# REPORT ON THE MINERAL EXPLORATION IN THE PACHAPIRIANA AREA REPUBLIC OF PERU

(PHASE II)

MARCH 1990

JAPAN INTERNATIONAL COOPERATION AGENCY

METAL MINING AGENCY OF JAPAN

JICA
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ON

# THE MINERAL EXPLORATION

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## Preface

In response to the request of the Government of the Republic of Peru, the Japanese Government decided to conduct a Mineral Exploration in the Pachapiriana Area and entrusted the survey to the Japan International Cooperation Agency (JICA) and the Metal Mining Agency of Japan (MMAJ).

The JICA and MMAJ sent to the Republic of Peru a survey team headed by Mr. Hiroshi Hama from July 10 to December 29, 1989. The team exchanged views with the officials concerned of the Government of the Republic of Peru and conducted a field survey in the Pachapiriana area. After the team returned to Japan, further studies were made and the present report has been prepared.

We hope that this report will serve for the development of the Project and contribute to the promotion of friendly relations between our two countries.

We wish to express our deep appreciation to the officials concerned of the Government of the Republic of Peru for their close cooperation extended to the team.

February, 1990

Kensuke Yanagiya
President
Japan International Cooperation Agency

Gen-ichi Fukuhara
President
Metal Mining Agency of Japan

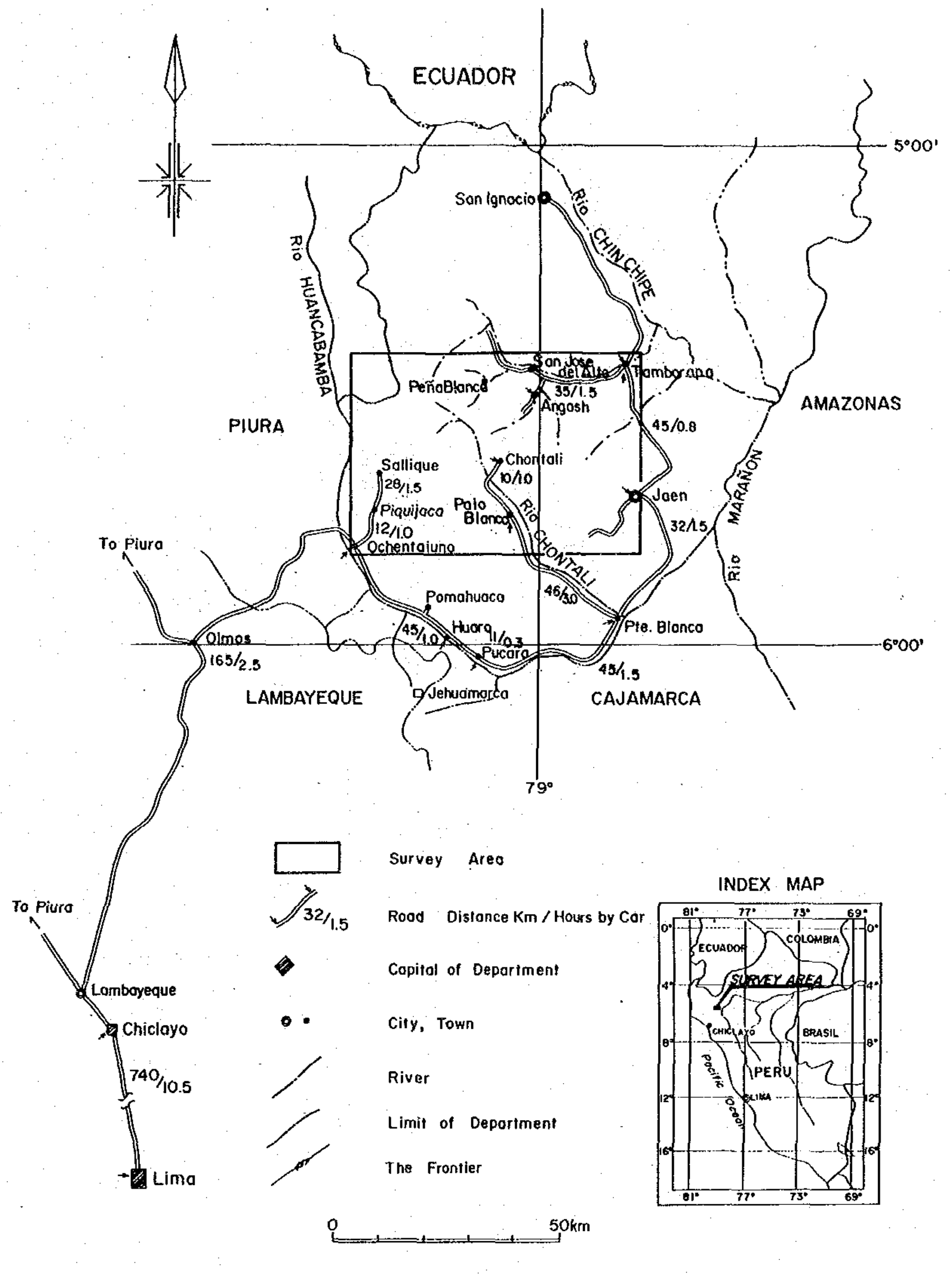


Fig.I－1 (1) Location and Accessibility of the Survey Area

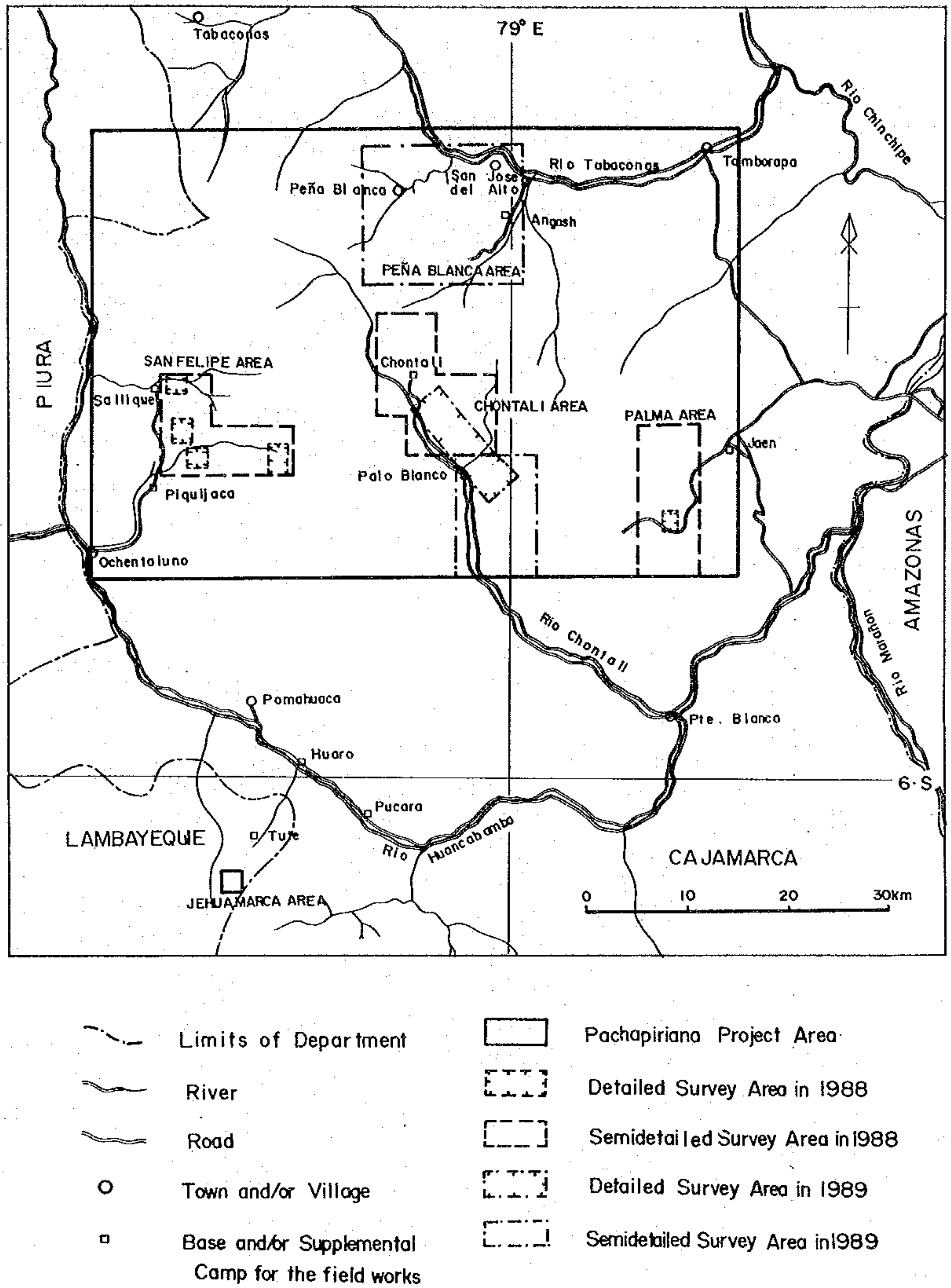


Fig. I-1 (2) Location of the Survey Area

## SUMMARY

This report summarizes the phase II results of the surveys conducted in the Pachapiriana area, the Republic of Peru. The surveys aimed to reveal potentiality of existence of useful mineral resources in the area through clarification of geological setting in the area. The field survey was carried out from July to December, 1989.

The phase II survey included drilling at 3 sites which had been assessed to be prospective through the results of detailed geological survey and geophysical survey of the phase I. Total hole length was 816.25 m. In the area where indications of promising alteration zones had been extracted through semi-detailed geological survey, an additional detailed geological survey was also conducted over an area of 42 km2 and geophysical survey(using the CSAMT method) was also implemented over 35 km2 with 102 points. Semi-detailed geological survey was conducted over a total area of 300 km2, where geochemical anomalies were extracted by INGEMMET (Instituto Geologico, Minero y Metalurgico).

Drilling survey was performed in Jehuamarca area. Although the recognition of underground continuation of fissures distributed at the surface was not necessarily successful, but the quartz rich zone with intense mineralization was found at two localities, and silicified zone which had been assessed prospective through the results of the phase I survey was verified and recognized to show auri-argentiferous base metal dissemination.

Detailed geological survey was carried out in Chontali area, and in alteration zone which had been assessed prospective through the results of the phase I survey, abundant auriferous quartz veins were found.

Geophysical survey implemented contemporaneously revealed that the alteration zone was characterized by low resistivity zones and that the area with closely developed quartz veins was extracted as high resistivity within the low resistivity zone, and that the high resistivity zone continued toward deeper underground and the highest part overlapped to the part with large-scaled quartz veins within the area with closely developed quartz

veins.

The analyzed results by homogeneous temperature of fluid inclusion for auriferous quartz veins ranged from 96 to 271℃, and the values for the large-scaled quartz veins was lower than 150℃ suggesting that beneath the area there existed a zone most adequate for the auri-argentic mineralization. The grade of gold in veins was relatively so high in the area with large-scaled quartz veins (average width of six veins: 3.04 m, average value: gold 2.54 g/t) as concluded that in the area the possibility of existence of large-scaled and high grade auri-argentic ore deposits was conceived.

Semi-detailed geological survey was conducted in Chontali south and Pena Blanca areas. In the former area, it was recognized that the alteration zones found in Chontali area through the phase I survey extended toward the south in a small scale. In the latter area, the alteration zone similar to that in Chontali area as well as skarn zone were found but the indications of occurrences of mineralization was small-scaled and the distribution of geochemical anomaly was also small-scaled and not coherent, therefore, it is concluded that the possibility of existence of large-scaled ore deposits was low.

For the further survey, it is necessary to conduct drilling survey to estimate the potential of mineralization in Jehuamarca and Chontali with respect to extracted prospective mineralized zones and promising mineralized zones, respectively. In addition, the high resistivity layer assumed in the greatest depth suggested the existence of granitic intrusives, therefore gravity prospecting is recommended to reveal the intrusion form which gives the important indicator to deduce the place of formation of ore shoot.

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# PART I

## GENERAL REMARKS

# CHAPTER 1 INTRODUCTION

## 1-1 Antecedents of the Survey

The survey area is situated in a part of the region for which a geochemical survey using stream sediments was carried out under the Northern Geochemical Project (Proyecto Geoquimico del Norte) sponsored by the U.K. The detailed survey for the extracted geochemical anomalous zones was realized partially by INGEMMET itself and partially by German and French organizations. However, the major part has remained pending due to shortage of funds.

Under these circumstances, INGEMMET requested, through the Ministry of Foreign Affairs of the Republic of Peru, a technical cooperation from the Japanese Government for the follow-up survey in March 1988. In August 1988, a delegation for the preliminary survey and agreement negotiations for this purpose was organized among the Ministry of International Trade and Industry (MITI), Japan International Cooperation Agency (JICA) and Metal Mining Agency of Japan (MMAJ), and was sent to Peru. On August 15, 1988, the scope of work to the Pachapiriana area Project was signed between the parties.

According to the scope of work concluded among INGEMMET, JICA and MMAJ, the survey encompasses an area of 2,820 km2.

The phase I survey included a semi-detailed geological survey which was conducted over a total area of 300 km2 in three regions among the geochemical anomalous zones assessed prospective by INGEMMET, combined with the LANDSAT image analysis of entire survey area. An additional detailed geological survey was also conducted over a total area of 25 km2, in five regions (21 km2) extracted from semi-detailed survey area and one region (4 km2) extracted by INGEMMET. Geophysical survey using CSAMT method was implemented over 25 km2 in two regions.

## 1-2 Conclusion and Recommendation of the Phase I Survey

### 1-2-1 Conclusion of the Phase I Survey

The conclusion of the phase I survey is summarized as follows:

1) This survey area consists of rocks from Precambrian to Cenozoic.
2) Mineralized alteration occurs in Oyotun and Porculla Volcanics, belonging to Mesozoic and Cenozoic, respectively.
3) The alteration occurs through the NE-SW and its subsidiary NW-SE trending fissure systems.
4) The alteration is related to the epithermal mineralization and suggests the possibility of existence of porphyry copper type, epithermal silver and gold vein type, and auri-argentiferous base metal dissemination type ore deposits.
5) The mineralization of epithermal silver and gold vein type was found in the Chontali area, and as for the analytical results of ore samples from quartz veins at Chontali, average values were 1.37 g/ton Au and 7 g/ton Ag (from 17 samples).
6) The mineralization of auri-argentiferous base metal dissemination type was found in Jehuamarca, where geophysical survey was implemented to show a mushroom structure of high resistivity zones indicating silicification.
7) The mineralization of porphyry copper type was found in La Huaca and Zonanga mineralized alteration zones.

### 1-2-2 Recommendations for the Phase II Survey

The following surveys are proposed for the phase II survey based on the results obtained in the phase I :

1) A detailed geological survey and geophysical survey in the Chontali alteration zones extracted from semi-detailed survey areas of the phase I .
2) Drilling survey for the Jehuamarca alteration zones where a clear survey target was found out by geophysical survey of the

phase Ⅰ.

3) A high probability of occurrences of Mineralization has been verified by the phase Ⅰ survey for the geochemical anomaly based on the stream sediments by INGEMMET. Therefore, it is recommended for the phase Ⅱ that a reconnaissance geological survey be conducted around the north and south of Chontali, Pena Blanca and Tuna principally, in areas which were left unsurveyed, to check for geochemical anomaly there.
4) A detailed geophysical prospecting (by the SIP or IP method, for example) for the alteration zones at La Huaca and Pena Verde where reconnaissance prospecting has been conducted during the phase Ⅰ survey.
5) An additional detailed geological survey along extension of north and east from the Zonanga alteration zones, and a reconnaissance geophysical prospecting of the entire area (by the CSAMT method, for example).

## 1-3 Outline of the Phase Ⅱ Survey

### 1-3-1 Area and Purpose of the Phase Ⅱ Survey

The phase Ⅱ survey was conducted according to priority of recommendations of the phase Ⅰ.

1) Chontali area

A detailed geological survey was conducted in the Chontali alteration zones (42 km2) including quartz veins, extracted from semi-detailed survey areas of the phase Ⅰ. The aim of the survey is to confirm the dimension of surface exposure of quartz veins (thickness and elongation), grade of ore deposits and alteration grade of country rocks. Moreover, geophysical survey using the CSAMT method was performed to evaluate potentials in underground extent of the alteration zones. The survey was implemented over a 35 km2 with 102 points dispersed throughout the area where the detailed geological survey was conducted phase Ⅱ ( recommendation 1 of the phase Ⅰ ).

The alteration zones have been found through the phase Ⅰ survey but their southern extension has not yet been confirmed and a high probability of occurrences of mineralization has been verified at about 5 km south of the surveyed area by the phase I survey for the geochemical anomaly based on the stream sediments by INGEMMET. Therefore, semi-detailed geological survey was conducted around the southern extension(80 km2) of the area to confirm the southern extension of the alteration zones as well as to check for geochemical anomaly in stream sediments( recommendation 3 of the phase I ).

2) Jehuamarca area

Drilling survey was performed at three sites and total hole length reached 816.25 m. The purpose of the drilling was to verify the mineralized conditions in underground silicified zone with a mushroom structure, which has been interpreted to exist through the detailed geological survey and geochemical and geophysical prospectings during the phase I (recommendation 2 of the phase I ).

The propose of drilling at each site is as follows:

MJPJ-1; to verify the mineralized conditions of the central part of the deeply seated underground silicified zone inferred to show a mushroom structure and to verify those in the deep underground extension of the silicified veins exposed at the surface

MJPJ-2; to verify the mineralized conditions of the southeastern limb of the deeply seated underground silicified zone inferred to show a mushroom structure and to verify those in the deep underground extension of the silicified veins exposed at the surface

MJPJ-3; to verify the mineralized conditions of the northwestern margin of the deeply seated underground silicified zone inferred to show a mushroom structure and to verify those in the silicified rocks with the highest value of geochemical anomaly in the area

3) Pena Blanca area

Semi-detailed geological survey was conducted around Pena Blanca (220 km2) to check for the geochemical anomaly based on the stream sediments by INGEMMET (recommendation 3 of the phase I).

## 1-3-2 Survey Procedure

The procedure of each survey will be outlined as follows.

1) Semi-detailed geological survey

① Chontali area

A topographical map on the scale of 1/25,000 published by IGN (Instituto Geografico Nacional) was used as the base map for the survey. Base camp was set up at Palo Blanco. In general, three survey teams were organized pairing one Japanese engineer and one of counterparts of Peru. Five teams were organized in order to be observed by each of Japanese engineers and counterparts and to arrange survey routes closely when the detailed survey was needed.

② Pena Blanca area

As no topographic maps had yet been published for the area, a SLAR (Side Looking Airborne Radar) image on the scale of 1/100,000 compiled by ONERN (Oficina Nacional Evaluacion de Recursos Naturales) are enlarged to the scale of 1/25,000 to be used as the base map. On the image, were shown no indication for villages, roads, mountains and so on but only shadows reflecting the topographic unevenness, thus it was difficult to specify the location. As there was a small difference in the UTM co-ordinates, latitude and longitude between on the SLAR image and on the topographic map on the scale of 1/100,000 published by IGN, the UTM co-ordinates were revised according to the data in the Chontali area. The base camp was set up at Angash. In general, three survey teams were organized in the same manner in case of Chontali area. Six teams were organized to arrange survey routes closely if needed.

2) Detailed geological survey

Detailed geological survey was conducted only in Chontali area in phase Ⅱ. A topographical map on the scale of 1/25,000 published by IGN was enlarged to the scale of 1/5,000 and used as the base map for the survey. The survey was carried out using string measures and clinometers and/or clinocompasses with a scale of 1/5,000. Correction of measurement errors was made at such topographically characteristic points as a junction of streams and a summit. In the area extracted as an alteration zone during the phase Ⅰ, a closing measuring line drawn using pocket-compasses was combined with each measuring line at outcrops to make the relative positioning of each outcrop accurate. The survey was performed by three teams.

3) Geochemical survey

Samples for geochemical survey were taken together with geological survey. Sampling at the outcrop was carried out as a rule every 500 m along the measuring line for detailed and semi-detailed geological surveys. Sampling density was lowered in the semi-detailed survey area in Chontali than planned and importance in sampling was given more in detailed survey area in Chontali and semi-detailed survey area in Pena Blanca.

4) Geophysical survey

Electromagnetic survey using the CSAMT method was performed. Required equipment and materials were mainly transported from Japan with partial local procurement of survey articles. In this regard, the work included grounding, wiring and removal of the transmitting and receiving stations. Transmitting stations were set up in Pachapiriana and Las Pinas. The base camp was set up in Chontali and an advanced camp in Palo Blanco. The density of survey stations was changed based upon the results of detailed geological survey.

5) Drilling survey

Drilling was performed taking the local drilling company GEOTEC, S.A. into employment. As no roads were passable for motorcars, drilling rigs were transported by a helicopter chartered from the Peruvian Air Force No.3. The base camp was set up on the summit of Mt. Jehuamarca. The supply bases were set up in Pucara, Huaro and Tute to replenish mending parts, fuel oil, drilling mud, cement and food. Due to the steep configuration, it took two days on outward way and one to two days on homeward to transport the materials from Huaro to Jehuamarca.

The survey of phase II is summarized as follow:

| | Geological & Geochemical | | | Geophysical | | Drilling | |
|---|---|---|---|---|---|---|---|
| | Area (km2) | Rout Length (km) | Geochem. Samples (pcs.) | Area (km2) | Survey Points (points) | Dril. Hole (holes) | Dril. Length (m) |
| Chontali detailed | 42 | 143.17 | 270 | 35 | 102 | | |
| Chontali semi-detailed | 80 | 115.75 | 126 | | | | |
| Pena Blanca | 220 | 208.85 | 366 | | | | |
| Jehuamarca | | | | | | 3 | 816.25 |

The rock samples taken for laboratory test are summarized as follows:

| | Ore Anal. | Fluid Inc. | X-ray Diffr. | Whole Rock | Thin Sect. | Polish Sect. | K-Ar Age |
|---|---|---|---|---|---|---|---|
| Chontali detailed | 100 | 30 | 12 | 3 | 4 | 2 | - |
| Chontali semi-detailed | 2 | - | 1 | 1 | 2 | - | 1 |
| Pena Blanca | 9 | - | 7 | 6 | 14 | 3 | 4 |
| Jehuamarca | 125 | - | 8 | - | 4 | 4 | - |
| Total | 236 | 30 | 28 | 10 | 24 | 9 | 5 |

1-3-3 Organization of the Survey Group and Period of the Survey

The representatives from Japanese government for the phase II survey and agreement negotiation were dispatched to Peru during the period from October 9 to 17, 1989. The delegation members and their counterparts in Peru are shown below:

From Japan:

| | |
|---|---|
| Mr. Hideya METSUGI | Metal Mining Agency of Japan |

From Peru:

| | |
|---|---|
| Mr. Guillermo BALCAZAR RIOJA | INGEMMET |
| Mr. Gregorio FLORES NUNES | INGEMMET |
| Mr. Luis DYARCE GONZALES | INGEMMET |

The survey group was organized by geological and geochemical survey team, geophysical survey team and drilling survey team, the first being sent during the period from July 17 to October 19, 1989 , the second from August 7 to October 13, 1989 and the third from July 17 to December 29, 1989. The leader was sent for the selection of local contractor of drilling, the negotiation before the survey and the conduct after the survey during the period from July 10 to December 29, 1989

The group members from Japan and their counterparts from Peru are as shown below:

From Japan:

| | | |
|---|---|---|
| Mr. Hiroshi HAMA | MINDECO; | leader of the survey team and geological, geochemical and drilling survey |
| Mr. Kazuhiro ADACHI | MINDECO; | geological and geochemical survey |
| Mr. Kazuhiko YAMANAKA | MINDECO; | geological and geochemical survey |
| Mr. Manabu KOBAYASHI | MINDECO; | geophysical survey |
| Mr. Takeshi YOSHIMOTO | MINDECO; | geophysical survey |
| Mr. Mitsuyoshi SAITO | MINDECO; | geophysical survey |
| Mr. Yuuji KATABE | MINDECO; | drilling survey |

MINDECO:Mitsui Mineral Development Engineering Co., Ltd.

From Peru:

| | | |
|---|---|---|
| Mr. César VILCA NEIRA | INGEMMET; | general review and geological and geochemical survey |
| Mr. Emilio ROJAS RIVERA | INGEMMET; | geological and geochemical survey |
| Mr. Luis QUISPE ARANDA | INGEMMET; | geological and geochemical survey |
| Mr. Carlos A. GAMARRA ROMERO | INGEMMET; | geophysical survey |
| Mr. Walter PARI PINTO | INGEMMET; | geophysical survey |
| Mr. Carlos JIMENES VELASCO | INGEMMET; | drilling survey |

During phase II survey, complying the request from INGEMMET, three students assistants from San Marcos University (Universidad Nacional Mayor de San Marcos) and San Augustin University (Universidad Nacional de San Augustin) were accepted. Two of them in geological survey team and one in geophysical survey team were coached the field survey all through the period of each survey team.

# CHAPTER 2 GEOGRAPHY OF THE SURVEY AREA

## 2-1 Topography and Drainage System

The phase Ⅱ survey was conducted in the central part of the survey area as shown in Fig. I-1(2).

In Chontali area, as described in phase I, the Chontali River (called as the Huayllabamba River or the Chunchuca River, on other topographic maps) runs along the west boundary. It runs southward and changes the direction from NW-SE in the detailed geological survey area to N-S in semi-detailed survey area. Each tributary tends to meet nearly at right angles to the Chontali, namely they are arranged in the direction of NE-SW in the northern detailed survey area, but E-W in the southern semi-detailed survey area.

In Pena Blanca area, the drainage system of the Tabaconas that runs along the north boundary of the survey area is not irregular one as seen in the Chontali but rather dendritic. It seems to have the tendency, if anything, that the main tributaries run in the direction of NE-SW, combined with the creeks running E-W and N-S to show dendritic drainage system.

Both of Chontali and Pena Blanca areas are topographically so steep that, owing also to vegetation shown later, it was difficult to obtain the survey routes. In Chontali area, the elevation is 1,650 m between the Chontali(1,050 m above the sea level) and the highest peak( 2,700 m). In Pena Blanca area, the elevation is as high as 1,900 m between the Tabaconas(750 m) and Mt. Huayanche, the highest peak where the survey team climbed, with the altitude of 2,650 m estimated by barometer.

## 2-2 Climate and Vegetation

As reported in phase I, vegetation in the survey area show a particularly remarkable variation due to the difference of elevation. Another critical factor for the variation is whether the land is reclaimed or not. The area belongs essentially to tropical to subtropical rainforest zones characterized by thick virgin forests with trees of 10 to 15 m high. In the progress of

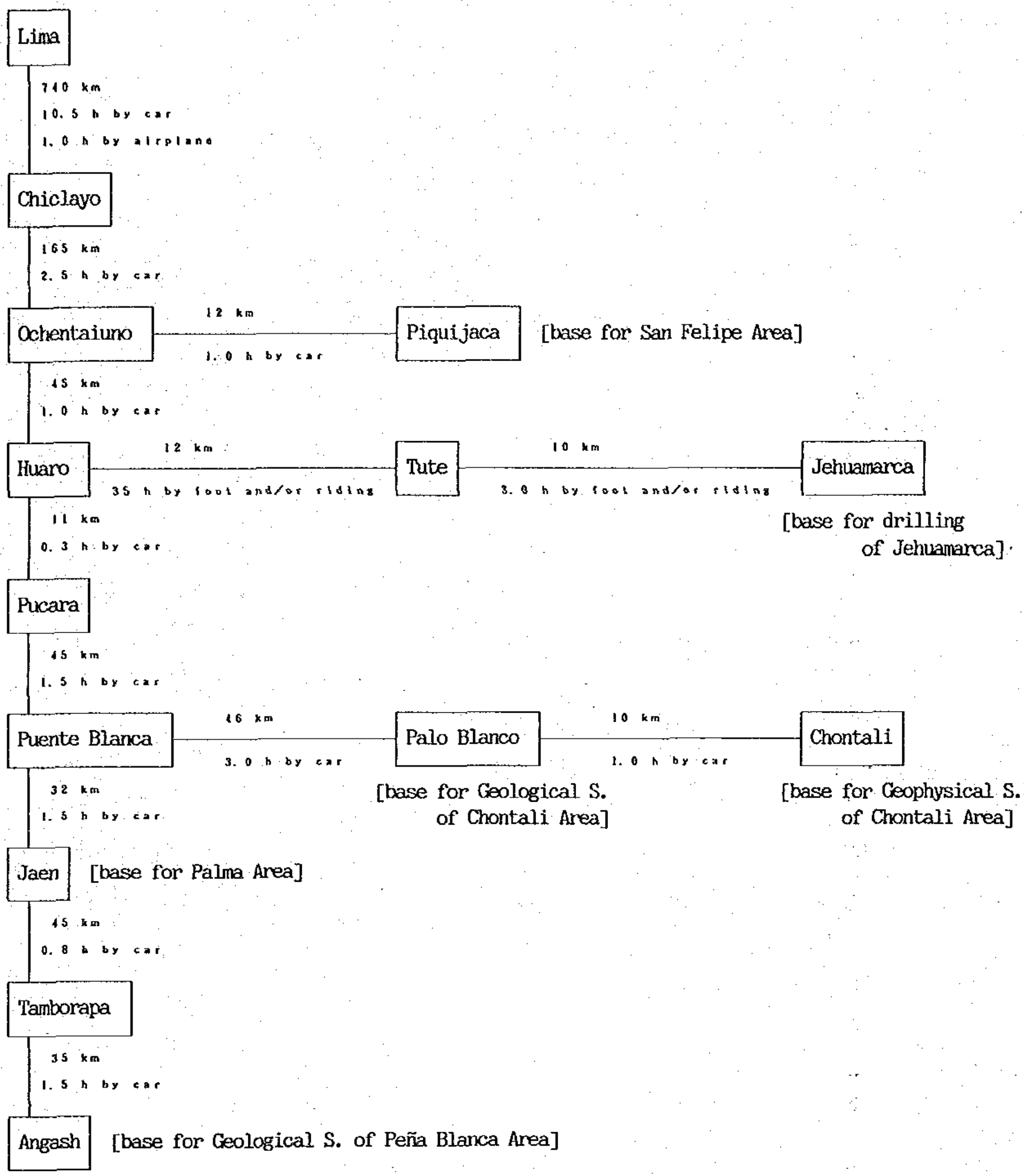



Fig. I-2 Summarized Accessibility of the Survey Area

disaforestation, the desert has been expanded but the irrigated area are preserved as agricultural lands but non-agricultural lands become dry shrubbery zones.

The whole area for detailed geological survey in Chontali has been reclaimed to be used as agricultural or pasture lands. In the semi-detailed survey area in Chontali, the lowland has almost been reclaimed but the highland above 2,000 m still belongs to the jungle zone as felling of virgin forest has been continued.

In Pena Blanca, whole area except along the main rivers has not yet been reclaimed and covered with virgin forest, thus the survey is very difficult, coupled with the steep topography. Cutting down timber has been developed at present suggesting the expansion of desert will be advanced in this area.

Although climate in the survey area seems to show remarkable local variation, it is difficult to systematize the variation because meteorological observation stations are few and meteorological data are poor. Table I-1 summarizes the meteorological observation data at Jaen and Chontali as well as at Tabaconas (out of the survey area, northeastern extension).

Temperature shows a remarkable variation due to the altitude. The average values are higher at Jaen situated in lower land, decreasing as the altitude becomes higher toward Tabaconas via Chontali. At the three stations shown above, the average temperature variation for each month is so small that it can be said the seasonal variation of temperature is slight. However, it is suggested that the diurnal variation is very large, as the difference between maximum and minimum temperatures for each month is more than 10℃ at the three stations.

Relative humidity tends to be higher as the altitude becomes high in contrast to the case of temperature. Judge from the average humidity for each month, the variation seems to coincide with that of average temperature, independently to dry or rainy period.

The precipitation is not dependent on the altitude but fairly on the presence of virgin forest in the surrounding. At Jaen station around which reclamation advances and the area is used as agricultural or pasture lands, numbers of rainfall days are similar to those at other stations, but the precipitation is only around 70 % of others. The precipitation data of Chontali suggest the thick vegetation condition as the observation station is located in the area where virgin forest has been preserved near Pena Blanca. The data from Tabaconas suggests that the environmental condition there is mediate between above mentioned two stations.

Annual variation of precipitation is not so remarkable at the three station and there is not a clear distinction between the rainy and dry periods. If a month belonging to the rainy period is defined as with more than 100 mm precipitation, the rainy period covers December to March and the dry one June to November. Among the periods, January to April and July to September are relatively much and less precipitated, respectively.

## Table I-1 Meteorology of the Survey Area

Precipitation (mm)

| | | Jan. | Feb. | Mar. | Apr. | May. | Jun. | Jul. | Aug. | Sep. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Tabaconas | Mean | 114.1 | 107.1 | 115.1 | 113.3 | 90.6 | 67.7 | 53.4 | 58.0 | 54.4 | 88.1 | 73.1 | 111.4 |
| | Max. | 232.2 | 233.4 | 179.6 | 229.2 | 145.2 | 158.8 | 93.2 | 134.1 | 114.4 | 257.8 | 182.8 | 256.9 |
| | Min. | 63.1 | 42.2 | 45.4 | 41.7 | 25.1 | 13.5 | 16.2 | 13.0 | 5.6 | 11.6 | 10.0 | 0.3 |
| Chontali | Mean | 159.5 | 119.6 | 173.7 | 152.3 | 102.1 | 71.8 | 46.2 | 35.1 | 52.1 | 90.1 | 80.8 | 87.5 |
| | Max. | 676.5 | 204.9 | 830.0 | 380.8 | 206.5 | 187.0 | 123.3 | 79.9 | 134.3 | 195.4 | 221.5 | 215.5 |
| | Min. | 22.1 | 29.2 | 55.2 | 23.1 | 28.3 | 24.8 | 10.2 | 13.3 | 6.3 | 6.0 | 25.0 | 4.2 |
| Jaen | Mean | 73.2 | 79.2 | 110.2 | 100.9 | 70.4 | 42.5 | 33.6 | 25.9 | 46.4 | 74.0 | 65.1 | 62.8 |
| | Max. | 159.7 | 174.0 | 264.7 | 194.0 | 176.7 | 142.1 | 174.1 | 41.9 | 216.8 | 139.7 | 153.5 | 174.1 |
| | Min. | 11.0 | 13.0 | 23.9 | 40.9 | 17.4 | 7.8 | 10.0 | 6.5 | 5.4 | 14.2 | 11.7 | 9.2 |

Rainy Day (days)

| | | Jan. | Feb. | Mar. | Apr. | May. | Jun. | Jul. | Aug. | Sep. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Tabaconas | Mean | 17.7 | 17.5 | 17.1 | 17.1 | 15.7 | 15.0 | 13.1 | 12.1 | 13.0 | 14.0 | 12.4 | 16.0 |
| | Max. | 27 | 25 | 26 | 26 | 22 | 25 | 21 | 19 | 19 | 20 | 23 | 22 |
| | Min. | 7 | 8 | 10 | 9 | 5 | 8 | 7 | 1 | 5 | 5 | 7 | 1 |
| Chontali | Mean | 14.8 | 13.7 | 17.8 | 16.4 | 15.7 | 12.3 | 10.1 | 8.4 | 9.2 | 11.4 | 10.1 | 11.7 |
| | Max. | 25 | 20 | 26 | 25 | 24 | 19 | 14 | 15 | 16 | 24 | 15 | 22 |
| | Min. | 6 | 5 | 8 | 5 | 8 | 6 | 6 | 4 | 2 | 2 | 3 | 1 |
| Jaen | Mean | 13.9 | 13.6 | 16.3 | 15.9 | 13.5 | 12.1 | 10.6 | 10.0 | 10.5 | 12.6 | 11.1 | 12.5 |
| | Max. | 23 | 22 | 28 | 22 | 21 | 21 | 19 | 16 | 17 | 20 | 19 | 20 |
| | Min. | 6 | 7 | 8 | 8 | 6 | 3 | 4 | 5 | 3 | 6 | 4 | 1 |

Temperature (℃)

| | | Jan. | Feb. | Mar. | Apr. | May. | Jun. | Jul. | Aug. | Sep. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Tabaconas | Mean | 17.3 | 17.6 | 17.6 | 17.6 | 17.3 | 16.6 | 16.1 | 16.6 | 17.1 | 17.8 | 18.3 | 18.0 |
| | Max. highest | 23.6 | 23.1 | 23.1 | 23.0 | 22.5 | 22.1 | 22.0 | 23.1 | 23.2 | 24.2 | 24.8 | 28.1 |
| | lowest | 19.9 | 20.0 | 20.6 | 21.3 | 20.7 | 19.8 | 19.1 | 19.9 | 20.7 | 21.1 | 22.3 | 20.6 |
| | Min. highest | 8.4 | 8.4 | 8.4 | 8.4 | 6.6 | 5.9 | 6.4 | 5.7 | 5.8 | 8.3 | 7.7 | 7.5 |
| | lowest | 14.5 | 14.9 | 14.7 | 14.8 | 14.7 | 14.1 | 13.4 | 14.4 | 13.7 | 14.4 | 14.2 | 14.4 |
| Chontali | Mean | 19.1 | 19.2 | 19.3 | 19.4 | 19.2 | 18.7 | 18.3 | 18.7 | 19.1 | 19.6 | 19.9 | 19.7 |
| | Max. highest | 26.0 | 26.0 | 25.6 | 25.6 | 25.2 | 25.1 | 25.2 | 25.6 | 26.9 | 27.0 | 28.5 | 26.5 |
| | lowest | 21.4 | 22.2 | 22.6 | 22.9 | 22.6 | 22.1 | 22.2 | 22.2 | 23.4 | 22.8 | 23.2 | 23.1 |
| | Min. highest | 12.4 | 12.4 | 13.2 | 12.7 | 12.5 | 11.5 | 11.0 | 11.4 | 11.8 | 11.5 | 12.1 | 12.4 |
| | lowest | 16.9 | 16.4 | 16.5 | 15.8 | 16.6 | 15.1 | 14.6 | 14.5 | 15.6 | 15.6 | 15.5 | 16.5 |
| Jaen | Mean | 24.8 | 24.8 | 24.6 | 24.7 | 24.5 | 24.1 | 24.0 | 24.7 | 25.5 | 25.7 | 25.8 | 25.5 |
| | Max. highest | 33.6 | 32.6 | 31.5 | 32.4 | 30.7 | 30.9 | 30.8 | 32.6 | 32.6 | 33.3 | 33.0 | 34.0 |
| | lowest | 27.8 | 28.1 | 27.7 | 28.4 | 28.3 | 27.5 | 28.3 | 27.9 | 29.5 | 29.4 | 29.8 | 29.5 |
| | Min. highest | 17.6 | 16.6 | 17.2 | 16.4 | 16.4 | 16.5 | 16.0 | 16.5 | 16.4 | 16.6 | 16.3 | 17.4 |
| | lowest | 22.0 | 21.5 | 21.0 | 20.8 | 21.4 | 20.4 | 20.2 | 20.9 | 21.5 | 21.8 | 22.0 | 21.7 |

Humidity (%)

| | | Jan. | Feb. | Mar. | Apr. | May. | Jun. | Jul. | Aug. | Sep. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Tabaconas | Mean | 87.1 | 87.6 | 88.0 | 88.8 | 89.1 | 90.0 | 88.7 | 88.0 | 87.9 | 85.9 | 83.5 | 84.7 |
| | at 7 am. | 91.3 | 91.6 | 93.6 | 93.7 | 94.5 | 94.9 | 95.1 | 94.7 | 95.1 | 93.4 | 90.7 | 90.2 |
| | at 1 pm. | 82.5 | 83.0 | 81.9 | 81.7 | 83.5 | 84.2 | 82.0 | 80.6 | 83.1 | 82.5 | 78.5 | 79.8 |
| | at 7 pm. | 88.1 | 89.4 | 90.0 | 90.6 | 91.0 | 90.3 | 91.9 | 90.2 | 91.5 | 89.7 | 87.8 | 88.3 |
| Chontali | Mean | 85.5 | 86.5 | 87.0 | 85.7 | 85.9 | 84.5 | 83.9 | 82.6 | 81.9 | 83.9 | 82.3 | 82.7 |
| | at 7 am. | 95.0 | 94.5 | 94.2 | 96.5 | 95.0 | 95.0 | 95.8 | 93.4 | 93.9 | 95.0 | 94.1 | 93.1 |
| | at 1 pm. | 82.8 | 81.3 | 81.0 | 79.5 | 79.7 | 77.8 | 75.8 | 75.6 | 75.8 | 80.1 | 77.6 | 77.6 |
| | at 7 pm. | 87.0 | 87.3 | 88.5 | 87.3 | 87.2 | 86.0 | 86.0 | 84.9 | 84.5 | 85.1 | 85.1 | 84.5 |
| Jaen | Mean | 70.3 | 72.9 | 74.6 | 75.1 | 74.4 | 74.0 | 68.8 | 66.6 | 65.5 | 66.4 | 65.9 | 67.9 |
| | at 7 am. | 86.5 | 88.4 | 88.5 | 90.3 | 89.7 | 89.8 | 85.4 | 84.8 | 82.5 | 81.9 | 81.2 | 82.5 |
| | at 1 pm. | 61.1 | 61.5 | 60.7 | 60.8 | 61.0 | 60.0 | 53.0 | 52.9 | 51.4 | 53.6 | 54.1 | 56.5 |
| | at 7 pm. | 71.5 | 72.4 | 74.1 | 76.3 | 76.7 | 74.9 | 67.6 | 67.0 | 66.5 | 66.9 | 67.1 | 67.2 |

| | Elevation | Lat. | Long. |
|---|---|---|---|
| Tabaconas | 1860 m | 5° 19' | 79° 17' |
| Chontali | 1610 m | 5° 45' | 78° 58' |
| Jaen | 620 m | 5° 40' | 78° 51' |

## CHAPTER 3 GENERAL GEOLOGY

The survey area is situated in a tectonically disturbed zone, so called Huancabamba deflection zone. This causes a great variation in the sedimentary environment of each geological unit. In addition most of the survey area is uninhabited and the obtainment the survey routes is not easy, thus bringing some confusion to correlate geological formation and it requires further study.

An geological outline of the area is given below after Wilson(1984), Reyes y Caldas(1987) and Davila et al.(unpublished), revised after the results of phase I and phase II survey. A geological map and a stratigraphic column are generalized as shown in Figs. I-3 and I-4, respectively.

The survey area consists of metamorphic rocks correlative with Precambrian to Paleozoic, Mesozoic sedimentary and volcanic rocks and Cenozoic volcanic and intrusive rocks. The metamorphic rocks, consisting of the basement Maranon Complex, Ordovician Olmos Complex and Silurian Salas Group, have such a wide lithofacies as gneiss, semi-schist and phyllite. They are developed in the western half of the survey area.

Mesozoic rocks are the main constituent of the survey area and consist of the following units in ascending order: Leche Formation (mainly calcareous rocks), Tinajones Formation (arenaceous rocks intercalated with tuffaceous rocks), and Inca, Chulec, Pariatambo and Pulluicana Formations (mainly calcareous rocks).

Cenozoic rocks composed mainly of volcanic rocks which in ascending order are Llama, Porculla and Shimbe Volcanics are distributed in western and southwestern parts of the survey area. Tamborapa Formation consists of conglomerate, with loose consolidation, being correlative with the Quaternary sediments. This Formation occurs at the eastern flange of the survey area.

Intrusive rocks consist of gabbros, diorites and granites. Generally, gabbros and diorites are older than granites which are intruding even Porculla Volcanics. The absolute ages determined using K/Ar method are 119± 6 million years for quartz diorite, 106± 5 million years for quartz monzonite, 82.5± 4 million years for granodiorite, 78± 3.9 million years for monzonisyenite and

47.6± 2.4 for adamellite.

The intrusive trends are NW-SE, N-S and NE-Sw, reflecting the geological structure. Two granodiorite bodies hitherto unknown were found in Pena Blanca area during the phase II survey.

Geological structure of the survey area is characterized by its situation of which located at the south flange of a distorted zone of general Andean Trend. This distorted zone, so called the Huancabamba Deflection Zone, corresponds to the area at which the general NNW-SSE direction, the basic characteristic of the Andes, changes direction to the NE-SW trending of the Colombia-Venezuela area. This deflection zone is assumed to have been formed during the Mesozoic tectogenetic movement. This means it is the process of change in the Alpine type geosyncline and/or intercontinental environment rather than in the Andes type continental environment.

Two combined fault systems are observed in the survey area; one is E-W with NE-SE trending caused by an east-west lateral compression, and the other is N-S with NNW-SSE trending by northwest-southeast one. Both these systems reflect the tectonic movement at the time when the Huancabamba Deflection Zone was formed.

As the results of the phase II survey, it is confirmed that the NE-SW trending fault, which was assumed to exist to the south of Chontali Village through the semi-detailed geological survey in Chontali area, extends for around Angash Village in Pena Blanca area, being relatively large-scaled one.

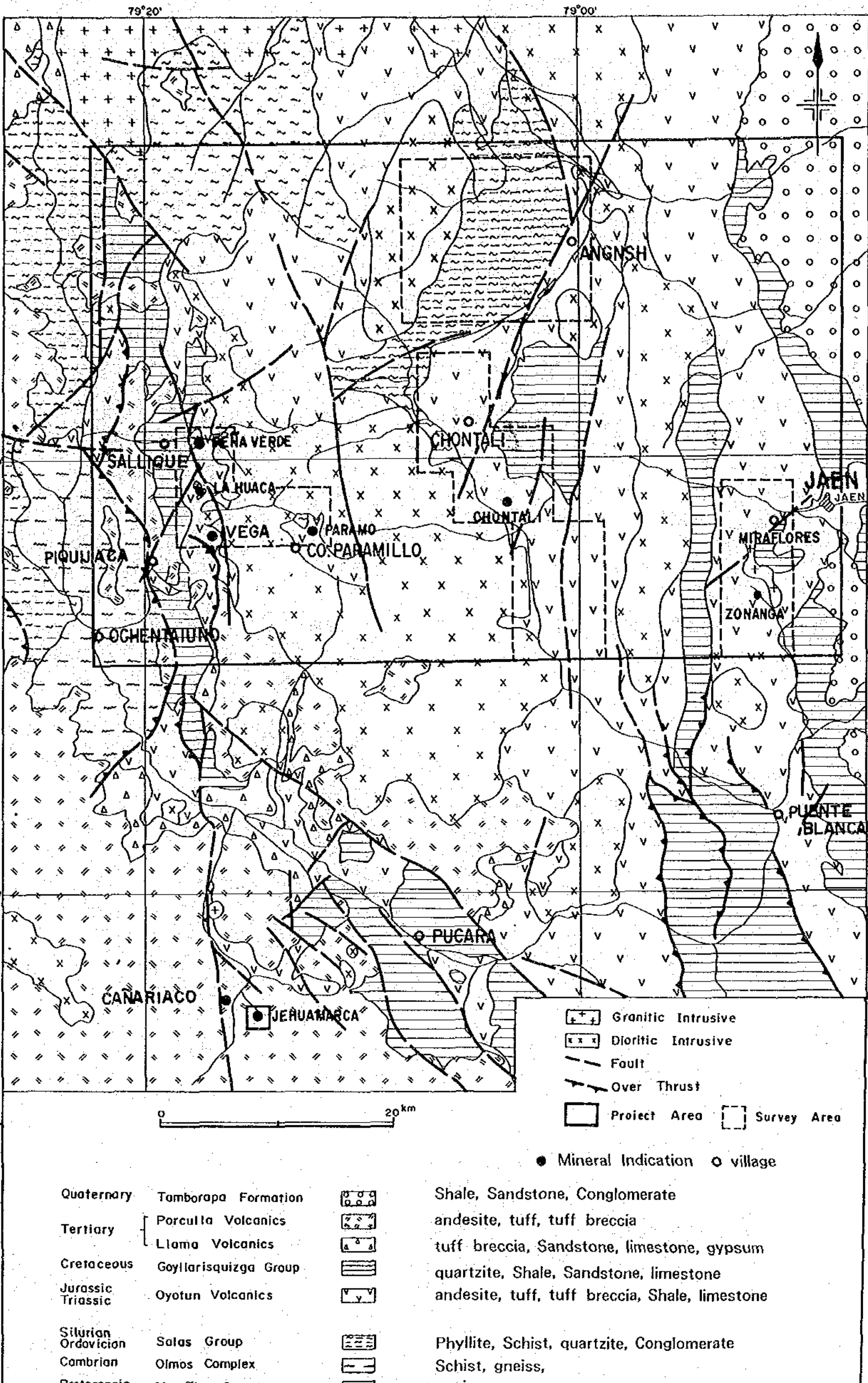
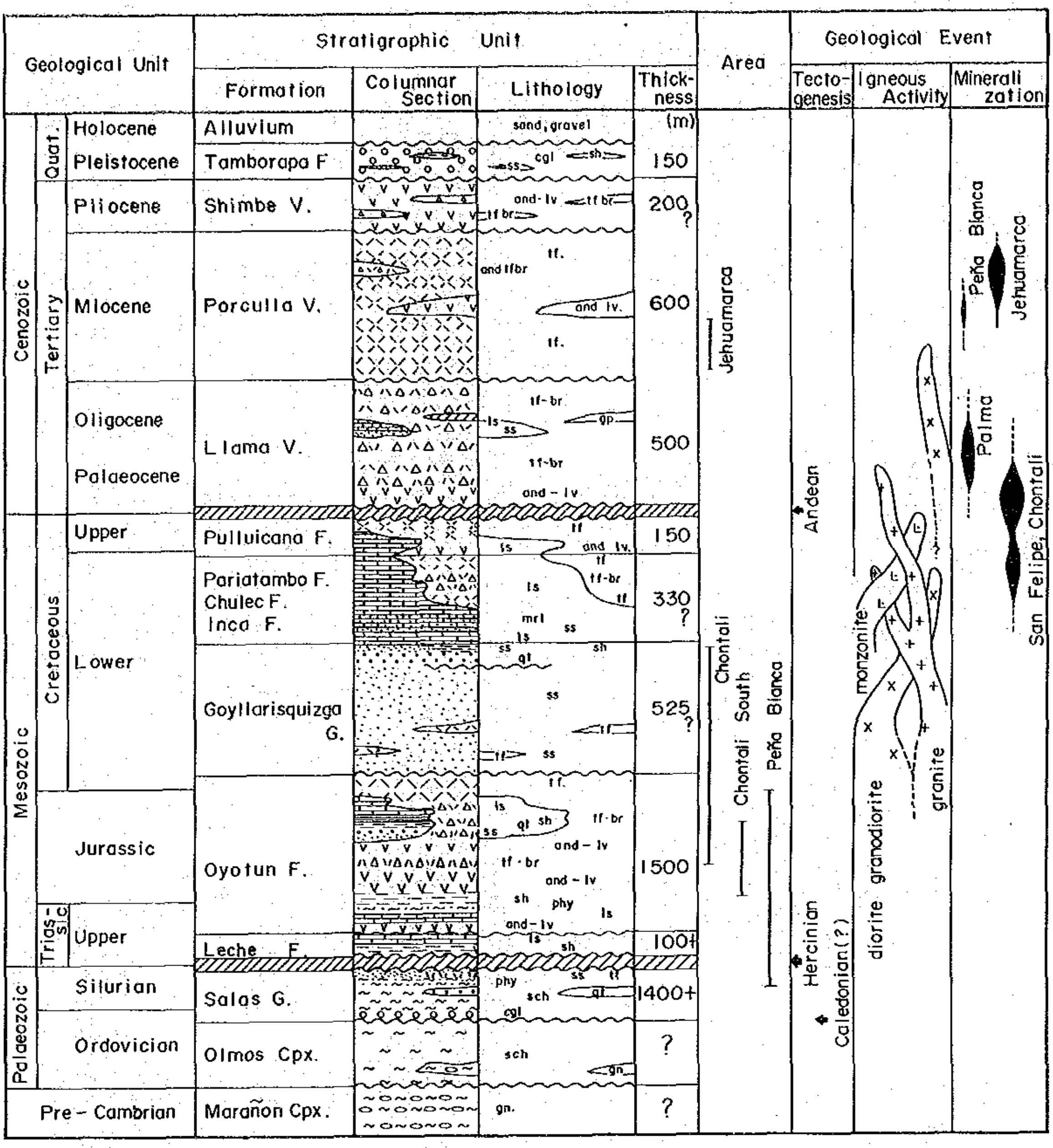



Fig. I－3 Generalized Geological Map of The Survey Area

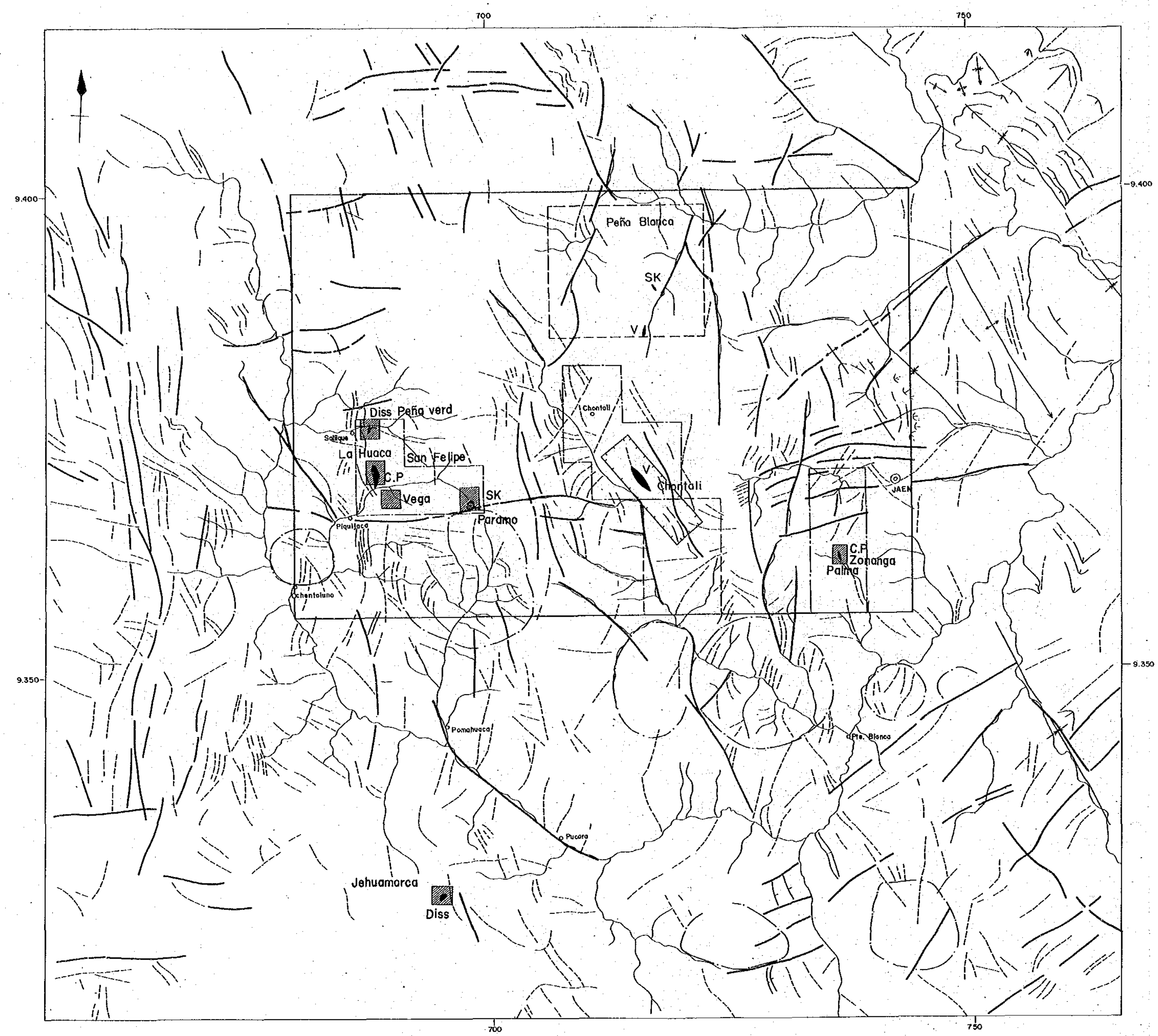
modified from Wilson (1984), Reyes et al (1987) and Davila et al (inedited)




Abbreviations.

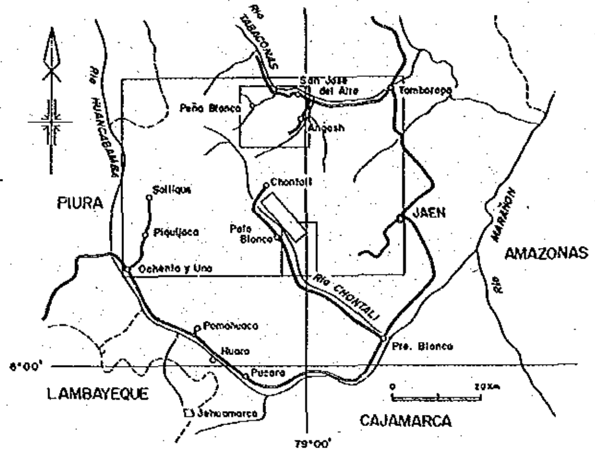
| | | | | | | | |
|---|---|---|---|---|---|---|---|
| and | andesite | gn | gneiss | md | mudstone | sch | schist |
| acd | acidic | gp | gypsum | mrl | marl | sh | shale |
| br | breccia | ls | limestone | phy | phyllite | ss | sandstone |
| cgl | conglomerate | lv | lava | qt | quartzite | tf | tuff |
| F. | Formation | V. | Volcanics | G. | Group. | Cpx. | Complex |

Fig. I-4 Generalized Stratigraphic Column of the Survey Area




THE MINERAL EXPLORATION
IN
THE PACHAPIRIANA AREA, REPUBLIC OF PERU
( PHASE Ⅱ )

## DISTRIBUTION OF MINERALIZATION IN THE SURVEY AREA




JAPAN INTERNATIONAL COOPERATIÓN AGENCY
METAL MINING AGENCY OF JAPAN
FEBRUARY 1990
Prepared by MINDECO

0 10 20Km

LEGEND

MAJOR LINEAMENTS
MINOR LINEAMENTS
CIRCULAR FEATURE
BEDDING
ANTICLINAL AXIS
SYNCLINAL AXIS
Pachapiriana Project Area
Detailed Survey Area in 1988
Semidetailed Survey Area in 1988
Detailed Survey Area in 1989
Semidetailed Survey Area in 1989
Mineral Indication

C.P : Porphyry Copper Type
Diss : Dissemination of Base Metal Type
V : Vein Type
Sk : Skarn Type

Fig. Ⅰ-5 Distribution of Mineralization in the Survey Area

## CHAPTER 4 SURVEY RESULTS, COMPREHENSIVE ANALYSIS

### 4-1 Geological Structure, and Characteristics and Controlling Factors of the Mineralization

This survey area is regionally located in the Huancabamba Deflection Zone, that is, the area belongs to a distorted zone of the general Andean trend in NW-SE changes to NE-SW trending.

The extracted lineament frequency and its scale based on the LANDSAT image analysis during the phase I survey, N15° W trend is distinctive in the region, which is so called Andean trend. Lineaments study in each semi-detailed surveyed area shows that for the phase I survey areas the NNW-SSE trend is predominant both in the Chontali and Jehuamarca areas, and the E-W or N-S lineament in the San Felipe and Palma areas, and that for the phase II survey areas, the NNW-SSE trend is predominant in the Chontali South area as in the case of Chontali shown above, and the NNE-SSW trend in the Pena Blanca area.

According to the field survey in the Chontali South area, it was assumed that the N-S trending fault traverses in the central part of the semi-detailed surveyed area, which is identified through aerial photographic interpretation. In the Pena Blanca area, the extracted lineament based on the LANDSAT image analysis in the eastern part was identified to be the fault. The extracted lineament in the western part suggests the intrusive boundary of granites. The similar relationship, that is an intrusion boundary is extracted as a lineament, is identified for the diorites in the Pena Blanca and the Chontali East areas (Fig.I-3).

If it is assumed that the intrusion form of intrusives reflects the fissure systems, the distribution pattern of fissure systems in each surveyed area is as follows. Namely, the NW-SE and NNW-SSE trending fissure systems, accompanied with less weakly developed NE-SW trending one, are predominant in the western part.

On the contrary, in the central part NE-SW trending fissure systems is predominant with subordinate NW-SE trending one. In the eastern part, N-S fissure system is developed in contrast to in the other areas. The local variation in trend of fissure systems could indicate the local change of the forming process of the Huancabamba Deflection Zone, thus as shown in the report of the phase I survey, it will be difficult to explain the entire survey area based on a single force field. Therefore, the structural analysis for the survey area will be needed as forming a part of the regional analysis of geological structure.

If the mineralization is interpreted as mineralized-alteration process, it is important to confirm the localities of alteration zone as the alteration suggests the evidence of mineralization.

Fig. I-5 shows the mineralized-alteration zones extracted through the phase II survey as well as through the phase I survey.

The mineralized-alteration zones extracted in phase I in the Chontali area occur on the NW-SE fissure zone with abundant quartz veins developed filling the NW-SE fissure systems, and they are called as the mineralization along the secondary-derived NW-SE fissure system. Detailed geological survey of the phase II makes this relationship more clear. The main alteration zone is confirmed at the fault (its vertical displacement was estimated to be about 500 m through the phase I survey) running along the Tabacal and at the north flange of the detailed surveyed area. The alteration zone extends as a great fault in the east flange of semi-detailed surveyed area in Pena Blanca, where Salas Group is in fault contact with Oyotun Volcanics. In the alteration zone, fissure systems with quartz veins trend NW-SE and NNW-SSE, associated with N-S or NE-SW trending fissures. The fissure systems, therefore, have been second-derived ones, formed under the stress related to the fault movement on which the great displacement was caused.

In Chontali South, small-scaled alteration zones were frequently found but rarely associated with quartz veins. This distribution trend of alteration is not so remarkable, and if anything, the zones traverse along the N-S trending fault in the central part. Therefore, it is interpreted that in the area, as conjugated faults is absent, the stress condition which regionally formed secondary fissure systems has not been realized.

In Pena Blanca, small-scaled silicified zones were extracted in Oyotun volcanics, where found is the junction between the fault extended from Chontali and its subsidiary ENE-WSW trending fault. But the development of fissure systems with quartz veins are not so distinct due to the absence of conjugated sets of fault as in the case in Chontali South. In the area, hydrothermal metasomatism characterized by an addition of Mg or high-temperature metasomatism with skarnization are observed in Leche Formation unconformably covering Salas Group. It is possible that these are formed by the granites intrusion along before-mentioned NE-SW trending fault. Namely, very young granodiorite (16.4 ± 0.8 million years, middle Miocene; Apx. 4) intrudes along this fault and it is assumed that these metasomatism was formed during the post-magmatic stage.

Considering the results of phase I survey, it was concluded that the Jehuamarca area was characterized by the epithermal mineralization along the NE-SW trending fissures. Although the recognition of underground continuation of fissures distributed at the surface was aimed for the drilling survey in phase II, but the quartz veins or silicified zones which can be confirmed to be the continuation have not been verified. The fissures distributed at the surface does not continue underneath toward deep underground but, for example, are intermittent as echelon veins or are aggulutinated veins after taking the role of the path for hydrothermal ore solution. The area is lacking of regional structural data, thus it is needed to make regional structural analysis as well as re-examination of fissure systems base on the detailed surface mapping.

## 4-2 Potentiality of an Existence of Ore Deposits

The survey area contains numerous geochemical anomalous zones with using the stream sediments which were previously sampled by INGEMMET in the "Proyecto Geoquimico del Norte" and the "Proyecto Integral Chinchipe". Semi-detailed geological survey has been continued to implement from phase I to find out to what origin these anomalies were attributed. As a result, obvious mineralized alteration was verified in the backland of the rivers where geochemical anomaly is marked, except for Pena Blanca area.

In the semi-detailed surveyed area in Chontali South, alteration zones, similar to the alteration zone with quartz veins extracted by the phase I survey but smaller-scaled, were confirmed. In Pena Blanca, alteration zones similar to those in Chontali as well as skarnized indications with pyrite were confirmed in Angash anomalous zone. Therefore, we can conclude that the geochemical anomaly extracted by INGEMMET suggests an existence of mineralized indications.

While no economical ore deposits have been found as yet, the follow-up study of the aforementioned "Proyectos" verified that the existence of La Granja ore deposits and Canariaco ore deposits. In addition, it is reported that a stratiform gold deposit and an epithermal gold deposit have been found in the northern part of this survey area by the "Proyecto Integral Chinchipe:Cordillera del Condor" which is currently under way. It is certain that the area contains promising mineralized area.

Detailed geological survey was conducted for the Chontali alteration zone extracted in the phase I survey, to confirm the existence of predominant silicified alteration zone with abundant quartz veins and veinlets. Moreover, the geophysical survey conducted in phase II confirmed a three-dimensional distribution of mineralized alteration zones with quartz veins, further verifying the high probability of existence of ore deposits in the survey area. Preliminary drilling survey was performed in Jehuamarca area, where a three-dimensional distribution of mineralized alteration zone was assumed by the phase I survey. Although the recognition of underground continuation of fissures distributed at the surface was not necessarily successful and left for future survey, but the quartz rich zone with high grade mineralization was found from two drilling holes, and silicified zone which had been assessed prospective through the results of the phase I survey was verified and recognized to show auri-argentiferous base metal dissemination from all three drilling holes. It is concluded, therefore, that there is a possibility to uncover some promising ore deposits when a future detailed survey is conducted.

## 4-3 Relation between Geochemical Anomaly and Mineralization

Geochemical anomalies obtained by phase I survey were assumed to be classified into tow categories; one deriving from mineralized alteration and the other indicating specified geological horizons. The latter is inferred to correspond to the anomalous values found by geochemical survey, whose distributions were detected in the Salas Group, Chontali. Through phase II survey in Pena Blanca area, it is clarified that the Salas Group is widely distributed but the geochemical anomaly indicating horizons is not obtained in the group. It is concluded, thus, the aforementioned assumption is plausible only in Chontali area.

Therefore, paradoxically speaking, every geochemical anomaly suggests the existence of mineralized indications.

Geochemical anomalies obtained in phase II tend to be distributed overlapping to or around the mineralized alteration and alteration zones and/or structurally-distorted zone (including with intrusive bodies).

In Hualatan West, which was extracted as suggesting a high possibility of existence of epithermal gold and silver vein type ore deposits, gold anomaly tends to be distributed in the central part and lead and silver anomalies in the outer part surrounding it.

In Tabacal South, which was extracted as suggesting a high possibility of existence of epithermal auri-argentiferous base metal vein type ore deposits, gold and lead anomalies tend to be distributed along the alteration zones, which are surrounded by small-scaled and intermittent anomalies of zinc and copper, if the relation to the other alteration zones is omitted.

As the silicified alteration zone extracted in Oyotun Volcanics in Pena Blanca area is overlapped by gold and lead anomalies, which are surrounded by anomalies of zinc and copper, high possibility of existence of epithermal auri-argentiferous base metal vein type ore deposits is suggested as in the case of Tabacal area.

In the skarnitized alteration zone extracted from Leche Formation, it is interpreted that copper and zinc anomalies tend to be distributed, which are surrounded by small-scaled and intermittent anomalies of silver and lead.

## Chapter 5 CONCLUSION AND RECOMMENDATION

### 5.1 Conclusion

This survey area consists of rocks from Precambrian to Cenozoic. Mineralized alteration occurs in Mesozoic Leche Formation and Oyotun Volcanics and Cenozoic Porculla Volcanics. The alteration is related to the skarnization by granitic rocks intruded along the NE-SW trending fault systems as well as to the epithermal mineralization through the NE-SW and its subsidiary NW-SE trending fissure systems. The former is characterized by the occurrence of such skarn minerals as garnet, vesuvianite and clinopyroxene, and the latter by the occurrence of such hydrothermal alteration minerals as quartz, sericite, smectite and kaolinite.

The skarnization zones were extracted as gold, copper and zinc anomalies to suggest the existence of auriferous base metal dissemination type ore deposits. Hydrothermal alteration zones were extracted commonly as gold anomaly, and partly as silver, lead and zinc anomalies to suggest the existence of epithermal gold and silver vein type and epithermal auri-argentiferous base metal vein type ore deposits. Auriferous base metal dissemination type were found between Angash and Triunfo in Pena Blanca area, and epithermal gold and silver vein type at the Hualatan west in Chontali area, and epithermal auri-argentiferous base metal vein type at Tabacal in Chontali area.

Geophysical survey implemented in Chontali area revealed that the alteration zone was characterized by low resistivity zones and that the silicified and silicified-argillized zones with closely developed quartz veins was extracted as high resistivity within the low resistivity zone. The high resistivity zone continued toward deeper underground as far as the highest part, which is inferred to be connected with the granitic intrusion structure, based upon geological setting and the analyzed results by homogeneous temperature of fluid inclusion for quartz veins. The highest part overlapped to the part with large-scaled quartz veins within the area with closely developed quartz veins extracted in Hualatan west. Average width and length of six quartz veins in the area with large-scaled quartz veins are 3.04 m and 80 m, respectively. The grade of gold in veins was relatively so high, giving the average values of 2.54 g/ton Au, and 13.99 g/ton Ag. The analyzed results by homogeneous temperature of fluid inclusion for auriferous quartz veins ranged from 96 to 271℃, and the values for the large-scaled quartz veins was lower than 150℃ suggesting that beneath the area there exists a zone most adequate for the silver and gold mineralization. These indicate a very high potential of an existence of large-scaled and high grade silver and gold ore deposits in the area.

Drilling survey performed in Jehuamarca area revealed that the high resistivity zone extracted through geophysical survey is silicified zone with mineralization of gold, silver, copper, lead and zinc and that the zone can be characterized by a mushroom structure as interpreted. In addition, a layered ore body of high grade gold, silver, copper, lead and zinc was found in the silicified zone. Silicified breccia widely distributed at the surface with high anomalies of gold and silver suggests a high possibility of existence of high grade gold and silver mineralization zone in it.

## 5-2 Recommendation for the Phase Ⅲ Survey

The following surveys are proposed in the order of priority for the phase Ⅲ survey based on the results obtained in phase Ⅱ survey:

1) Jehuamarca area

1. Drilling survey for silicified zone with high grade layered quartz zone and for silicified breccia.
2. More detailed geological survey in the area where the drilling survey will be conducted (with a scale of 1/2,000, for example).

2) Chontali area

1. Drilling survey for Hualatan west where a high possibility of an existence of high grade gold deposits has been verified.

2. More detailed geological survey in the area where the drilling survey will be conducted (with a scale of 1/2,000, for example).
3. Geophysical survey in the area including Hualatan west to clarify the geological structure of basement rocks(gravity prospecting, for example).

3) Tuna area

1. Semi-detailed geological survey for the geochemical anomalous zones extracted by INGEMMET.

4) Pena Blanca area

1. Detailed geological survey for mineralization zone extracted in Oyotun Volcanics.
2. Geophysical prospecting for the mineralization zone (by the CSAMT method, for example).

# PART II

# PARTICULARS

# CHAPTER 1 CHONTALI AREA

## 1-1 Geological and Geochemical Surveys

### 1-1-1 Purpose of the survey and Procedure used

The Chontali area concerns the zones where anomalies were extracted through geochemical survey using the stream sediments by INGEMMET as a part of the "Proyecto Integral Chinchipe". Through the phase I survey, semi-detailed geological survey combined with geochemical survey were performed for the northern part among the extracted anomalous zones. As a result, mineralized alteration zones including numerous quartz veins were extracted combined with gold and silver anomalies overlapping them.

A detailed geological survey was conducted in the Chontali alteration zones(42 km2) including quartz veins, extracted by semi-detailed survey of the phase I. The aim of the survey is to confirm the dimension of surface exposure of quartz veins (thickness and elongation), grade of ore deposits and alteration grade of country rocks. Moreover, geophysical survey using the CSAMT method was performed to evaluate potentials in underground extent of the alteration zones. The survey was implemented over a 35 km2 with 102 points dispersed throughout the area where the detailed geological survey was conducted in phase II. There were the geochemical anomalous zones left unsurveyed, which had been extracted by INGEMMET as a part of the "Proyecto Integral Chinchipe", to the south of the semi-detailed surveyed area of the phase I. Semi-detailed geological survey combined with geochemical survey was conducted for the area (80 km2) to confirm the southern extension of the extracted alteration zones as well as to find the source of said anomalies.

A topographical map on the scale of 1/25,000 published by IGN was enlarged to the scale of 1/5,000 and used as the base map for the detailed geological survey. The survey was carried out using string measures (50 to 100m) and clinometers and/or clinocompasses. Correction of measurement errors was made at such topographically characteristic points as a junction of streams, passes, and summits. In the area extracted as an alteration zone during the phase I survey, a closing measuring line drawn using pocketcompasses was combined with each measuring line at outcrops to make the relative positioning of each outcrop accurate. A topographical map on the scale of 1/25,000 published by IGN was used as the base map for the semi-detailed geological survey. The survey was carried out using clinometers and/or clinocompasses and barometers to confirm the localities.

Base camp was set up at Palo Blanco in the central part of the survey area. We made a survey for most of roads passable for cars and/or for horses and agricultural roads in the detailed geological surveyed areas. A path cleaning group was organized to obtain the survey routes in the area where quartz veins were expected to occur. Roads passable for cars and/or for horses were mainly used as surveying routes and sometimes agricultural roads were used in the semi-detailed geological surveyed areas.

Three survey teams were organized pairing one Japanese engineer and one of counterparts of Peru for derailed survey. Five teams were organized in order to be observed by each of Japanese engineers and counterparts for semi-detailed survey.

### 1-1-2 Analysis Method

We first analyzed the geological structure of the semi-detailed survey area. Based on this result analysis of geological structure of the detailed survey areas was conducted. Aerophotographs, Series 359-73A and 222-72A taken by SAN (Servicio Aerografico Nacional) under direct control of Department of the Air Force, were used as auxiliary means of analyzing the semi-detailed survey areas, being on the scale of about 1/30,000 and 1/25,000, respectively. The SLAR (Side Looking Airborne Radar) image on the scale of 1/100,000, published by ONERN, were also used for the analysis of lineaments.

The geochemical samples and ore samples were sent for analysis to Chemex Labs Ltd., Canada and to C.H. Plenge & Cia, S.A., a Peruvian Laboratory, respectively.

In the assay results of geochemical samples, distinct characteristics could not be obtained for semi-detailed survey areas and/or detailed survey zones by statistical processing con-

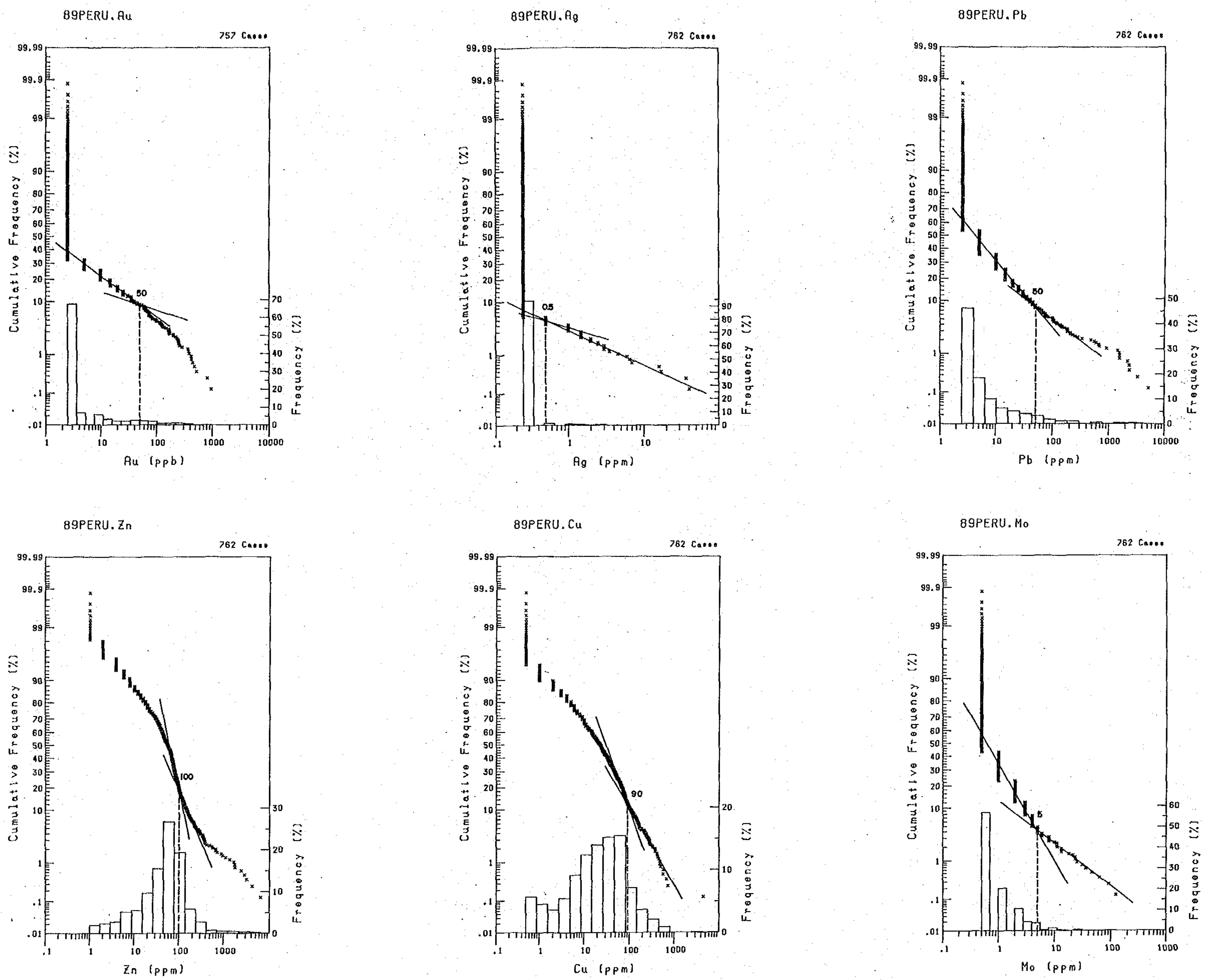



Fig.II－1　　Histogram and Cumulative Frequency Diagram

Table Ⅱ-1 Geochemical Threshold of the Surveyed Area

| Area | Statistic Element | Au(ppb) | | Ag(ppm) | Pb(ppm) | Zn(ppm) | Cu(ppm) | Mo(ppm) |
|---|---|---|---|---|---|---|---|---|
| | | Whole Sample | Selected Sample | Whole Sample | Whole Sample | Whole Sample | Whole Sample | Whole Sample |
| Whole Area | Number of Sample | 762 | 757 | 762 | 762 | 762 | 762 | 762 |
| | Mean | 48.57 | 21.34 | 0.47 | 47.88 | 107.91 | 53.86 | 1.87 |
| | Standard Deviation | 370.21 | 71.89 | 2.19 | 293.25 | 354.27 | 179.53 | 6.75 |
| | Threshold | 50.00 | 50.00 | 0.50 | 50.00 | 100.00 | 90.00 | 5.00 |
| Chontali Detailed | Number of Sample | 270 | 266 | 270 | 270 | 270 | 270 | 270 |
| | Mean | 91.81 | 41.20 | 0.74 | 84.77 | 97.40 | 66.82 | 2.11 |
| | Standard Deviation | 443.92 | 92.55 | 3.49 | 415.55 | 197.82 | 107.80 | 9.52 |
| | Threshold | 50.00 | 50.00 | 0.50 | 50.00 | 100.00 | 90.00 | 5.00 |
| Chontali Semidetailed | Number of Sample | 126 | 125 | 126 | 126 | 126 | 126 | 126 |
| | Mean | 70.08 | 14.48 | 0.38 | 10.14 | 101.60 | 45.52 | 2.44 |
| | Standard Deviation | 623.36 | 46.88 | 1.49 | 21.99 | 292.94 | 52.37 | 4.66 |
| | Threshold | 50.00 | 50.00 | 0.50 | 32.13 | 100.00 | 90.00 | 5.00 |
| Peña Blanca | Number of Sample | 366 | | 366 | 366 | 366 | 366 | 366 |
| | Mean | 9.26 | | 0.31 | 33.66 | 117.84 | 47.17 | 1.49 |
| | Standard Deviation | 57.34 | | 0.45 | 223.97 | 450.84 | 239.80 | 4.52 |
| | Threshold | 50.00 | | 0.50 | 50.00 | 100.00 | 90.00 | 5.00 |

ducted separately for each individual area and/or zone. The data were processed in a batch for the entire survey area, a cumulative frequency distribution was plotted on normal probability graphs, and the relevant threshold value(A) was extracted as bending point of the cumulative frequency distribution curve, which would discriminate between the background and anomaly values(Fig. II-1). This threshold value was compared with sum(B) of the standard deviation and the average obtained individually from statistical processing of each area. (A) was taken if the comparison result (A)<(B), and (B) if resulted in (A)>(B), as the definitive threshold value of each area. Geochemical anomaly distribution map was prepared for each element, except for molybdenum, based on these threshold values. In calculating the standard deviation per each area, as the values above 1 g/ton Au, 200g/ton Ag, 2 % Pb, 5 % Cu and 0.1 % Mo which can be deemed as obvious anomalous values responding to the ore grade, the relevant elements were excluded from the statistical processing as in the phase I survey. Threshold values used for analysis and the statistical data obtained from the calculation using them are shown in Table II-1.

1-1-3 Geology

According to Reyes et al.(1987), this survey area consists of the Jurassic Oyotun Volcanics as basement, the early Cretaceous Goyllarisquizga Group overlying it and the diorites intruded into them (Fig. I-3 in the report of the phase I survey).

As a result of the phase I survey, it is clarified that this survey area consists of the Salas Group of crystalline schists and phyllite as basement, the Oyotun Volcanics unconformably covering it, the Goyllarisquizga Group of quartzites almost conformably overlying the Volcanics and overlying calcareous formation correlative with Inca or Chulec Formation. These rocks are intruded by diorite-granodiorite, granite, monzonite, quartz porphyry-granite porphyry and andesite. Based on the aerophotograph analysis, significant two lineaments trending NE-SW were extracted. Of these two, the one at the southern part is supposed to be a relatively large-scaled fault as small outcrop of schist removed by a tectonic movement was observed near the lineament and the vertical displacement of the fault is assumed to be about 500 m, based on the structural analysis for quartzites of Goyllarisquizga Group.

### 1-1-4 Survey Results

#### 1) Geological survey

The Chontali area consists of pyroclastic rocks as basement, overlying quartzite and such intrusive rocks which intrude the formers as diorite-granodiorite, granite, monzonite, quartz porphyry and andesite (Figs. II -2, II -3).

As a result of the phase I survey, it was clarified that the pyroclastic rocks were correlative with Oyotun Volcanics as they covered the Salas Group unconformably. Oyotun Group was described to be composed mainly of andesitic lava in the phase I survey area, but in the phase II survey area the Group consists mainly of andesitic to dacitic tuff intercalated with tuffaceous sedimentary rocks and quartzite. Andesitic lava is rather subordinate, scattered in a small-scaled body except for comparatively larger-scaled one at the southeastern flange of the semi-detailed surveyed area. The tuffaceous sedimentary rocks are developed not only on the low hill of the northern bank of the Tabacal River as already reported by the phase I survey but around the summit on the southern bank of the River associated with quartzite. Under the microscope, andesitic lava (H072511) is porphyritic with phenocrysts of plagioclase, quartz and hornblende embedded in a matrix, which is composed of such alteration or accessory minerals as quartz, plagioclase, sericite, carbonate minerals, chlorite, opaque minerals, sphene, and zircon. Pyroclastic rocks with distinct columnar joint on the southern bank of the Tabacal River was named in the field as silicified tuff but through the microscopic observation the rock (Apx. 1; T082603) is concluded to originally be an andesitic lava, though undergone intense silicification and sericitization.

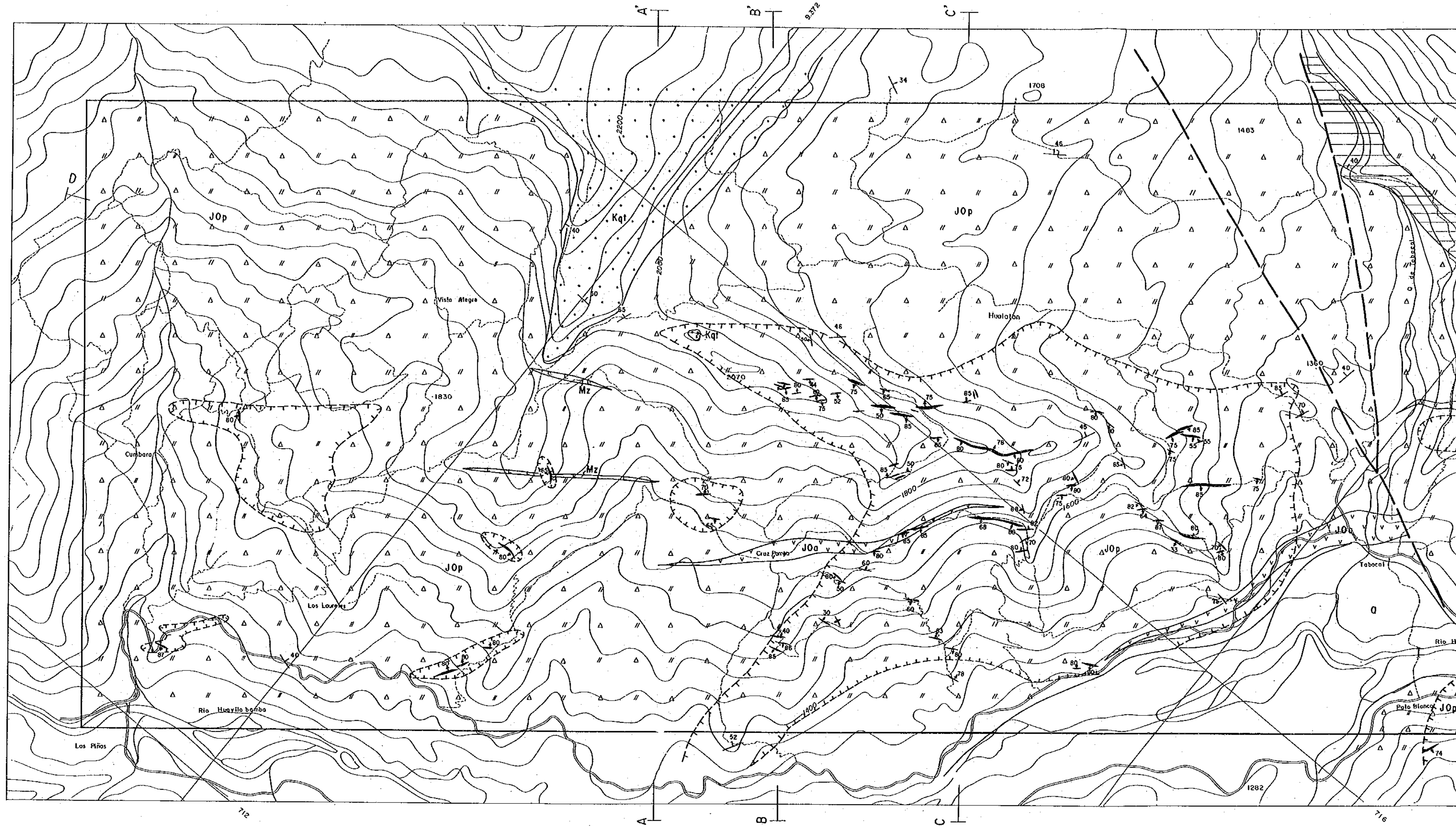
Quartzite formation occurs around summits above 2,000 m in the northeastern part of the detailed surveyed area. The rock is characterized by well developed cross bedding, being a part of the quartzite formation which was correlated with the Goyllarisquizga Group through the phase I survey. Quartzite formation in the Group and that in the aforementioned Oyotun Volcanics are similar in rock facies to each other but different in thickness and geological units overlying them. Namely, quartzite formation in the Oyotun Volcanics is about 50 m thick with overlying pyroclastic rocks, while that in the Goyllarisquizga Group is, as a result of the phase I survey, more than 400 m thick with overlying limestone. Quartzite formation in the phase II survey area is more than 250 m thick, though only a part of it appears.

Intrusive rocks in the area are diorite-granodiorite, granite, monzonite, quartz porphyry-rhyolite and andesite. The diorite-granodiorite are developed in the western part of the semi-detailed surveyed area. Through the phase I survey they are found out in the western part of the survey area, therefore these dioritic rocks constitute an intrusive body (Fig I-3). With the naked eye, it (Y072504) is composed mainly of plagioclase, quartz, orthoclase and hornblende with alteration minerals of sericite, chlorite and epidote. The absolute age of the sample is estimated at 64± 3.2 million years using K/Ar method, which is obviously younger than the values estimated in phase I for diorites (119± 6 million years) of the northern extension and for granites (106± 5 million years). The sampling point is very close to where the probable fault runs across the Tabacal River and younger intrusive rocks can occur along the fault. The evidence for this, however , has not been extracted through the phase II survey.

Granite is found out as small bodies diorite-granodiorite body developed in the western part of the area. It can not be confirmed whether the granite is a variation of the diorite-granodiorite body or is a head of younger intrusive body intruding through the diorite-granodiorite body as seen in the phase I survey area. Monzonite is found out as three bodies in the detailed survey area. Among them, that occurring at the north of Cruz Pampa Village is a same intrusive body as in the semi detailed survey area of the phase I survey. Each body intrudes as extended dyke trending NW-SE. Under the microscope, it (Apx. 1;Y080304) is porphyritic and main constituent is plagioclase, next in abundance is quartz and orthoclase(microcline), then augite, opaque minerals, chlorite, sericite and apatite. It was named as andesitic rock but can represent the chilled margin of the monzonite body, because it is more intensely altered and coarser than andesitic rock described below. Quartz porphyry-rhyolite occupy mainly in the southern flange of the semi-detailed survey area. Quartz porphyry tends to occur as a small scaled dyke intruding near vertically. Under the microscope, it (Apx. 1;H072507) is porphyritic with plagioclase and lesser amounts of quartz and orthoclase embedded in a matrix of quartz, plagioclase, sericite, chlorite, epidote, opaque minerals and zircon. Rhyolite intrudes as a sill in the area. Under the microscope it (Apx. 1; A082911) shows a flow structure sometimes with phenocrysts of quartz and biotite. The flow structure is characterized by the lamination of felsic minerals, mainly quartz, and sericite with opaque minerals. Andesite is found often as a very small scaled body. Under the microscope, it (Apx. 1; H081804) is porphyritic. Phenocrysts of plagioclase and a few augite are embedded in a matrix of plagioclase, orthoclase, opaque minerals, chlorite, sphene and carbonate minerals, all of which are microcrystalline and less intensely altered.

Two faults-fissure systems trending NE-SW and N-S are developed in the central part of the detailed survey area and from southern flange of the detailed survey area to central part of semi-detailed survey area, respectively. The vertical displacement of the former was estimated to be about 500 m through the phase I survey. The latter was assumed to exist according to the structural analysis of the phase I, being identified through aerial photographic interpretation. The NE-SW trending faults becomes southwestward unclear in the granodiorite body. Based on the absolute age determination using K/Ar method, younger intrusive rocks can occur along the fault to conceal it.

Alteration is found throughout the surveyed area and silicification zone and combined silicification and argillization can be observed mainly in the three areas of northern bank of the Tabacal River, eastern flange of the detailed survey area and



A'
B'
C'
9372
D
1708
1483
2200
2050
JOp
Kqt
Vista Alegre
Hualatán
Mz
1830
2070
1800
1600
1400
1360
Cumbara
Cruz Pampa
JOa
Tabacal
Los Laureles
Río Huayllabamba
Los Piños
Poto Blanco
1282
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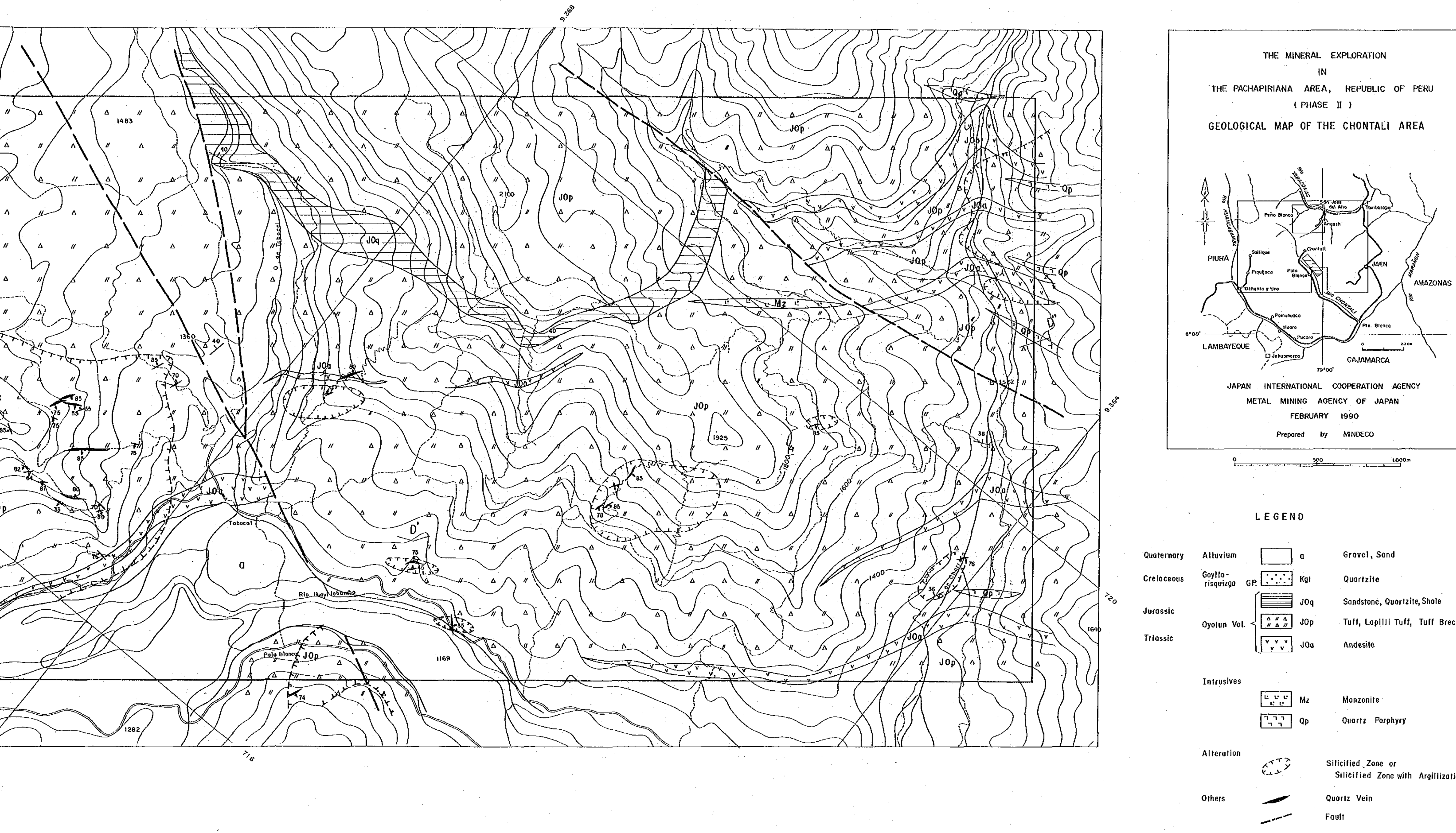


Fig. II-2 (1) Geological Map of the Chontali Area