	286,154	114,312	1,138	7,920	18,894	337,370	1,026,700	6,273	7,928	4,661
Accomayo	824	2,660	4,202	8,275	24,701	2,998	58	124	200	17,264	5,677	52,844	103,224	13,456	3,102	101,765	8,612	117,485	189,972	1,856	5,811	5,579
Chumbivilcas	16,227	50,190	16,704	8,643	34,440	8,620	3,026	6,200	1,950	16,699	12,876	181,997	327,340	75,699	3,627	117,920	42,972	561,040	985,050	26,893	17,936	14,325
Espinar	31,216	99,776	31,775	43,983	184,590	12,055						257,334	509,476	178,652			31,658	556,820	567,400	8,092	8,349	6,541
Yauri	1,633	5,216	1,578	10,558	44,310	2,914						74,125	146,762	52,251			9,249	162,690	208,050		3,598	2,518
Pichigua	277	864	266	4,020	16,884	1,110						42,642	84,425	29,423			7,114	125,180	15,750		1,495	1,046
Pollpata	2,247	7,168	2,169	3,816	16,002	1,052						57,255	113,355	39,505			6,668	117,260	150,000		1,259	881
Coporaque	3,338	10,656	3,224	14,556	61,110	4,017						45,913	90,904	31,679			5,790	101,860	130,200		2,269	1,588
Quoruns	2,186	6,976	2,111	2,797	11,718	772						15,706	31,097	10,837			1,569	27,610	35,250		270	189
Condoroma	16,552	52,960	15,989	3,312	13,902	914						10,116	20,020	6,980			179	3,080	3,900		67	46
Suycutombo	4,982	15,936	6,418	4,925	20,664	1,276						11,577	22,913	7,987			1,089	19,140	24,450		391	273
Total	127,534	428,494	138,607	101,361	423,602	44,139	3,124	6,423	2,150	61,040	22,840	730,142	1,397,584	432,378	8,706	249,385	122,889	1,898,715	3,335,647	61,777	60,840	45,766

Source: Division de Estadistica Sicuani Agencia de Produccion Sicuani



1-3-3 The Livestock Raising Techniques

The natural pasture in the highland region does not receive any special management at all, except for the burning of the natural pasture lands by the peasants.

In the natural pasture lands is found the variety of grass called "ichu," the leaves of which are sharp and hard like thorns, and which is not a suitable fodder for the domestic animals. To eliminate them, the pastures are burnt in the months of September and October, before the rainy season, when the pasture is in the most dry state. After the burning come the rains, and thus, the more suitable pastures for the livestock can grow conveniently. However, the burning of the pasture is not made everywhere in the Project Area.

The weeds like the ichu tends to grow rapidly and spread over the area as the number of domestic animals increases, since they eat selectively only the pastures meeting their taste, leaving intact the weeds like ichu.

The growth of weeds not suited for pasture, observed in some restricted areas, is presently not yet a serious problem for the peasants of the Area.

However, if the livestock raising methods presently in practice, is kept indefinitely, the natural pastures of good quality, suited as fodder, may suffer a decline, resulting into the deterioration of the cattle breeding productivity per unit area of the land.

As shown in Table 8-17, the cattle breeding productivity of the natural pasture lands in the Province of Espinar is 1 head of sheep per hectare, and 1 head of cattle per 8 hectares. According to the data from the La Raya Livestock Experimentable Station, the area required to breed a head of cattle is 6.5 hectares, indicating that the Project Area has unfavourable conditions. As for alpacas and llamas, it is assumed that, under more normal conditions, an area of the order of 2 hectares is required to breed a head.

In the rainy season the pastures grow rapidly, and sufficient fodder is easily available for the domestic animals. However, in the dry season as the temperature decreases suddenly, the pastures decay, resulting in the shortage of fodder. Since in the Project Area, there is no fodder storage facility at all, in order to cope with the fodder shortage during the dry season. As a consequence, during the dry season the cattle becomes very thin, and almost all animals have weights below 180 kg.

Table 8 - 17 Required Surface per Head to Breed Domestic Animals

Region		Sheep	Cattle	Llama Alpaca	Horse
		ha	ha	ha	ha
Espinar		1	8	3	4
La Raya	Good	0.3	2	0.6	1.2
	Bad	1.7	11	3.4	6.8
	Average	1	6.5	2	4
Estimated Quantity of Pasture (by Calculation)	Average per Hectare	1,300 kg			

Source: La Raya
Agencia de Produccion Espinar

1-3-4 Management of Domestic Animals

The livestock raising is made by grazing them on the pasture lands extending throughout the whole Province of Espinar. Since no fences are used at all, there is always a watchman taking care of the cattles and moving them toward places where pasture is found. Children before school age, aged people and women are generally used as watchmen. The cattle is grazed freely until the sunset. Since the pasture lands are not provided with water supply facilities, the cattle drink water in the rivers existing nearby. During the night the cattle is accommodated in enclosures surrounded by mud walls, located close to the farm-house of each peasant. As additional care, there is the management of the health of the cattle. However, the vaccination to prevent diseases like aphthous fever, contagious diarrhoea of calfs (salmonella) is used very seldom by the peasants.

Most of the sheep and cattle bred in the Project Area are of the native varieties existing since before, but there are some inbreedings with improved varieties like Holstein and Brunswick.

As described in the previous paragraph, the peasants do not have sufficient fund, so they cannot afford to acquire the expensive improved breed cattle.

Domestic animals in this Area are reproduced by means of the natural crossing, making it difficult to control the process artificially. The breeding season lasts from the end of the dry season through the rainy season, due to the fact that during the dry season the temperature becomes low, resulting in withering of the pasture. With the shortage of the fodder, the growth of the calfs becomes very difficult during the dry season.

1-3-5 Distribution of the Livestock Products

As can be seen from Table 8-16 (mentioned before), the major product is the meat, consisting mostly of beef and mutton. About 90% of the beef produced in this Area is shipped to Arequipa, while the remaining 10% if for the local consumption.

Since the cattle of the Province of Espinar is generally very thin, they are transported alive to Arequipa by trucks or cattleback and then fattened for a certain period. The skin, which is a by-product of the cattle slaughtered in Espinar is sold in the semi-dried state to the tanneries in Arequipa, Puno and Juliaca, because there are no tanneries at all in the Province of Espinar.

As for sheep, 85% of their products are also shipped to Arequipa, as in the case of the cattle. Most of the wool sheared from the sheep of the Province of Espinar is sent to Arequipa and to Puno.

In Marangani, of the neighboring Province of Canchis there is a wool processing factory, but only a small quantity is sent to that factory. This is because of the limited capacity of the factory of Marangani.

The meat of alpaca and llama, salted or dried (sometimes raw meat in small quantity), is sold mostly to Lima. Since the Pan-American Highway between Arequipa and Lima is fully paved, the transportation to Lima is made via Arequipa. Since the transportation distance to Lima is very long, the freight becomes expensive. The wool and the skin of the llamas and alpacas are shipped to Puno and to Arequipa, as in the case of the sheep.

The quantities of the livestock products in the Departments of Cuzco, Puno and Arequipa in 1976, are shown in Table 8-18. In the Department of Cuzco, the production of beef is more than the double of the production of the Department of Arequipa, and as for mutton that ratio is 6 times. Those products in Cuzco Department are shipped to the Department of Arequipa where the population is larger.

As for the meat of llama and alpaca, the production is almost even between the Departments of Arequipa and Cuzco, and the product is mostly shipped to Lima.

As shown in the Table 8-19, wool is produced also in the Departments of Puno and Arequipa. These two Departments are provided with factories for processing of wool.

As for the Department of Cuzco, the Provinces of the southern highlands are not provided with factories for processing of wool with an exception of the Province of Canchis. Thus, the wool sheared in the Province of Espinar is mostly shipped to Puno and Arequipa.

Table 8 - 18 Production and Number of Heads of Domestic Animals in 1976

Department / Summary / Name	Cuzco Department			Puno Department			Arequipa Department		
	Number of Bred Heads	Number of Slaughtered Heads	Fresh Meat t	Number of Bred Heads	Number of Slaughtered Heads	Fresh Meat t	Number of Bred Heads	Number of Slaughtered Heads	Fresh Meat t
Alpaca	275,000	27,500	990	1'200,000	108,000	3,888	250,000	22,500	842
Chicken	1,095,100 467,000	628,100	730	1,239,750 558,000	681,750	787	2,992,000 935,000	2'057,000	2,880
Goats	28,200	8,460	101	1,200	310	4	48,000	16,000	165
Cuyes	7,050,800 1,642,000	5'430,800	1,358	1,739,260 431,200	1,308,060	327	4,894,500 1'095,000	3'799,500	972
Llama	153,000	13,770	490	390,000	39,000	1,326	195,000	19,500	684
Sheeps	1,560,000	187,200	2,282	4'970,000	745,500	6,710	294,000	36,250	380
Pigs	98,500	59,675	2,521	104,200	62,770	1,903	53,100	35,060	1,690
Cattle	372,000	67,400	9,077	430,500	77,325	7,749	193,500	29,025	4,121

Source: Anuario Estadístico Agropecuario 1976-OSEI-MIN. de Agricultura y Alimentación

Table 8 - 19 Production of the Livestock Indstury in 1976

		Cuzco Department	Puno Department	Arequipa Department
Classification		Weight (t)	Weight (t)	Weight (t)
Alpaca	Wool	211	1,566	259
Llama	"	85	124	104
Sheep	"	1,116	4,374	122
Goat	Milk	5		196
Cattle	"	34,230	14,732	97,190
Chicken	Egg	212	193	819

Source: Anuario Estadístico Agropecuario de Agricultura y Alimentación, 1976–OSEI–MIN

1-3-6 The Trade of Cattle, Sheep, etc.

Most of domestic animals of the Province of Espinar are traded by the cattle dealers of that Area, but a small portion of them is also traded in the local market (feria) which opens once a week.

2. Government's Plan to Develop Agriculture and Livestock Farming in the Highlands

The list of ongoing projects in the Department of Cuzco, and projects presently in the early stage of preliminary survey, which will be executed after studies, is presented in Table 8-20.

The ongoing projects include the irrigation of Tintaya and Mollapata. This project is being executed by the Inter-American Development Bank, and the Tinta irrigation projection project has already been completed, and the completion ceremony was carried out on October 15, 1978. The production activities utilizing that irrigation facility is expected to start this year. Tinta is located in the Province of Canchis, and is an area with high agricultural productivity in the southern region. Mollapata is located north-west of Cuzco, an area with relatively high agricultural productivity. Other irrigation projects are presently being surveyed, and their execution depend upon the results of feasibility studies.

There are also other projects intended to raise the technical level of the utilization of water resources, and to contribute to more effective agricultural production, related to the Tinta and Mollapata irrigation projects.

Other projects in the southern region include: the Social Development Plan in Quispicanchis, the mountainous region, and the project for maintenance of the ditches for water service in Canchis and other Provinces.

As for the livestock farming, a typical project is the promotion of milk production and stabilization of the market in the Department of Cuzco, specifically in the city of Cuzco, where exist the large population of the capital city of the Department, and the tourists coming from many parts of the world.

According to ORDESO, there is also a plan to develop the plantation of 1,000 hectares of cacao in the low lying lands in the northern region of Cuzco.

All projects mentioned above are intended to increase the production in the farming centers already existing in the Department of Cuzco, and areas like Espinar, where the agricultural is remarkably low, are not covered by those projects. However, we believe that in the future, those areas should be developped under well-designed development plans.

Table 8 - 20 Projects for Modernization of the Agriculture in the Depatment of Cuzco

1. Ongoing irrigation projects

(1)	Name of Project	Tinta	Mollepata
(2)	Area	Prov. Canchis	Prov. Anta
		Dist. Canas	Dist. Mollepata
		Canchis	
		Tinta	
(3)	Command area	Total 1,185 ha	1,800 ha
		Area to be developed: 0 ha	1,400 ha
		Area already developed: 1,185 ha	400 ha
(4)	Number of benefited peasant families	326 fam.	416 fam.
(5)	Total investment	46,800,000 Soles	165,200,000 Soles
(6)	Agricultural production	5,351 ton	27,885 ton
(7)	Livestock industry production	0	1,175 ton

2. Projects presently under study

Project name	Project area	Benefited families
Pisac	500 ha	360 families
Maranura	1,300 ha	Unknown
Echarate	500 ha	Unknown
Hantanay	1,700 ha	Unknown

3. Agricultural development

Area:	Prov. Anta, Canchis
Purpose:	Preparation of the conditions and materials required to introduce the products in the areas affected by the irrigation projects.
Affected area:	2,985 hectares
No. of benefited peasant families:	742 families
Contents:	Technical assistance for utilization of the water resources by the 742 families.

4. Social development projects in the highland regions

Affected area:	Prov. Quispicanchis
Purpose:	Survey in the whole area aiming to improve the agricultural production, by securing water resources and preserving the soil.

* Studies being presently carried out.

5. Maintenance of ditches for water service

Project area:	Prov. Canchis, etc.
Purpose:	Prevention of innundation which can affect the urban areas and villages in the basins of rivers.
Execution:	Enlargement of the bed of the Vilcanota river in the area of Chacacupe, of the Province of Canchis.

6. Miraflores-Pampa drainage project in Anta

Location:	Prov. Anta
Purpose:	Solution of the problems involved in drainage and salt, in order to convert the land for agriculture and cattle breeding use.
Project area:	1,000 ha of arable areas.
Execution:	Under preliminary study.

7. Project for reforestation and formation of orchads

Project region:	Prov. Anta Dist. Mollepata
Purpose:	Completion of a nursery of 29 ha and a transplantation bed of 51 ha, with production of 1,750,000 saplings and 100,000 fruit trees. The development of 22% of the required area is already finished.

8. Project for promotion of production of milk

Project area:	Prov. Cuzco
Purpose:	Promotion of the livestock farming of the region, and ensurance of a stable market for the farmers.

Source: Anuario Estadístico Agropecuario 1976-OSEI-Min. de Agricultura y Alimentación

3. Development Strategy for the Highland Agriculture and Livestock

3-1 Agriculture

The reason why the cultivation of vegetables and other crops in the Province of Espinar is extremely difficult in the Project Area is due to the low temperature occurring during the rainy season, which is the seed-sowing season. In this Area the temperature becomes below 0°C during the rainy season. The outdoors agriculture in this region suffers severe restrictions in view of these unfavorable natural conditions.

The start of operation of the proposed 4 mines will certainly mean a rapid increase of the demand of vegetables and other foodstuffs with an increase of population the mine workers. The sole method which will be able to assure the supply of vegetables required by the mine workers will be the indoor agriculture to be developed in greenhouses, in order to cope with the severe natural conditions.

As for the required facilities, during the rainy season simplified greenhouses constructed of pipe structures and vinyl sheets are sufficient to grow vegetables, but during the dry season the temperatures become below −11°C, and as a consequence heat sources are required in order to assure the temperature so that the growth of the crops could be made possible.

Fortunately, in Quisicollo, distant less than 40 km from Yauri there is a hot spring, and presently studies aiming to verify the possibility of utilization of the geothermal energy is being carried out. If the power generation with utilization of the geothermal energy is possible, the high temperature steam, which is a by-product of the geothermal power generation could be utilized as a heat source for greenhouse agriculture.

The development of the greenhouse agriculture in the Province of Espinar presents the following problems:

1) The construction of the facilities requires investments, and as a consequence the cost of the vegetables grown in the greenhouses will be expensive, compared with those of Arequipa, in the low lying lands;

2) The greenhouse agriculture requires high level of intensive cultivation techniques. However, in view of the extensive agriculture being presently carried out in the Project Area, a long time is required until the assimilation of the techniques by the farmers; and

3) Extension services for the farmers regarding farming management should be strengthened substantially. Presently, in the Project Area the services are being provided only by a veterinarian and two assistants.

Presently in the Project Area, the potatoes and the cañihua, do not receive attention by means of intensive techniques. However, if the cultivation is made more intensively, with application of fertizers, etc., and irrigation during the dry season, an increase of more than 40% in the crops is expected.

In addition to the technical problems mentioned above, the selection of other crops, besides potatoes and cañihua suited to the conditions of the area is also required. For example, there is the Jojoba (Note 3), which is a variety suited to be grown in cold and dry regions. Tests with this product should be made, in order to verify its suitability in this Area. If proved feasible, its cultivation should be promoted, in order to improve the agricultural productivity.

Note (3)

Jojoba is a shrub native of desertic regions, and belongs to the oleaginous family. It bears fruits similar to acorns, which contain 50% of oil. The oil of jojoba can be used for cooking and cosmetic purposes, in addition to industrial and painting uses. This shrub is extremely strong to droughts, and is suited to be planted in sandy soils with good drainage. An annual rainfall exceeding 300 mm is sufficient to grow it. As for the temperature, adult shrubs resist temperatures below −10°C, but nursery trees are damaged with temperatures of −4°C, its transplantation being therefore required after getting strong enough against low temperatures. This crop is recently atracting the attention in view of its bright prospect to match the weather conditions of the Project Area.

3.2 Livestock Raising

The cultivation of agricultural products in the Province of Espinar is restricted, due to the severe climatic conditions of the cold highlands, but the livestock raising utilizing the natural pasture is perfectly possible. Thus, it is more feasible to transform this area into an important livestock raising center than a plan to develop the cultivation of agricultural products.

The first step for the modernization of the livestock raising in this area is the improvement of the pasture. The natural pasture lands available in the area for livestock raising is approximately 325,000 hectares. Assuming that an area of 6.5 hectares is required to breed a head of cattle, the capacity of the Province of Espinar is limited to 50,000 heads. Since the quantity of domestic animals existing presently in this area is composed of 31,000 heads of alpacas, 44,000 heads of llamas, 257,000 heads of sheep and 31,000 heads of cattle, there is very little room for expanding livestock raising on the natural pasture lands in the area.

According to the data obtained in La Raya Livestock Experimental Station, the adoption of improved breeds makes possible the cultivation of the quantities of pasture listed in Table 8-21.

As breeds especially suited for cultivation in cold highlands, can be mentioned the Lolium Perenne "S23", the Lolium Perenne "Alemana," the Lolium Multiflorum "Tetraploide Tetila," the Feetuca Rubra, and the Feetuca Rubra "Estoniffera" belonging to the Graminaceoe, and the Trifolium Pratense "Kendland," the Trifolium Pratense "Alemana" and the Trifolium Pratense "Ladino," belonging to the bean family.

The yield of fresh pasture per hectare is less than 1,300 kg in case of the native natural pasture, while in case of improved breeds suited for highlands that rate is of the order of 8,230 kg through 23,341 kg, i.e., more than 8 times.

While in case of natural pasture an area of 6.5 hectare of pasture land is required to breed a head of cattle weighing approximately 180 kg, in case of improved breeds of pasture that area ranges through 0.5 hectare through 1.4 hectares, depending upon the variety of pasture, to breed a head of cattle of 250 kg. If the target weight of the living cattle is 300 kg, the required area ranges from 0.6 through 1.7 hectares.

As can be seen from the description presented above, the livestock breeding with utilization of improved pasture increases the breeding capacity per area of the pasture lands to at least 3.5 times the capacity prevailing with utilization of the natural pasture. The plantation of improved breeds of pastures, however, requires the application of fertilizers.

Presently, the livestock farming is performed freely, without adoption of fences surrounding the pasture lands. However, the improved pastures require a management with adoption of fences to separate the pasture land into various sections. The various sections of the pasture land should be used in rotation, with the pasture of one section being eaten by the cattle, while the pasture of the other sections grow.

Presently thin cattle are shipped from the Project Area and fattened in Arequipa, resulting therefore in very low economical efficiency to the cattle farmers of Espinar. However, the plantation of improved pasture will make possible the fattening of the cattle in the production source, contributing therefore to the more effective livestock raising in the Project Area, and to the increase of production of wool, etc.

After increasing the quantity of the native domestic animals by means of the process described above, it is recommendable to introduce improved breeds, with higher productivity of meat, wool, etc., in order to improve furthermore the efficiency of the livestock industry in the area.

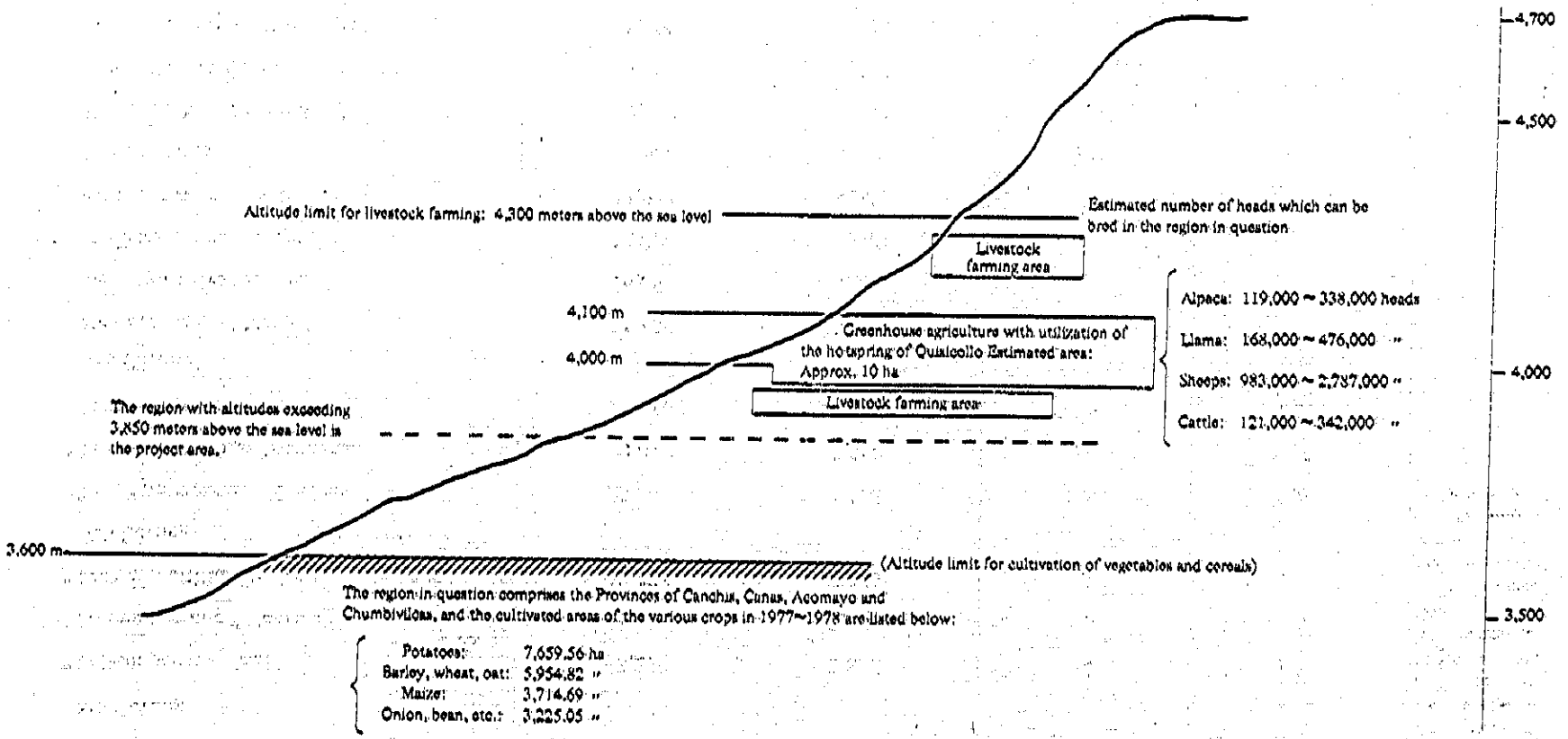
The summary of the plan for the livestock farming in the Province of Espinar with the adoption of the proposed improvements is presented in Fig. 8-4.

Table 8 - 21 Test Results Referring to Improved Pasture in the Highland Region

Name	Quantity of Pasture		Area Required to Breed a Head		Remarks
	Fresh Grass	Hay	Live Cattle 250 kg	Live Cattle 300 kg	
	kg/ha	kg/ha	ha	ha	To calculated the required area, a loss of 20% due to hoots is taken into consideration. It is assumed that the cattle consume 10% of its weight in fresh grass.
8th Cutting					
*Lolium perenne "S23"	8,230	2,836	1.4	1.7	
*Lolium perenne "Alemana"	8,559	2,939	1.3	1.6	
*Lolium multiflorum "Tetraploide Tetila"	10,471	3,345	1.1	1.4	
7th Cutting					
*Trifolium pratense "Kendland"	23,341	4,565	0.5	0.6	
*Trifolium pratense "Alemana"	20,072	3,950	0.6	0.7	
*Trifolium pratense "Ladino"	17,686	3,515	0.6	0.7	
4th Cutting					
Medicago sativa "Moapa"	11,806	3,070			
Medicago sativa "Alemana"	16,053	4,066			
Medicago sativa "Ranger"	12,886	3,640			
Medicago sativa "Du Fuits"	14,977	4,000			
Festuca rubra	11,608	4,505	1.0	1.2	
Festuca rubra "Estlonffera"	10,178	3,560	1.0	1.4	
Arrenatherum elatius	13,283	4,750			
Dactylis glomerata "Alemana"	8,990	3,538			
Dactylis glomerate "Pestura Late"	9,016	3,216			
Dactylis glomerate "S143"	10,442	3,685			
Phleum pratense "Inglés"	14,491	4,643			

Source: La Raya, Livestock Experiment Station

Fig. 8 - 4 Plan of Distribution of the Livestock Farming and Agriculture According to the Altitudes



Note: 1) The estimation of the number of heads of domestic animals of the region is made based upon the number of heads existing in the Province of Espinar in 1977 ~ 1978. The number of heads existing presently refers to the natural pasture. For the improved pasture the number of heads is calculated based on the data of Table 8-20, assuming a weight of 300 kg for the cattle alive.

2) The area assumed for greenhouse agriculture is 10 hectares, but this figure should be confirmed after a new survey.