4-2 Consideration of survey results of La Industria-Yatubi area

Summarizing the mineralized zone mentioned in item 5-1-3, such a model is considered that white argillized alteration zones are distributed below and silicificated zones above and that metallic sinter-needle-like mineral-hematite-quartz-white clay network veins extend through both. This model closely resembles so called hot spring type Au deposit model. The results of the assay confirmed concentration of gold to a certain degree. The above network veins exist more in the silicificated zone. The intensity of silicification increases toward the center part of hydrothermal activities, where the silicificated zone is likely to extend downward. Outcrops of silicificated rocks are distributed only at the mountaintop and white argillized alteration zone appears near the mountaintop and dominates downward. Network quartz veins in the silicificated rocks show crystalline structure, and the host rock is subjected to addition type and strong silicification. "Leached silicification", due to leaching of other components, is only observed in a part of boulders in the valley. From these facts, it is considered that the greater part of this silicificated rock have been eroded, and the silicificated rocks at the mountaintop is the lower part of the silicificated zone.

The fact is not known generally that dorabaito is present in druses of network veins in hot spring type gold ore deposit. Since this mineral is crystallized in druses, this mineral should be studied further whether it is associated with hot spring type gold ore deposit or whether it is associated with another type of hydrothermal activities overlapped.

In this area, alteration zone (white argillized zone and weak silicificated zone) is distributed in quartz diorite, and partly overlaps with hot spring type gold ore deposit. This alteration zone is accompanied by sulfide minerals instead of oxides. Marakaito is also observed locally, which originates from chalcopyrite. On the other hand, porphyry copper type mineralized zone is distributed in the north of this area. Therefore, this alteration zone considered to be associated with porphyry copper type mineralization.

As regards the relationship between the porphyry copper type mineralization and the the mineralization which closely resembles hot spring type gold ore deposit, it is considered that the former had been produced by earlier hydrothermal activities than the latter because the white argillized alteration zone accompanied with pyrite was cut by network veins accompanied with silicification in the summit of the Cerro Barranco Amarillo. Comparing this with three stages of thermal activities in the Bolivar area classified last year, followings are considered: the porphyry copper type mineralization corresponds to thermal activities of the 1st stage (the Miocene to the Pliocene), and the mineralization which closely resembles hot spring type gold ore deposit.

Chapter 5 Las Guardias area

The Las Guardias area is situated 5 km southeast of the Balzapamba area. It takes half an hour by car. In this area, detailed geological survey was made.

5-1 Geological survey

5-1-1 Geology

The area is underlain by the Macuchi Formation and granitic rocks which were emplaced in the Macuchi Formation (Fig.II-5-1 and II-5-2).

(1) Macuchi Formation

The Macuchi Formation consists of member An-1 and member Qan-1. Member An-1 corresponds to the member A of the Balzapamba area, and member Qan-1 to the member B respectively.

1) Member An-1

Member An-1 of the Macuchi Formation is distributed in the southwestern part (southern bank of river Rio Jorge) and the northern part. Lithology mainly comprises coessential tuff (Tf).

2) Member Qan-1

Member Qan-1 of the Macuchi Formation is distributed only in vicinities of the summit of Mount Loma de Angas (altitude: 2,057 m) in the north. Lithology is andesite lava in dark gray with quartz phenocryst.

(2) Granitic rocks

Granitic rocks are distributed in the northwestern part to central part and in the southern part, and consist of melanocratic biotite-hornblende granodiorite to quartz diorite batholith (Gd), melanocratic diorite dike (Di) and porphyritic quartz diorite dike (PQd) and aplite dike (Ap).

1) Leucocratic biotite-hornblende granodiorite to quartz diorite batholith (Gd)

Leucocratic biotite-hornblende granodiorite to quartz diorite batholith (Gd) are

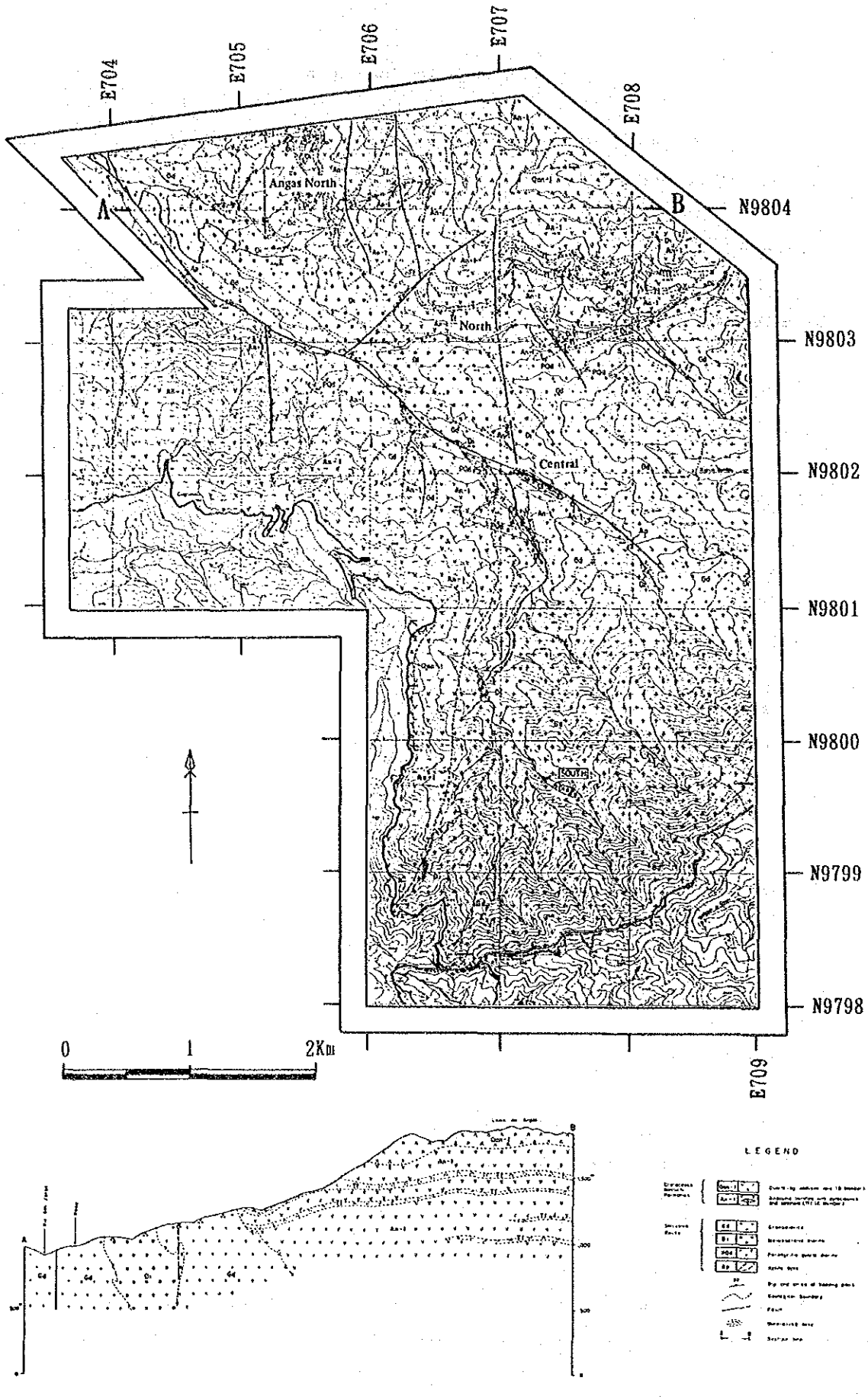
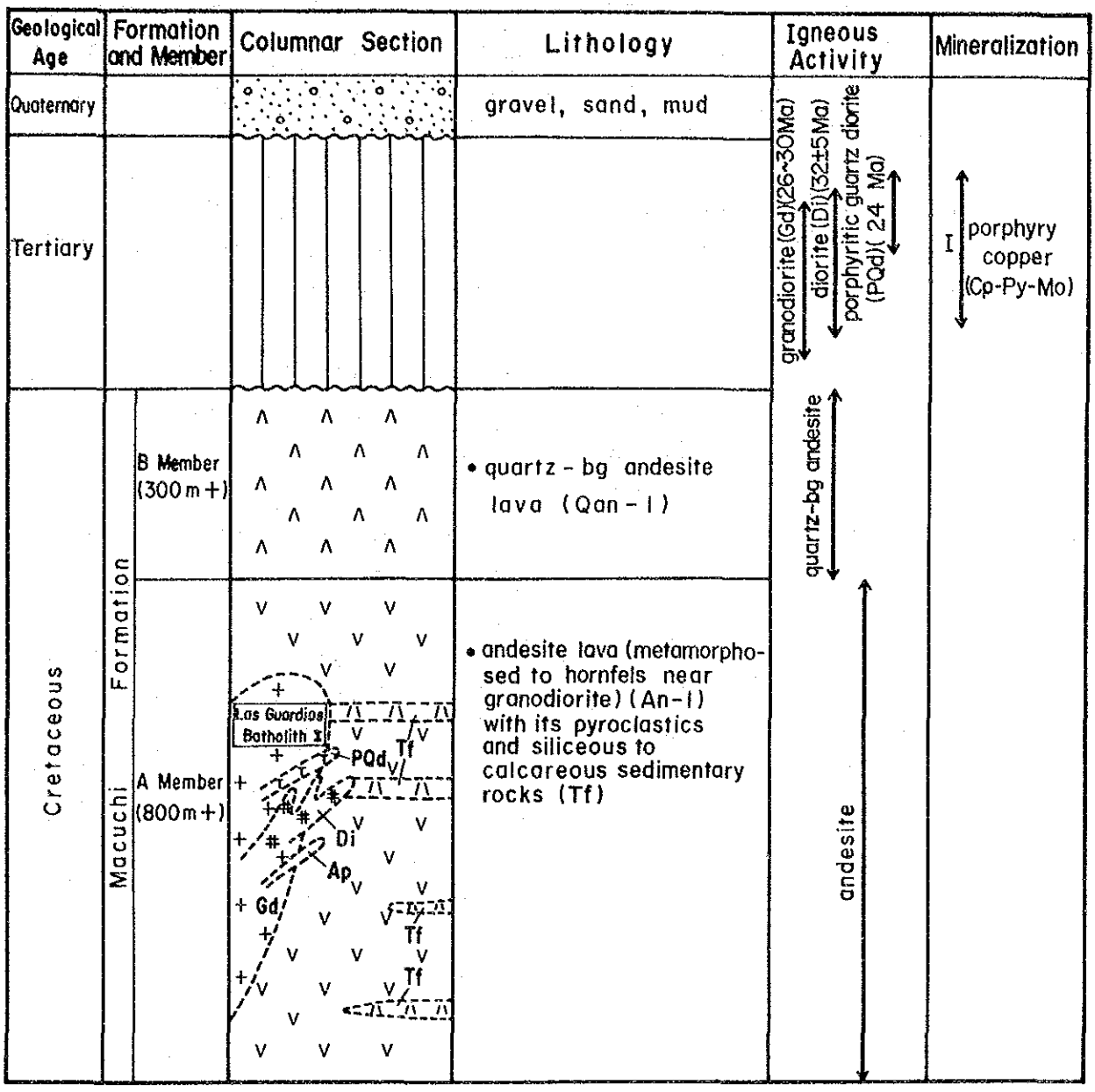


Fig. II-5-1 Geological map of the Las Gardias area



※ Las Guardias Batholith does not show the geological time of its intrusion but its occurrence.

Fig. II-5-2 Generalized stratigraphic section of the Las Gardias area

widely distributed in the northwestern to southern parts. Lithology is holocrystalline and equi-granular (medium-grain through coarse-grain). Hornblende is observed here more than in the Balzapamba area. Coarse grain tends to dominate in the northeast and south, and both coarse and medium grains in the central part.

2) Melanocratic diorite dike (Di)

Melanocratic diorite dike (Di) are intruded into the northern, central, and southern parts of Angas. The scale of each intrusive rocks are as follows:

a) In the northern part of Angas, four rock bodies (NE-SW trend for 3 bodies, sheet-like for 1 body) are observed. The scale of the rock bodies is presumed to range from 150 m long and 30 m wide to 100 m long and 20 m wide.

b) In the central part, 1 rock body (NE-SW trend for 1 body) is observed. The scale of the rock body is presumed to be about 3 km long and 0.7 km wide.

c) In the southern part, four rock bodies (NW-SE trend for 3 bodies, sheet-like for 1 body) are observed. The scale of the rock bodies is presumed to range from 900 m long and 80 m wide to 100 m long and 20 m wide.

d) In the eastern part, seven rock bodies (NE-SW trend for 3 bodies, NW-SE trend 1 body and sheet-like for 3 bodies) are observed. The scale of these rock bodies is presumed to range from more than 1.5 km long and 200 m wide to 100 m long and 20 m wide.

Biotite is partly affected by chloritization and epidotization.

3) Porphyritic quartz diorite dike (PQd)

The porphyritic quartz diorite dike (PQd) is observed in the central, southern and eastern parts. The direction and scale of intrusion are presumed as follows:

a) In the central part, 1 rock body, the intrusion is in NW-SE direction. The scale of the rock body is 150 m long and 40 m wide.

b) In the southern part, 2 rock bodies, in WNW-ESE, 800 m long and 60 m wide, and in N-S, 150 m long and 30 m wide.

c) In the eastern part, 2 rock bodies, in NE-SW, 200 m long and 80 m wide, and in NE-SW, 100 m long and 30 m wide.

For the rock body which is intruded in N-S direction into the southern part mentioned in b) conducted were microscopic observation, isotopic age determination and chemical analysis of whole rock.

Biotite is locally affected by chloritization and epidotization, and plagioclase is also locally metamorphosed to albite.

4) Aplite dike (Ap)

Aplite dikes (Ap) are observed in the northern part of Angas (1 rock body, sheet-like), in the northwestern part (1 rock body, NW-SE trend), and in the southern part (2 rock bodies, NE-SW trend). The scale of the rock bodies is all small and presumed to be less than 100 m long and less than 10 m wide.

Porphyritic quartz diorite dike (PQd) and Melanocratic diorite dike (Di) are dated as 23.9±4.8 Ma and 31.6±4.7 Ma respectively. The biotite-hornblende-quartz diorite conducted in the Phase I survey were dated as 30.1±1.1 Ma by K-Ar method.

5-1-2 Geological structure

For the geological structure in this area, NW-SE trend develops characteristically while NE-SW trend dominates in other areas. This is indicative for mineral exploration. For instance, faults which continues from the northwest to the southeast along the river San Jorge, melanocratic diorite dikes, and the mineralized zones extend in the NW-SE direction. In addition, NE-SW trend and N-S trend faults and N-S trend fold axis in the Macuchi Formation can be cited. This area is situated on the extension of the NE-SW trend structure, which develops in the Balzapamba area, and situated also in and around the intersection of NE-SW and NW-SE trends.

5-1-3 Mineralization and alteration

Trough the Phase II survey confirmed are twelve copper mineralized zones including zones confirmed last year. In these mineralized zones, porphyry-copper type mineralization is observed in granodiorite and the Macuchi Formation (Fig.II-5-1).

In the mineralized zones in this area, chalcopyrite and pyrite are present as scattered dissemination and film-like veinlets. In granitic rocks, both dissemination and veinlets are observed, while veinlets tend to abound in the Macuchi Formation. Molybdenite is locally observed in quartz veins.

For alteration, the chalcopyrite-pyrite mineralized zone is affected by silicification and chloritization, and the former is noticeably observed. Secondary biotite and epidote are locally observed. White alteration zone is also locally observed. Pyrite is only the ore minerals that exist in this alteration zone.

The principal mineralized zones in this area are scattered on the peripheral part of the melanocratic diorite intrusive rocks and along the faults in NW-SE trend. Individual mineralized zones trend mostly toward the NW-SE. These mineralized zones can be divided into three zones: Angas North; North; and Central.

The properties of these mineralized zones are as follows:

(1) Angas North mineralized zone

Angas North mineralized zone is situated around northwest of Angas. The mineralized zone comprises chalcopyrite-pyrite-(molybdenite) dissemination and veinlets which occur in melanocratic diorite and granodiorite. The individual mineralized zones are scattered in an area of 250 m x 500 m. The assay of ore samples was 0.2 g/t in Au, 8.3 g/t in Ag, 0.35 % in Cu and 0.79 % in Mo at maximum. Microscopic observation of sample No. C2043 showed that chalcopyrite, pyrite in broken form, molybdenite in dendritic form, sphalerite, and covelline occur in chalcopyrite-pyrite-molybdenite ore. Alteration of the host rock is characterized by silicification and chloritization. In addition X-ray diffractive analysis identified sericite.

(2) North mineralized zone

North mineralized zone is distributed along the river San Jorge in south of Angas. The mineralized zone occurs as chalcopyrite-pyrite dissemination and veinlets along NW-SE trend faults, in melanocratic diorite, granodiorite, and the Macuchi Formation. Dissemination zones with 50 m wide were detected at two places, which were thought to be as a principal mineralized zones in the Phase I survey and the other zone detected in the Phase II survey, are scattered further in an area of 100 m x 400 m in NW-SE direction. Individual dissemination and veinlet zones trend also toward the NW-SE. The host rock is subjected to strong silicification and biotization. Assay results of ores show 0.6 g/t in Ag and 0.04 % in Cu at maximum.

(3) Central mineralized zone

The mineralized zone in the central part is situated in Motilones valley. The

mineralized zone comprises chalcopyrite-pyrite dissemination and veinlets in melanocratic diorite, granodiorite and the Macuchi Formation. The individual mineralized zone is scattered in an area of 50 m x 350 m. Assay results of ores show 0.2 g/t in Au, 2.1 g/t in Ag and 0.47 % in Cu at maximum. The host rock is affected by strong silicification and weak chloritization. In addition X-ray diffractive analysis identified sericite.

(4) South mineralized zone

The south mineralized zone, which distributes in an area of 400 m x 100 m, is formed in melanocratic diorite dike and batholith of granodiorite-quartz diorite as dissemination of chalcopyrite, pyrite and molybdenite, the assay of which were of 0.06 % Cu and 0.01 % W. Microscopic observation proved that the mineral assemblage of a ore sample A1077 was chalcopyrite-pyrite-magnetite-hematite in the form of dissemination. Furthermore, a mineral assemblage of quartz-hornblende-(secondary biotite) was predominant in hydrothermal alteraation zone.

5-1-4 Magnetic susceptibility measurement

The data of the magnetic susceptibility measurement were analyzed in the same manner as in the Chaso Juan area. The result is shown together with geology in Fig.II-5-3.

For high and medium magnetic susceptibility anomalous zones, detected are small and intermittent zones at 20 places. Among them, 16 places are distributed in the northeastern to southern parts. These demagnetization are considered to be caused by mineralization. Four anomalous places in the north and northeast coincide with the tuff area in the Macuchi Formation.

5-1-5 Geochemical survey

The geochemical survey was undertaken in the central and south mineralized zones, and resulted in the detection of high factor scores of Factor 2 (Ag-Cu) and moderate factor scores of Factor 4 (Mo) in the central mineralized zone. In the south mineralized zone, however, only one low factor score of respective Factor 2 and 4 was obtained.

5-2 Consideration of survey results of Las Guardias area

As the result of the geological survey, magnetic susceptibility measurement and rock geochemical survey for two years, the properties of the mineralized zone in this area are

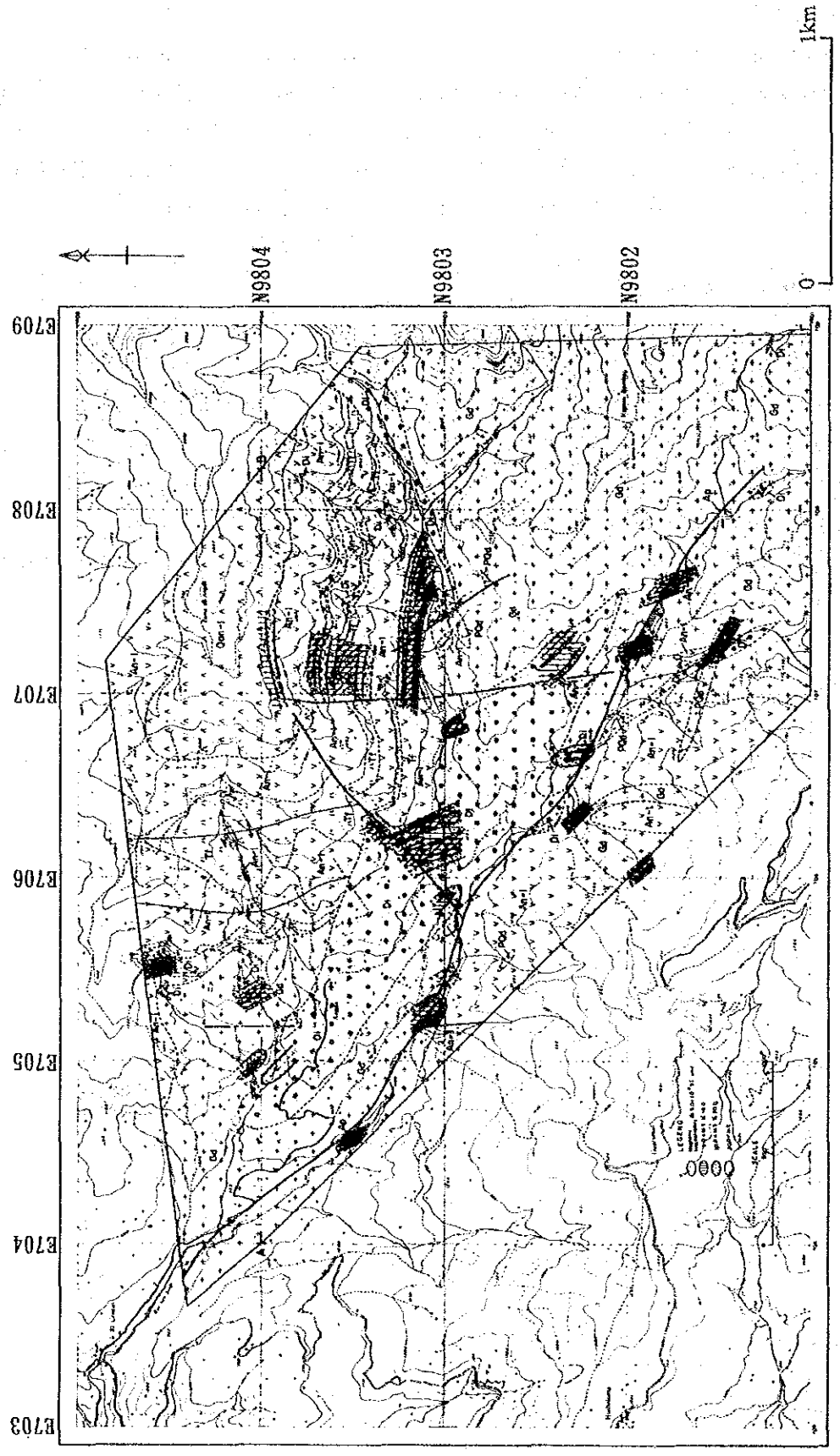


Fig. II-5-3 Interpretation map of magnetic susceptibilitity of the Las Gardias area

as follows.

The principal mineralized zones are distributed along the faults in NW-SE trend and on peripheral part of melanocratic diorite intrusive rocks trending toward the NW-SE. The direction of mineralized zones and intrusive rocks in the Balzapamba area and Telimbela area harmonize with those of the major tectonic lines, which extend from the central part of Ecuador to the north. Mineralization in this area, in contrast to NE-SW trend, is associated with the faults or intrusive rocks trending toward the NW-SE which may be a conjugate set of major tectonic lines.

The Angas North mineralized zone is situated at the intersection of two directions: NW-SE direction and NE-SW direction. In the former direction line up three mineralized zones, Angas North, North, and Central zones, while in the latter direction line up other mineralized zones such as El Torneado, Osohuayco, and Angas North. A intersection is preferable as structural trap or ore shoots for mineral deposits. This is the point why these mineralized zones have been taken up for the Phase II survey. Though mineralized outcrops are proved to contain high metal contents in gold, silver and copper, each mineralized zone in this area is small in scale and discontinuous.

Chapter 6 Other areas

6-1 Purpose and method of survey

The purpose of this survey, present semi-detailed survey, are to clarify the nature and sources of the known geochemical anomalies, and to evaluate ore potentiality for further detailed exploration work in each area.

The geological traverses were conducted along the selected routes designed prior to the commencement of the actual field work based on the previous undertakings. All the field observations were recorded as the geological route maps. these observations were elaborately compiled and interpreted together with the previous work results, then presented as the individual geological maps.

Adding to the ordinal field observation, a total of 34 rock chip samples were collected from outcrops of bedrocks in or near mineralized zones for geochemical study on behavior of metallic elements. These samples were quantitatively analyzed by the inductively coupled argon plasma emission spectrochemical analysis (ICP) for the selected seven elements of Ag, Cu, Pb, Zn, Mo, Co and Ni in Japan, then all of the analytical results were carefully interpreted together with those of 34 samples in the Balzapamba area for the purpose of discriminating the elements related to mineralization and their dispersion from the mineralized zone toward the host rock. The results of the previous geochemical surveys, particularly the analytical data of the rock chip sampling of the Telimbela area (Cu, Pb Zn abd Mo of 85 samples) and the San Miguel area (Cu and Zn of 54 samples), were used for reference in the present geochemical data interpretaion.

During the geological survey, the magnetic susceptibility ceasurement was also undertaken in the use of portable magnetometer on the representative mineralized and non-mineralized outcrops along the principal traverse routes to clarify the interrelation between magnetic susceptibility and mineralization or related alteration.

6-2 Geological survey

6-2-1 Tres Hermanas area

(1) Location

The Tres Hermanas area situates about 12km east of the La Industria, and about 20 km north-northwest of Balzapamba. It is accessible from Balzapamba via Babahoyo and takes about 3 hours by car.

(2) Geology

The area is lithologically dominated by three units of volcanic rocks classified as the Macuchi Formation (Figs.II-6-1 and II-6-2). These are basalt lava (Ba), basaltic andesite (Ban) and fine-grained tuff. The thickness of the Macuchi Formation in the area is estimated to be more than 940 m. The fine tuff layers trend N-S to NNW-SSE and dip 20° to 35°E.

(3) Mineralization

A weak and local mineralized zone consisting of dissemination and stringers of chalcopyrite and pyrite occurs in the basaltic andesite unit which crops out in the southern central part of the area. The representative sample gave the contents of 0.1 g/t Au, 4.6 g/t Ag and 0.03 % Cu.

(4) Magnetic susceptibility measurement

The magnetic susceptibility values varies from 21 to 86 x 19^{-3} SIU on the basaltic andesite zone and 1 x 10^{-3} SIU on the fine tuff zone. The demagnetization related to mineralization has not been observed in and around the mineralized zone.

6-2-2 San Miguel area

(1) Location

This area is situated about 15 km east of Balzapamba and it takes about 1.5 hours by car from Balzapamba (road sistance: 45 km).

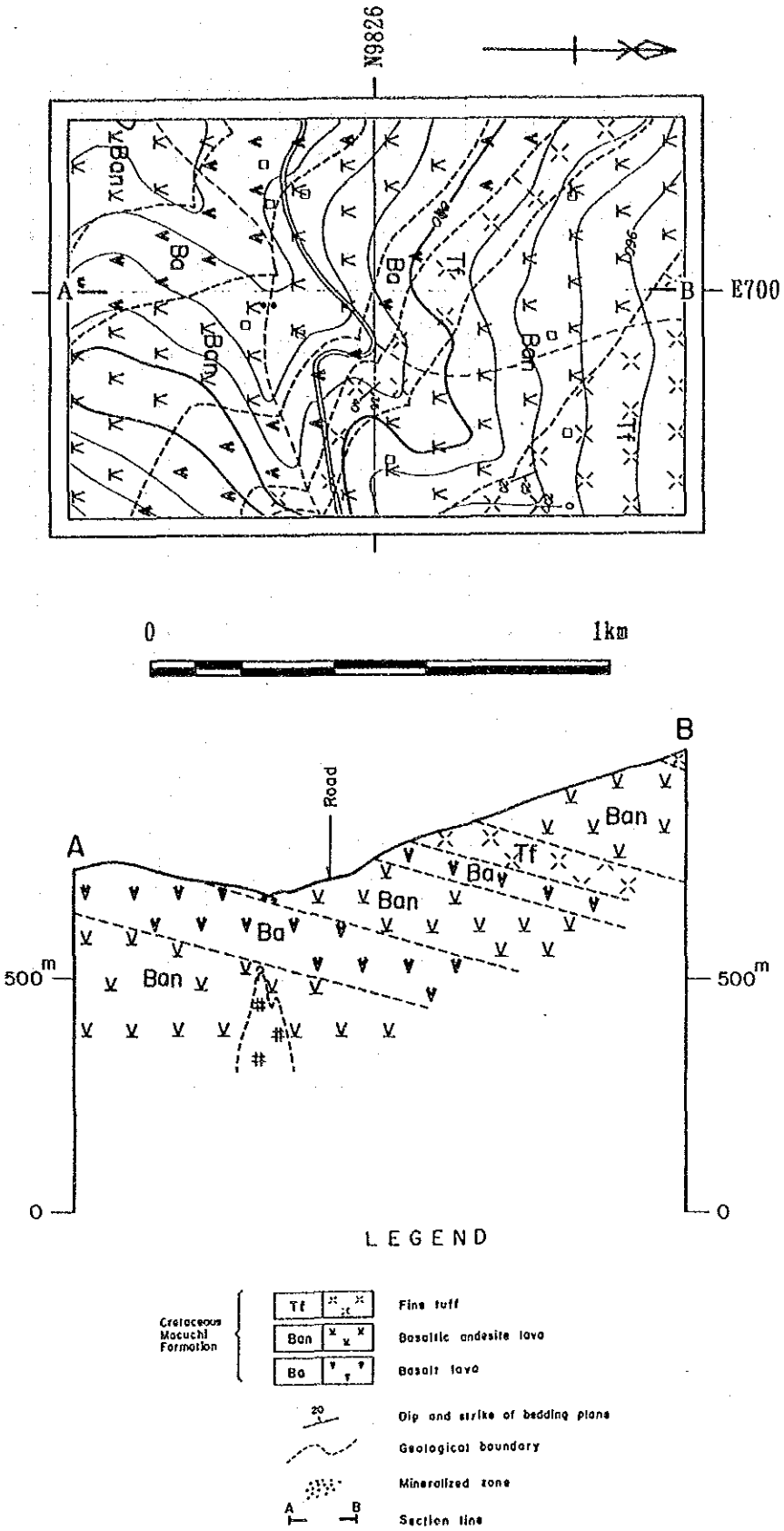


Fig. II-6-1 Geological map of the Tres Hermanas area

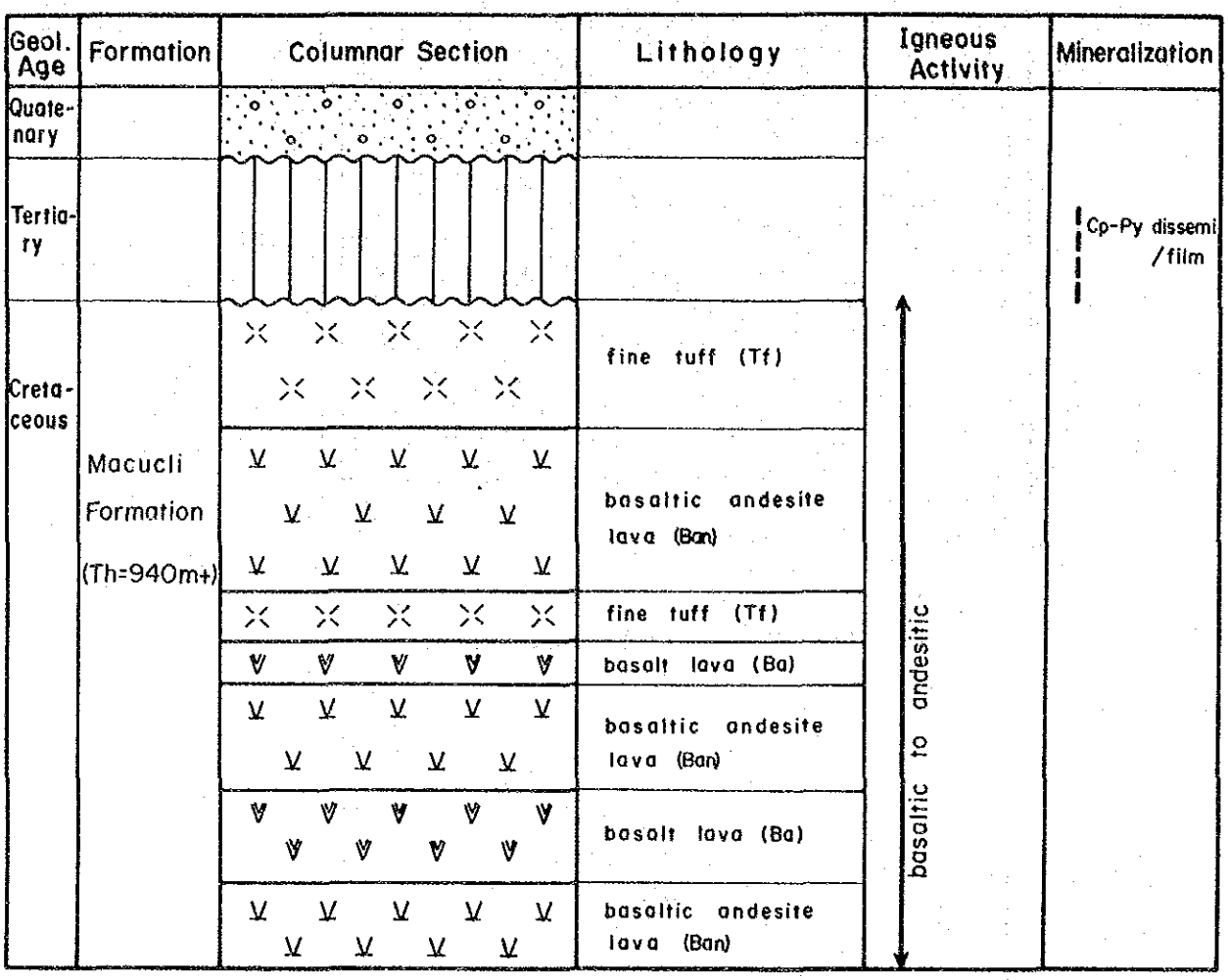


Fig. II-6-2 Generalized stratigraphic section of the Tres Hermanas area

(2) Geology

The basement in this area is the Macuchi Formation composed of andesite lava, its pyroclastic rocks (An) and quartz-bearing andesite lava (Qan). Lourdes volcanic rocks (Da, Cgl) comprising dacite and its pyroclastic rocks are of Pliocene to Pleistocene in age and distributed over this basement (Figs.II-6-3 and II-6-4). Further, Quaternary Guaranda Volcanic rocks (Ptf) consisting mainly of volcanic ashes and pumice are distributed, extensively covering these underlying rocks. Locally Las Guardias granodiorite (Gd) is exposed in a small range of area. In the central part of this area, a fault zone runs in NNW-SSE direction. These fault had made the eastern block dislocated downward and contacted with the Lourdes Volcanic Rocks but had not made the Guaranda Volcanic Rocks displaced.

(3) Mineralization

Mineralization in this area occurs in the fault zone mentioned above. Mineralized zones are distributed as echelon in the fault zone of about 100 m in width. Hydrothermal activity had taken place in these mineralized zones in three stages as described below. The total extension of alteration zones is about 1.5 km. First stage: hydrothermal activity accompanied by sulfide minerals; Second stage: hydrothermal activity accompanied by acid alteration involving hematite; and Third stage: hydrothermal activity accompanied by acid alteration involving no metallic elements. Hydrothermal activities in the 1st and 2nd stages alteration affect until the Lourdes Volcanic Rocks, and the 3rd stage until the Guaranda Volcanic Rocks.

A mineralized zone with sulfide minerals is well observed in Pahaca quarry. Geology of this place consists of dacitic tuffs of the Lourdes Volcanic Rocks and includes argillaceous patch of pumice. The mineralized zone is networked quartz veins containing a very small quantity of chalcopyrite and a small quantity of pyrite. Alteration of host rock mainly consists of silicification, which is accompanied by sericitization and chloritization. This mineralized zone can be traced in NNW-SSE direction for about 250 m. The fault observed on the south side of the quarry is about 10 m wide in which networked veins exist. About 2 m in width of these networked veins is strongly silicified and abundant of sulfide minerals. The mineralized zone strikes N50°W, and dips 80°N. Analytical results of chip samples collected from this area showed low in grade, as 0.01 % Cu. White colored soluble acid materials on the surface of the outcrops considered to be formed as secondary exuded products. Alteration minerals identified by X-ray diffractive analysis are sericite, chlorite and kaolinite. Kaolinite is considered to have close relationship to the 2nd stage or 3rd stage hydrothermal activity. Other mineralized zones containing

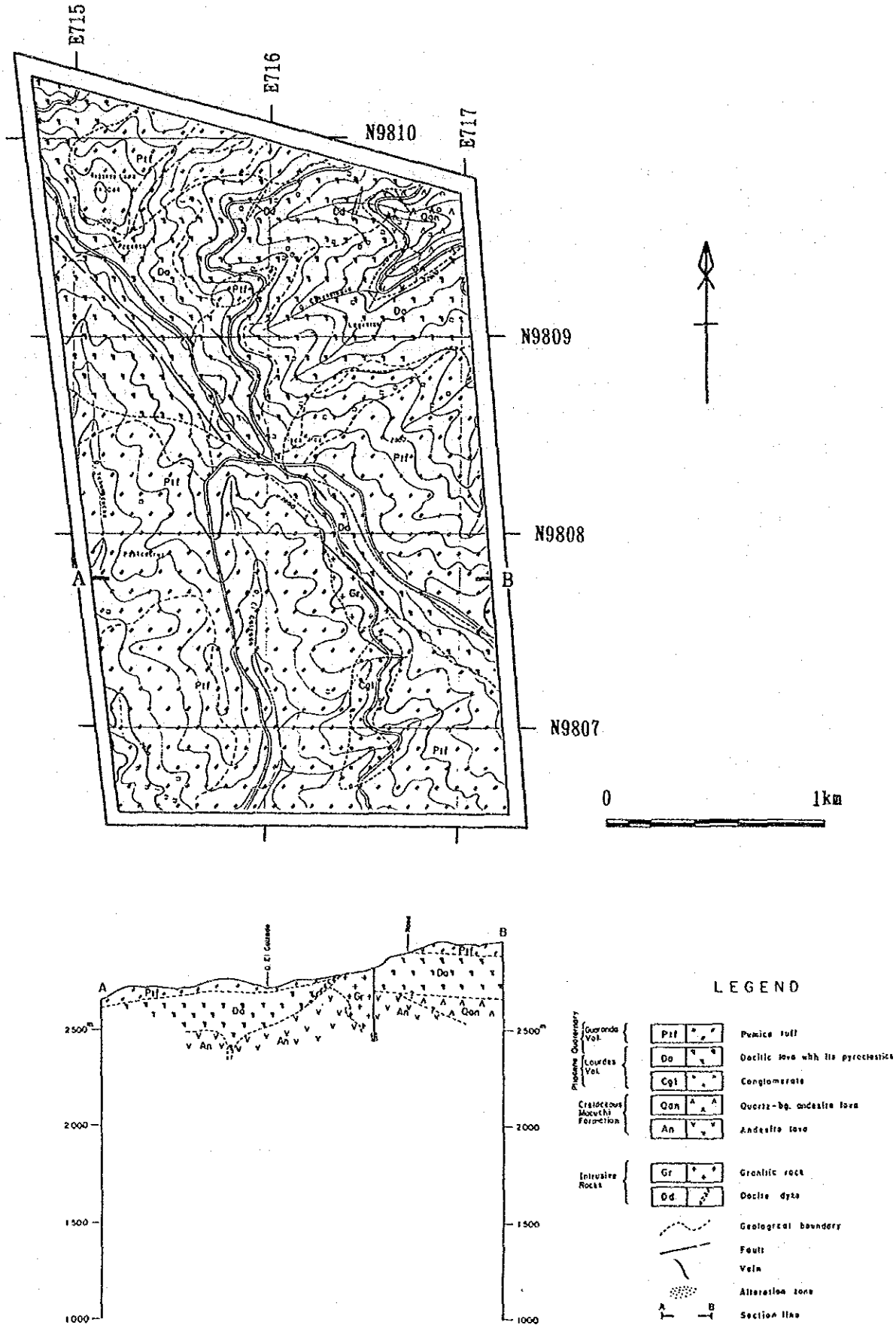


Fig. II-6-3 Geological map of the San Miguel area

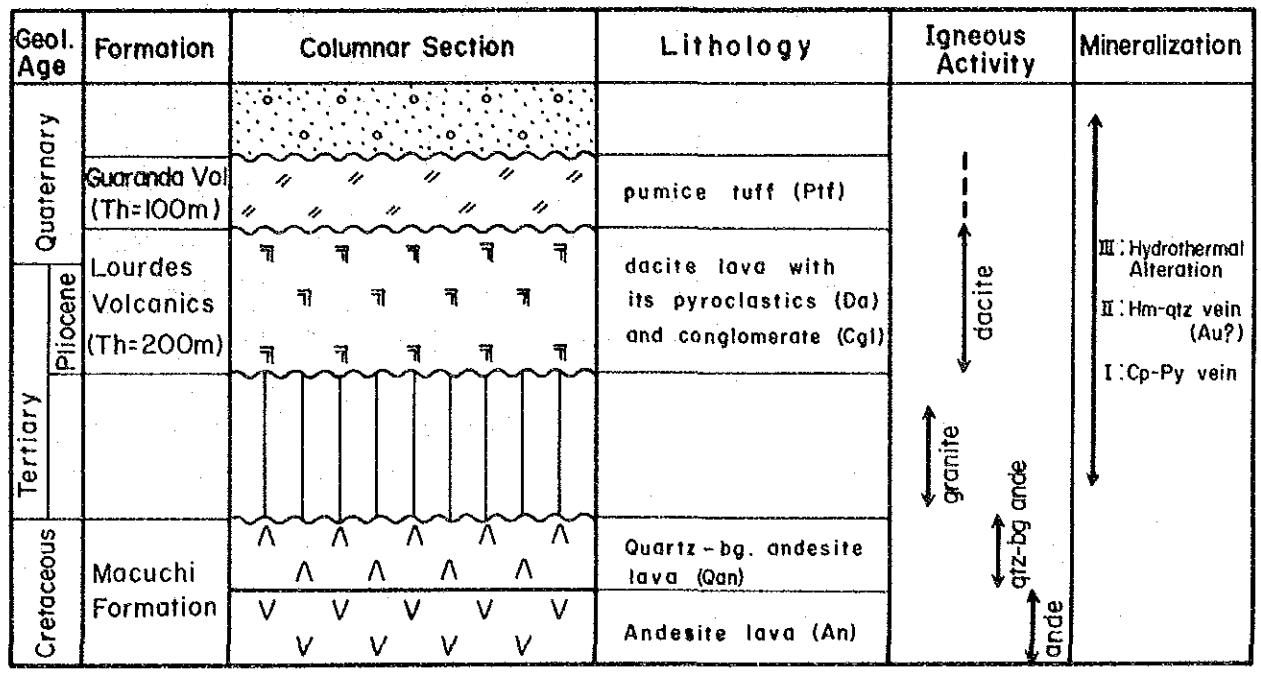


Fig. II-6-4 Generalized stratigraphic section of the San Miguel area

sulfide minerals include a pyrite disseminated zone and pyrite-(quartz) veinlet in an argillized zone which is exposed on the side of the newly built road in the south of Pisco Urcu. The latter is observed for about 50 m on the side of the road. The strike and dip of the veinlet is N79°W and 40° to 80°N, respectively.

Products of the 2nd and 3rd stage hydrothermal activities can be observed on the side wall of the road constructed recently in the south of Pisco Urcu and on the road at the summit. Products of the 2nd stage comprise hematite-(silica sinter) that exist in a irregular networked vein in white-argillized host rock. Products of the 3rd stage, which are accompanied by white argillization, are the result from the last stage hot spring activity.

X-ray diffractive analysis showed kaolinite of 2nd and 3rd stage alteration. These alteration zones are distributed as echelon in the fault mentioned above and extend in NNW-SSE direction.

(4) Magnetic susceptibility measurement

Since this area is in extremely advanced stage of weathering, magnetic susceptibility in all the outcrops were lowered comparatively. However, demagnetization was distinguished in hydrothermal alteration zones. In the above mentioned mineralized zone, a demagnetization zone extends in NW-SE direction.

(5) Geochemical survey

For geochemical survey, samples were collected to delineate halo of elements, around channel feeders of hydrothermal activity. Results of this investigation show that the more concentrated Zn, Co, and Ni tend to be the closer sampling points approach the channel feeder, while Cu presents opposite. The 2nd stage hydrothermal activity was an acid hydrothermal solution accompanying magnetite and hematite. From this fact, the concentration of Zn, Ni and Co may be the result of leaching out from the Macuchi Formation at a great depth. Contrary, Cu, may be moved away by 2nd stage hydrothermal activity, thouth 1st stage activity had been deposited this element once in the area.

6-2-3 Sicota area

(1) Location

This area is situated about 13 km southeast of Balzapamba and 1 hour ride away from Balzapamba settlements (road distance: 35 km).

(2) Geology

Tertiary granodiorite batholith (Gd) is distributed throughout this area. Conglomerate bed of Quarternary covers this rock partly (Fig.II-6-5) along valleys running to the southeast direction in the southern part of this area.

(3) Mineralization

Mineralization shows several products of hydrothermal activities. In the central part of this area, small outcrops are disseminated with euhedral pyrite crystals in altered granodiorite. The outcrops, which are exposed in an area of up to 2 m in diameter, occur in a 30 m range of area. Analytical results on ore samples showed 0.2 g/t Au, 3.9 g/t Ag, and 0.09 % Cu.

Alteration consists of silicification and white argillization. Granodiorite is altered partly with a kaolinite alteration zone of about 2 m thick, with which hematite associates. In the conglomerate formation of Quaternary interstices of pebbles are filled with fine-grained pyrite and white clay. Pebbles are also disseminated with fine-grained pyrite. This hydrothermal alteration zone is exposed over 20 m along the valley.

(4) Magnetic susceptibility measurement

In this area, weathering has extremely advanced but magnetic susceptibility of rocks were lowered slightly. However, the hydrothermal alteration zone mentioned above shows a range of magnetic susceptibility between 0.03 and 0.15 x 10^{-3} SIU, which indicates a demagnetizing phenomenon.

6-2-4 Tambillo area

(1) Location

The Tambillo area lies on the eastern steep slop of Chimbo river, about 28 km southeast of Balzapamba. The access by road can be done from Balzapamba to La Ensillada which is at about 4 km east of Chillanes. It takes about 2 hours by car. No motorable access is available, between La Ensillada and the survey area but by horse back, by foot and by manual ropeway require about one hour and a half.

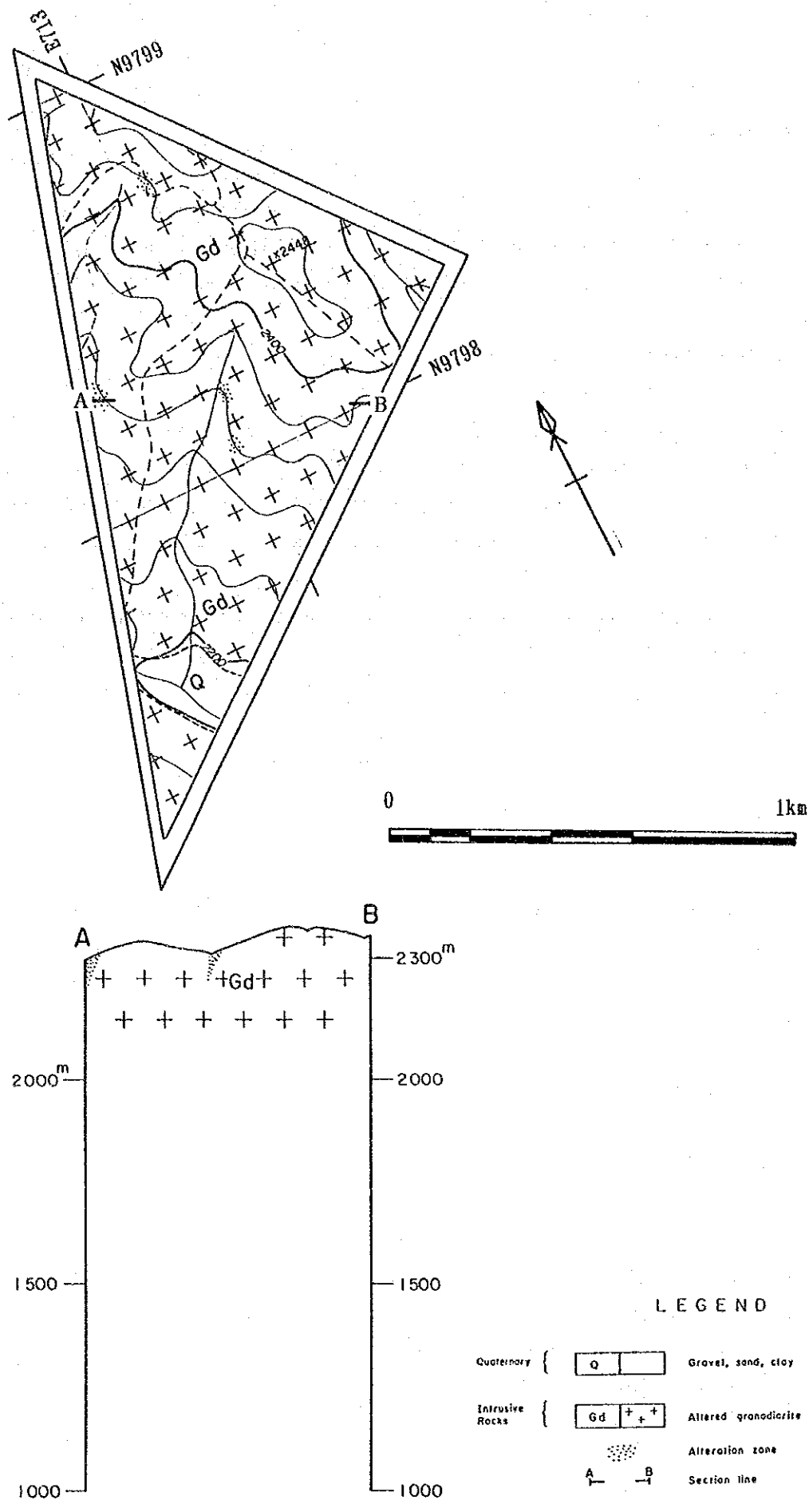


Fig. Ⅱ-6-5 Geological map of the Sicota area

(2) Geology

The almost all the area is underlain by volcanic rocks of the Macuchi Formation. small dykes of granite porphyry crop out only in the southwest and central parts (Fig.II-6-6 and II-6-7).

The Macuchi volcanic rocks is largely composed of dark green andesite lava (An) with intercalations of andesitic tuff (Tf) and quartz-bearing andesite (Qan). The andesite lava is underlain by basaltic pillow lava (Ba). These lithological units strike NE-SW and dip 30° more or less toward the northeast. The thickness of the volcanic rocks is estimated to be more than 1,800 m.

The granite porphyry (Gp) occurs in a small area as NE-SW trending dyke with 20 m wide in the southwest and central parts. Lithology of the dyke is coarse-grained, leucocratic and distinctly porphyritic. The dyke is silicified extensively.

(3) Mineralization

Three local mineralized zones are recognized in the middle reaches of Palmar valley and in the lowermost to middle reaches of Placer valley.

The former is dissemination of chalcopyrite and pyrite in the granite porphyry dyke and enclosing silicified andesite lava. It can be pursued for about 200 m long Palmar valley. The analytical result of the representative sample showed the content of 0.07 % Cu, but one of the geochemical samples contained 1,236 ppm. The X-ray diffractive analysis revealed two alteration mineral assemblages of quartz-sericite and quartz-halloysite.

The second is represented by disseminated chalcopyrite and pyrite hosted by silicified andesite. It has an extension of quartz-K-feldspar is predominant alteration minerals.

The last occurs as sparse dissemination of pyrite in silicified andesite, which extends for about 300 m along the middle streams of Placer valley.

(4) Magnetic susceptibility measurement

The magnetic susceptibility values in this area are less than 20×10^{-3} SIU, which are clearly lower than those in other survey areas. Particularly, the values in and around the mineralized zones did not exceed 9×10^{-3} SIU.

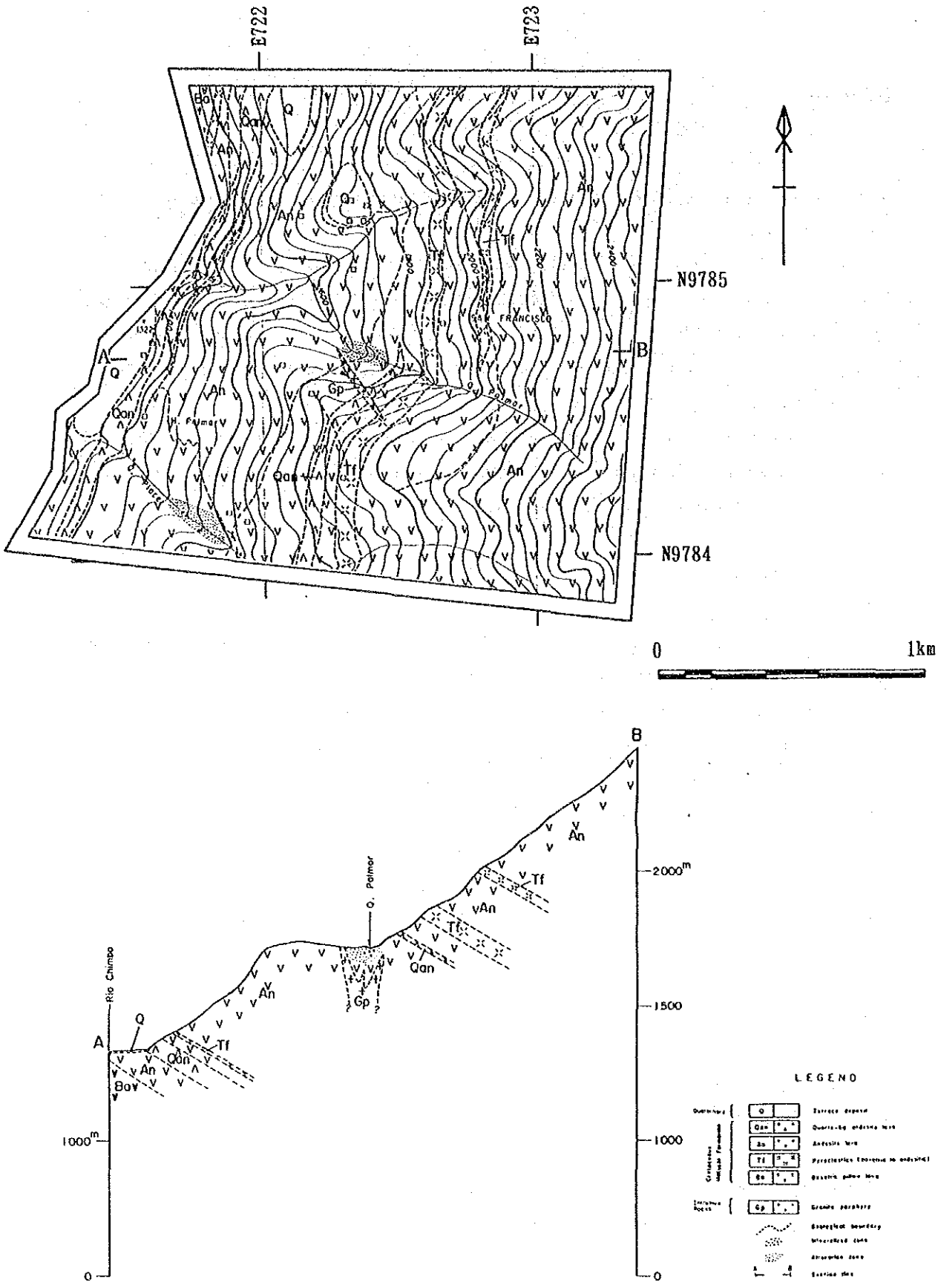


Fig. II-6-6 Geological map of the Tambillo area

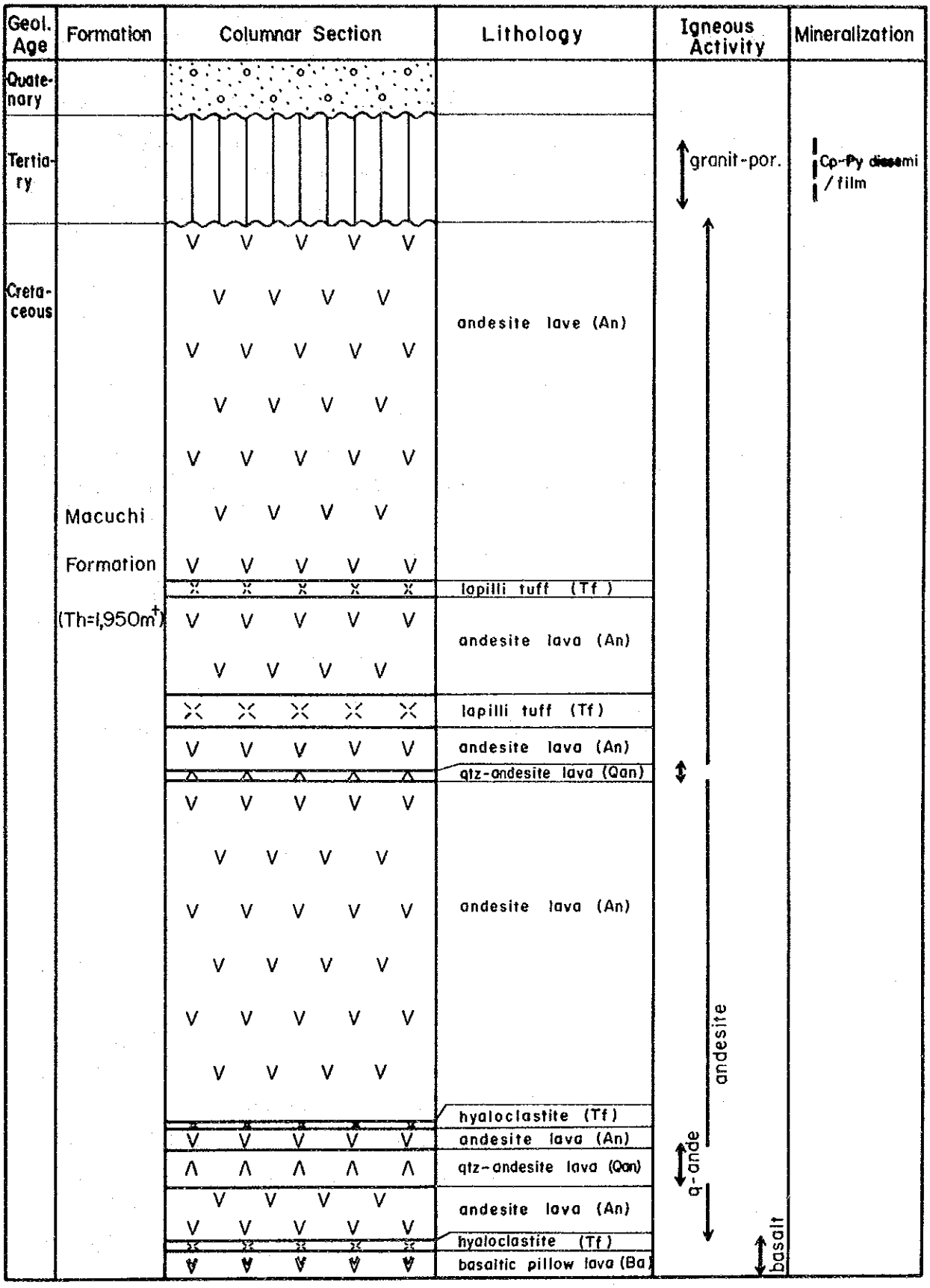


Fig. II-6-7 Generalized stratigraphic section of the Tambillo area

(5) Geochemical survey

As the result of the geochemical survey, only high factor scores of Factor 3 (Pb-Zn-Cu) were obtained over the mineralized zone in the lowermost reaches of Placer valley, but all of other factor scores on each mineralized zone were extremely low.

6-2-5 Tablas Pamba area

(1) Location

This area is located about 8 km southwest of the Tambillo area, 32 km south-southeast from Balzapamba. The access by road can be done from Balzapamba to Tablas Pamba village via Chillanes. It takes about 2 hours and a half. Between Tablas Pamba and the eastern boundary of the area, however, only trails are available, from which to the survey area it takes about 2 hours by horse back or on foot.

(2) Geology

Andesitic volcanic rocks spread over throughout the area. A small diorite stock is exposed only near the northeastern corner of the area (Figs.II-6-8 and II-6-9).

The andesitic volcanic rocks are stratigraphically subdivided into 6 members: An-1, Ba-1, An-2, Tf, Ba-2 and An-3, in ascending order.

The An-1 member, which occupies the easternmost of the area,consists mostly of grey andesite lavas with minor intercalations of basaltic andesite flows. The thickness of this member is more than 700 m.

The Ba-1 member is dark gray, brecciated basaltic andesite-basalt lavas and estimated to be 400 m thick.

The An-2 member is composed of gray andesite, and its thickness varies from 270 m in the east to 80 m in the west.

The Tf member is comprised of pale green andesitic fine to coarse Tf. It is exposed only in the east of the area, and usually forms very high precipices, occasionally over 200 m height. This member shows the thickness over 250 m as a maximum.

The Ba-2 member conformably overlies on the Tf member in the east and on the An-2 member directly in the west. It is dominated by dark gray basalt lavas associated with basaltic tuff in the north and by basaltic andesite lavas with basalt lava, which is metamorphosed to hornfels in the west. The thickness is estimated to be 280 m in the east and 200 m in the west.

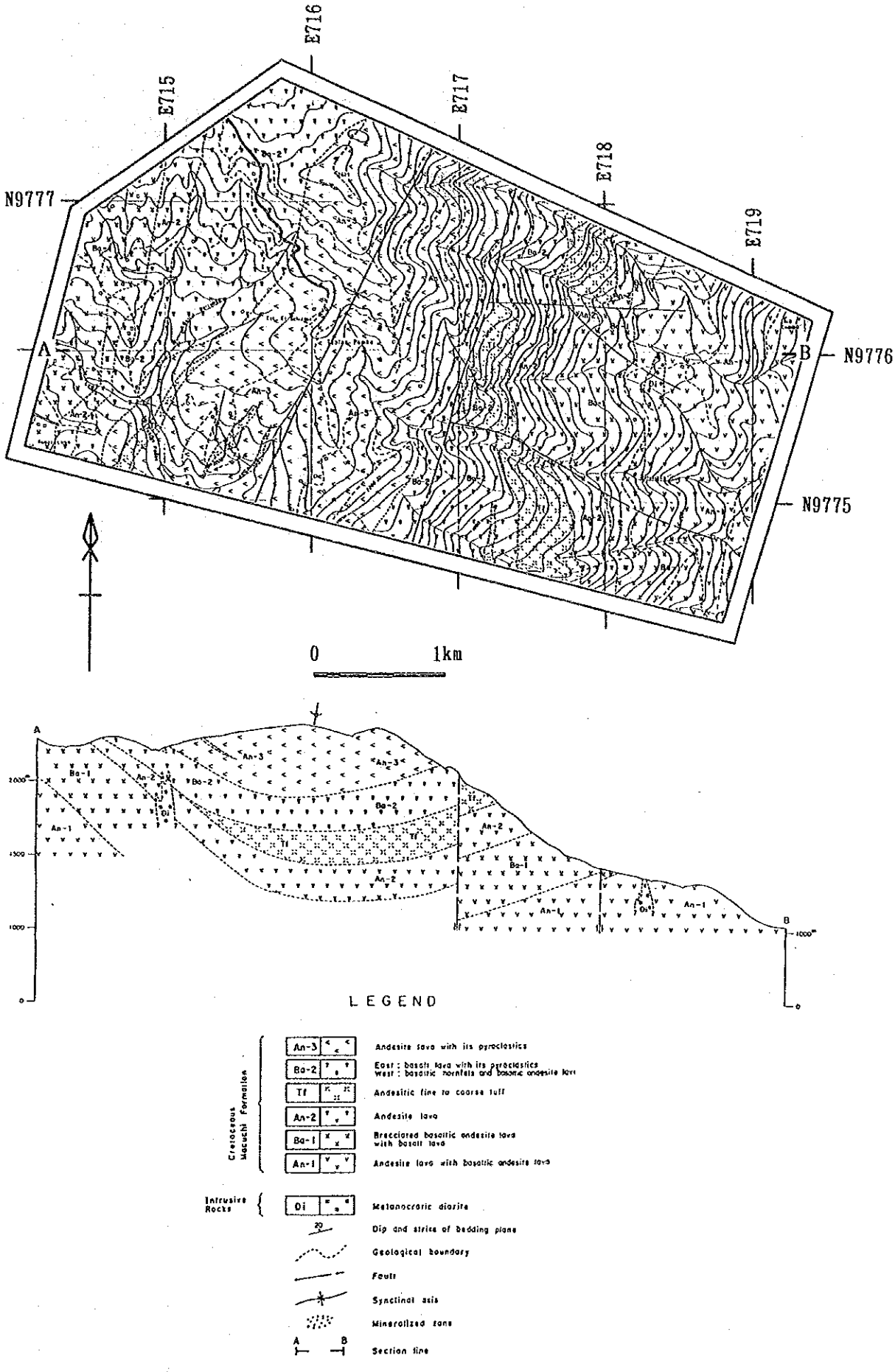


Fig. II-6-8 Geological map of the Tablas Pamba area

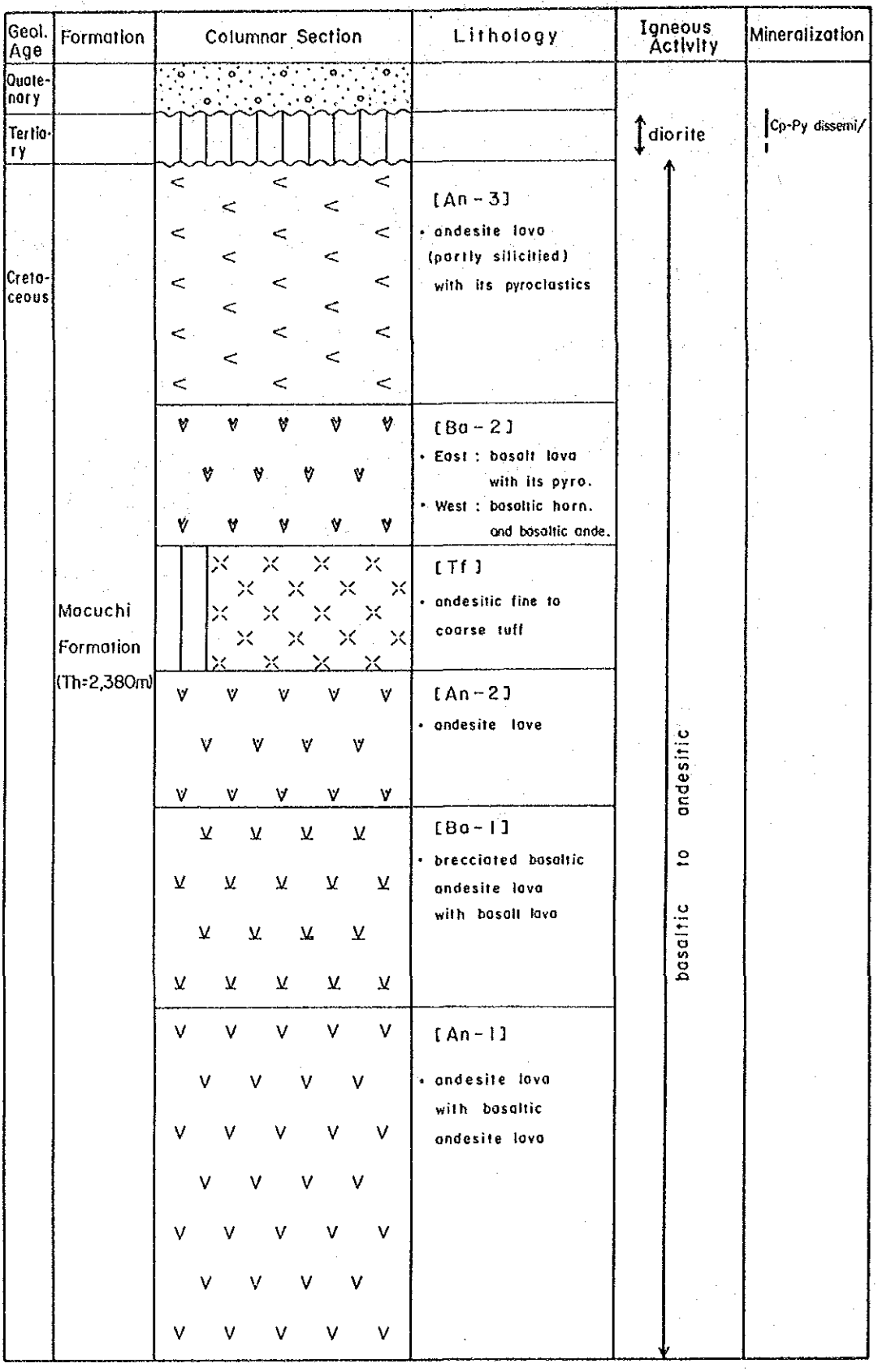


Fig. II-6-9 Generalized stratigraphic section of the Tablaspamba area

The An-3 member, the upper most unit in the area, consists mainly of dark gray andesite flows with thin layer intercalations of andesitic tuffs, and forms undulating plateau with elevation of 2,200 to 2,600 m in the central to western part of the area, where Tablas Pamba village is located. Around the north boundary of the area, andesite lavas are light in color and silicified. The thickness of this member is more than 480 m. A small stock of melanocratic diorite is exposed in the northeastern part of the area. Mafic minerals are altered to chlorite mostly and to epidote partly.

The area investigated is characterized by bimodal geological structures, fault and fold. Fault of three distinct sets, which is developed in NNE-SSW is in the central to eastern part of the area, is the largest and latest one that traverses at 1 km east of Tablas Pamba village forming large-scale scarps. The western side of it is faulted and dislocated about 150 m downward. All of the members of the Macuchi Formation strike NW-SE direction and dip 20° to 30°W in the eastern part, while they strike NE-SW and dip 30°E in the western part. From these evidence, it is inferred that the Macuchi Formation forms a broad syncline plunging down gently to the south.

(3) Mineralization

Chalcopyrite-pyrite dissemination zones are located in the west, southwest, and southeast of the Tablas Pamba area. The west mineralized zone is situated about 500 m westnorthwest of Tablas Pamba village, and occurs as a sparse dissemination of chalcopyrite and pyrite with an extent of 250 m N-S by 350 m E-W in andesite lava of the An-3 member. A representative sample assayed to be 0.02 % Cu. The assemblage of alteration minerals is quartz-chlorite-amphibole. The southwest and southeast mineralized zones are extremely localized. In addition, an extensive silicified zone accompanied with sparse pyrite dissemination is observed in andesite lava of the An-3 member close to the north boundary of the investigated area, but no chalcopyrite is identified in this zone.

(4) Magnetic susceptibility measurement

The magnetic susceptibility values obtained is 13 to 63 x 10^{-3} SIU in lavas, less than 8 x 10^{-3} SIU in tuff unit, and less than 1 x 10^{-3} SIU in mineralized zones.

(5) Geochemical survey

The geochemical survey was carried out on the west mineralized zone. As the result of the interpretation, high factor scores of Factor 1 (Co-Ni-Zn) are obtained. This appears

to reflect the characteristic of the host rock rather than the mineralization.

6-2-6 Balaron area

(1) Location

The Balaron area lies about 55 km south-southeast of Balzapamba. It takes 3 hours and a half by car from Balzapamba via Babahoyo and another 3 hours by horse back.

(2) Geology

The area is underlain by volcanic rocks of the Macuchi and Alausi Formations (Figs.II-6-10 and II-6-11).

The Macuchi Formation occupies most part of the surveyed area and is composed of basalt lava (Ba), basaltic andesite lava (Ban) and andesite lava (An). The porphyritic andesite lava (Po) of the Alausi Formation overlies on the andesite lava of the Macuchi Formation unconformably in the northern most of the area.

(3) Mineralization

Mineralization in the area is represented by a quartz vein observed at 800 m west of Remigon village and malachite dissemination in a basalt float obtained at the village, analytical values of which were 7.3 g/t Ag and 1.47 % Cu. Quartz-chlorite is the common assemblage of alteration minerals.

(4) Magnetic susceptibility measurement

The magnetic susceptibility values were generally 10 to 30 x 10^{-3} SIU, but around the mineralized zone the values were not over 1 x 10^{-3} SIU.

(5) Geochemical survey

The geochemical survey was carried out around the quartz vein, as the results of which moderate factor scores of Factor 1 (Co-Ni-Zn) were detected. this is interpreted, however, to be caused from the chemical characteristic of the host rock.

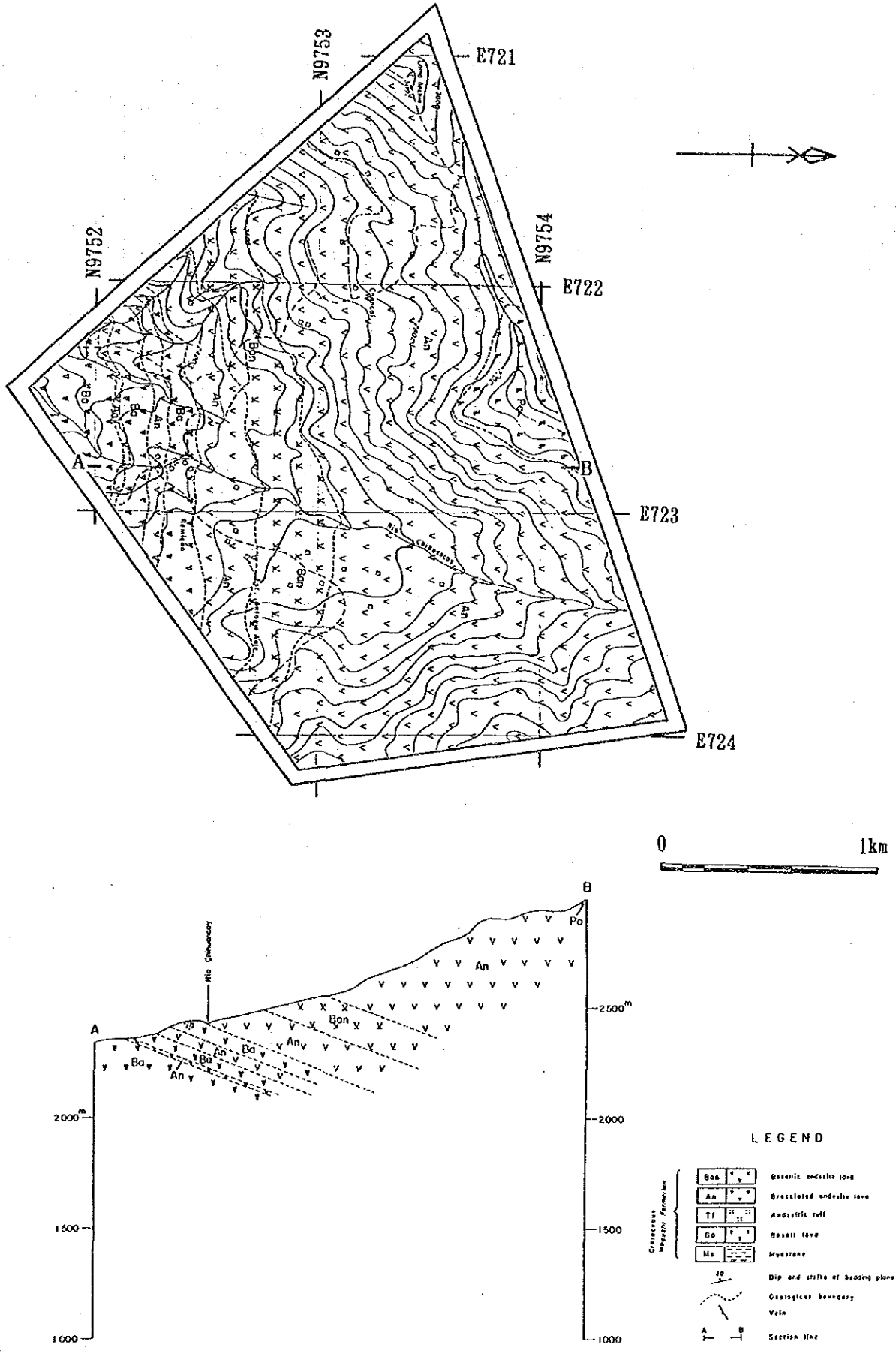


Fig. II-6-10 Geological map of the Balaron area

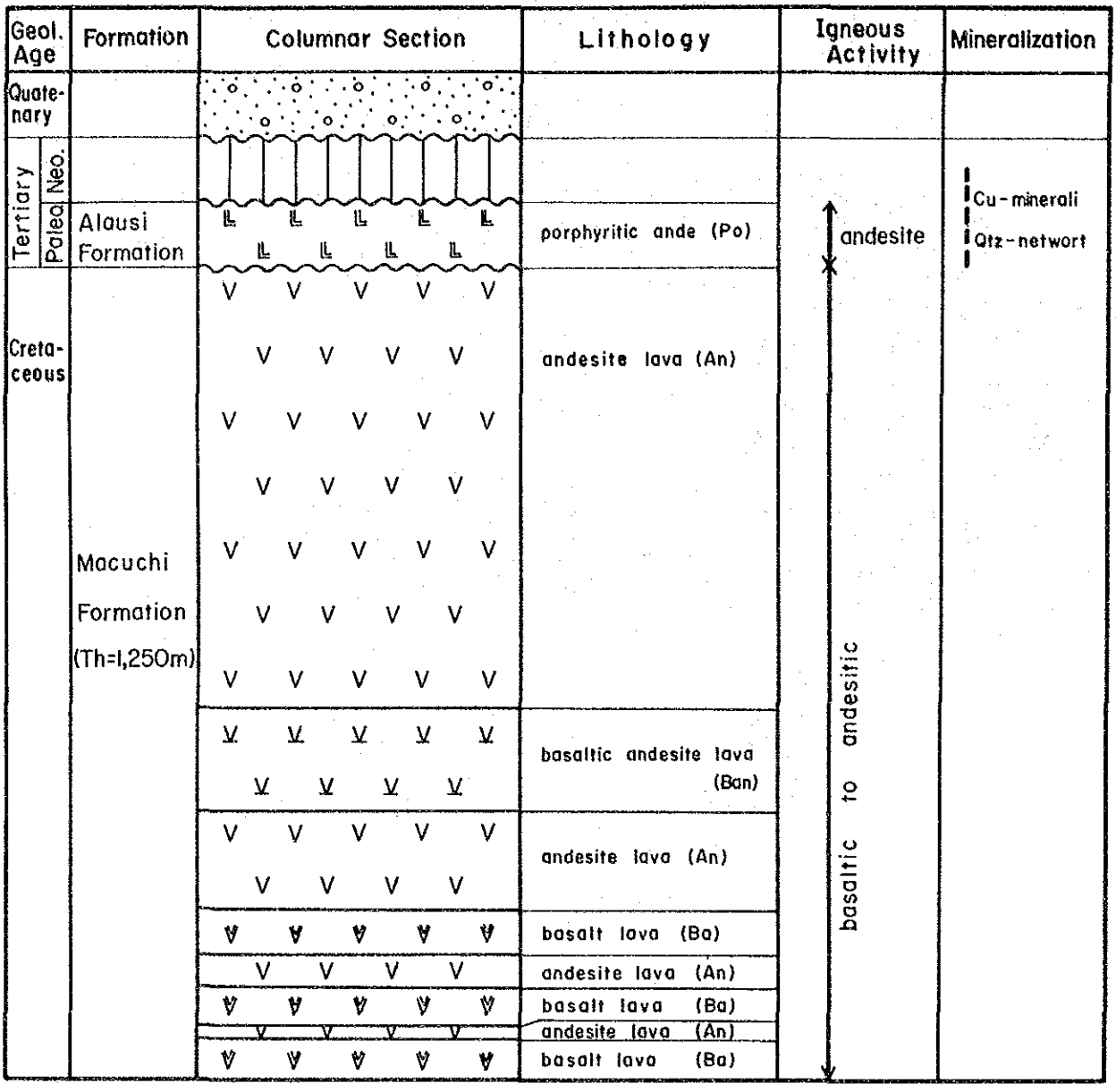


Fig. II-6-11 Generalized stratigraphic section of the Balaron area

6-2-7 Chilcales Alto area

(1) Location

The area is situated at the southern end of the project area, about 60 km south from Balzapamba. It is accessible from Balzapamba via Babahoyo. It takes 2 hours and a half by car.

(2) Geology

The area is completely underlain by volcanic rocks belonging to the Macuchi Formation (Figs.II-6-12 and II-6-13). The Macuchi Formation is comprised mainly of brecciated andesite lava (An) with intercalations of andesitic tuff (Tf) and basaltic andesite flows (Ban) which strike N60°E and dip 15°E . In the northwestern part, black mudstone is locally exposed. The entire thickness of the Formation is estimated to be more than 1,500 m.

(3) Mineralization

Dissemination and network of pyrite are recognized as well as network of quartz veinlets in the southern part of the area. The pyrite network assayed to be 0.01 % Cu.

(4) Magnetic susceptibility measurement

The magnetic susceptibility measurement resulted in detecting the values of 14 to 50 x 10^{-3} SIU in lavas, less than 1 x 10^{-3} SIU in the tuff, and 1 x 10^{-3} SIU in mineralized zone more or less.

As the result of geochemical survey, high factor scores of Factor 1 (Co-Ni-Zn) were obtained. These scores were interpreted to be caused from the chemical characteristic of the host rock rather than from the mineralization.

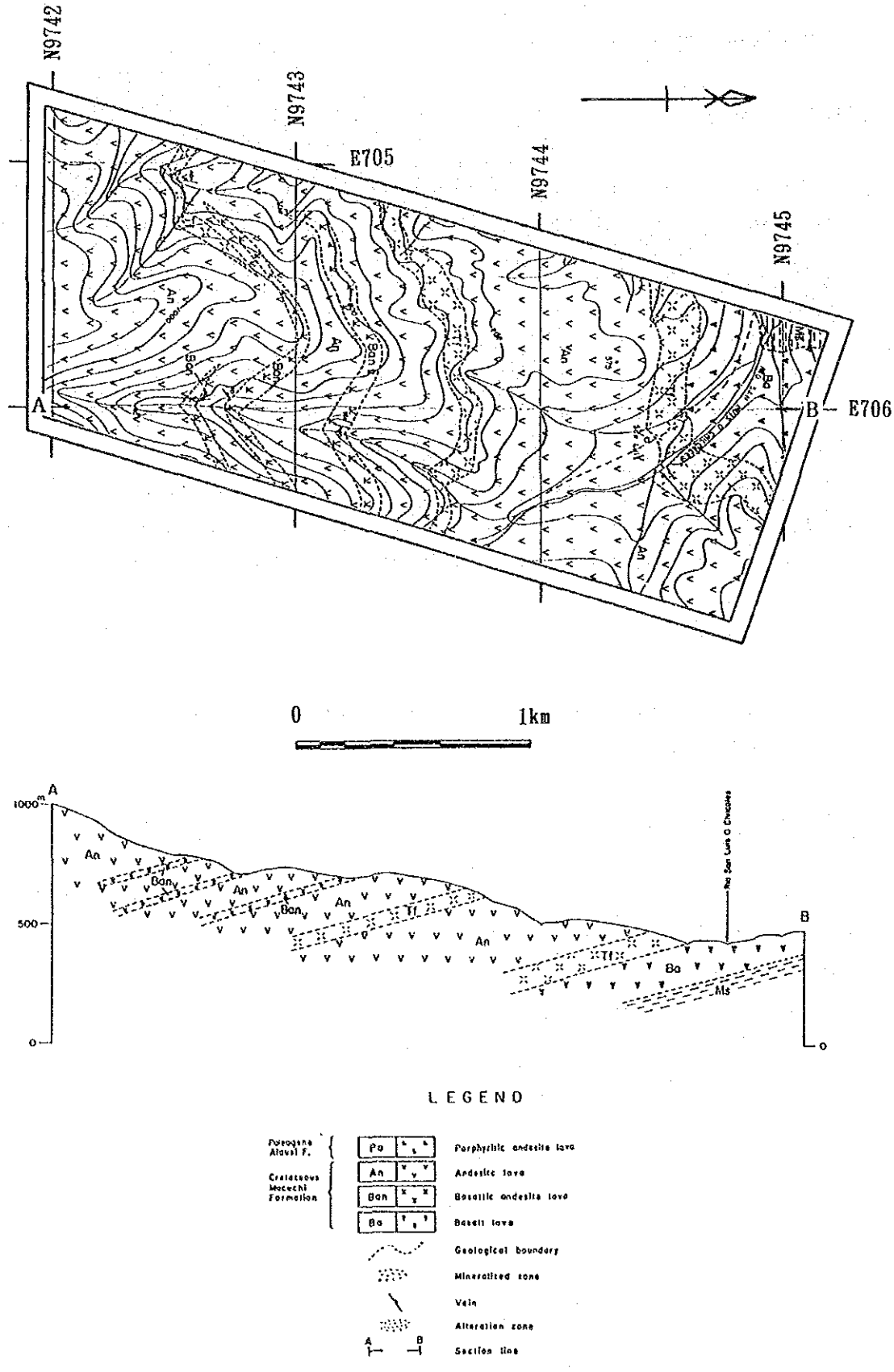


Fig. II-6-12 Geological map of the Chilcales Alto area

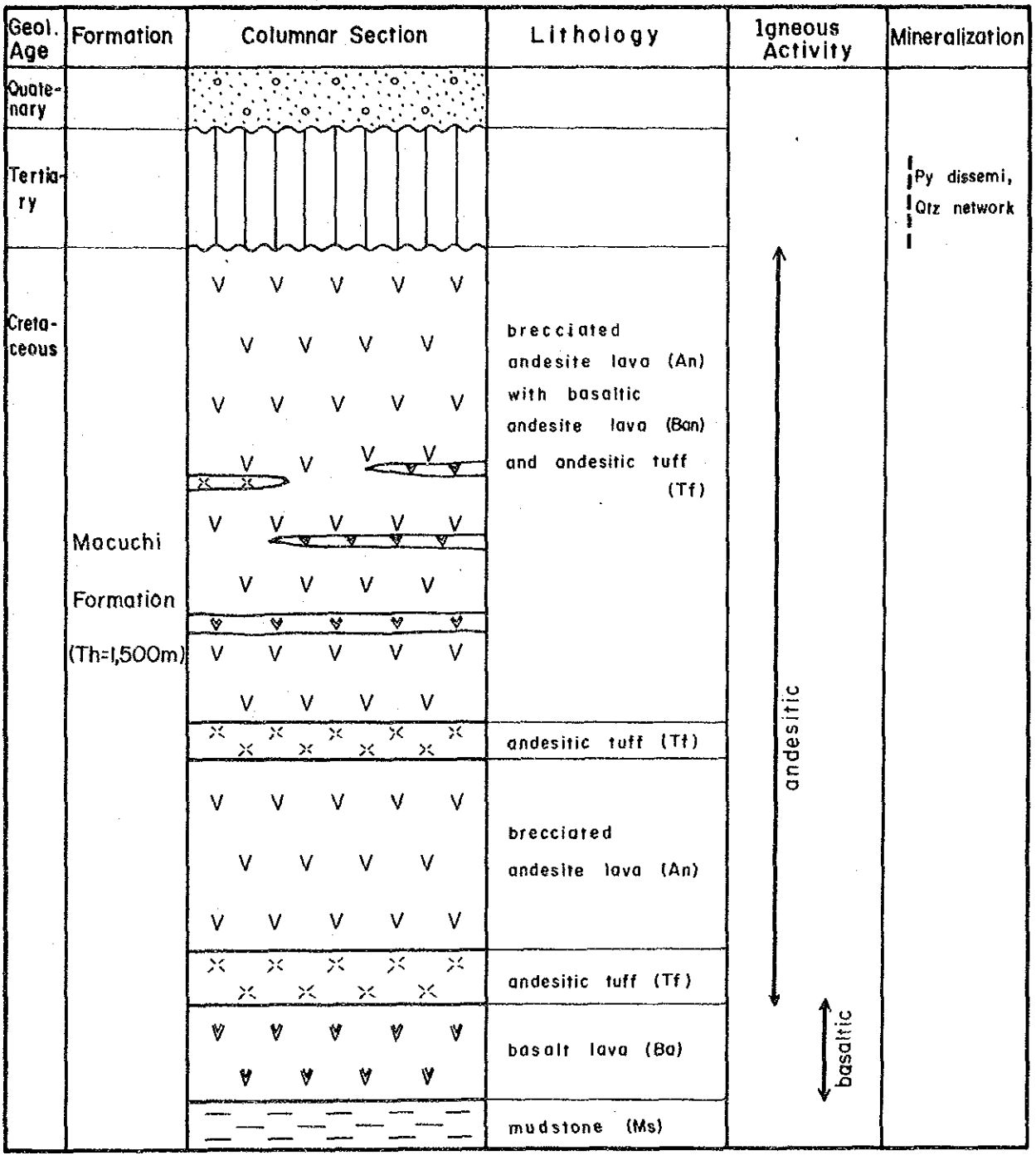


Fig. II-6-13 Generalized stratigraphic section of the Chilcales Alto area

PART III CONCLUSIONS AND RECOMMENDATIONS

Chapter 1 Conclusion

The survey of the Bolivar Project in the Republic of Ecuador has been conducted for three years to confirm the potentiality of mineral deposits by clarifying the geological and mineralogical conditions. Finally 12 areas have been investigated and evaluated. Followings are the summary of conclusions:

1-1 Balzapamba area

(1) Balzapamba area

The geology of this area consists of the Macuchi formation of Late Cretaceous and granitic rocks of Oligocene to Miocene that intruded into this formation.

Mineralization in this area can be broadly classified into three types that are porphyry copper type, vein type and hot spring type. Porphyry copper type mineralization occurs in granitic rocks and adjacent Macuchi formation, and vein type and hot spring type in Macuchi formation.

Mineralized zones found in El torneado, Osohuayco and Las Juntas belong to porphyry copper type, ones in El Cristal belong to vein type, and ones in Las Palmas and Cochapamba belong to hot spring type.

El torneado and Osohuayco zones are investigated in detail separately, therefore they are described in other sections.

Las Juntas: chalcopyrite-pyrite dissemination ingranodiorite and quartz diorite and pyrite-quartz networked veins in Macuchi formation. Each mineralized zone is small in scale.

El Cristal: pyrite-limonite-chalcopyrite-quartz vein in Macuchi Formation with the strike of E-W, width of about 17 m, and length of about 30 m. The mineralized zone is small in scale.

Las Palmas and Cochapamba: both alteration zones extend widely, resulted from acid alteration (quartz-kaoline-halloysite) relating to hot spring period. Dissemination of pyrite or hematite-quartz-clay veins are recognized locally. As a whole mineralization is weak.

(2) El Torneado zone, Balzapamba area

Mineralization observed in the El Torneado zone is of the porphyry copper type, and is divided into two sub-zones on the basis of their modes of occurrence: namely, a "dis-

semination" zone and a "network" vein zone. The former extends over an area of about 400 m x 400 m. The latter is distributed within the former zone in the direction of NNE-SSW, at a scale of 40 to 70 meters in width and 70 to 350 meters in length. The two zones are distributed in the manner where the former zone is cut by the latter. The geologic age of mineralization is earlier in the former.

Mineralized zone is generally low in grade. The geological and drilling surveys had revealed the conditions of mineral occurrence horizontally and vertically, as well as the states of paragenesis and alteration of constituent minerals microscopically. Since the results of the Phase II drilling indicate that the lower limit of the network vein zone was penetrated and that of the disseminated zone was almost reached in this drilling, it may be assumed that the center of mineralization in the El Torneado zone had been subjected to erosion, exposing as a result the lower most part of mineralization on the existing ground surface. The mineralized zone, therefore, may not be the potential target area of a mine.

(3) Osohuayco zone, Balzapamba area

The geology of the area consists of Macuchi Formation and granodiorite which intruded into Macuchi Formation.

Two mineralized zones are recognized in this area, one is Osohuayco North mineralized zone and the other Osohuayco South mineralized zone. Drilling survey was carried out to disclose geological and mineralogical conditions of the IP anomaly which showed high apparent resistivity and high FE (more than 5 %) around the Osohuayco South mineralized zone, as a result of previous year geophysical survey. Any mineralization, however, associating with skarnization was not encountered. Drill hole intersected disseminated mineralized zone of chalcopyrite and pyrite in hornfelsinized andesite of Macuchi Formation (AAn). The assay discolsed the grade of the minerqlized zone to be very low at a whole, actual range was 0.01 to 0.18 Cu (average 0.05 % Cu).

1-2 Chaso Juan area

Mineralization observed in the Chaso Juan area is of the porphyry copper type, and is grouped into four zones: namely, the North zone, the West zone, the South zone, and the Central zone.

Each mineralized zone is small in scale and discontinuous compared with other surveyed areas.

As the results of geophysical survey, IP anomalies were found in the midway between central and south mineralized zones, and in the west mineralized zone extending north-

south direction. The former indicates extension of south mineralized zone, and latter indicates a direction of mineralization. Priority of exploration, however, low in this area.

1-3 Telimbela area

(1) Telimbela area

The porphyry copper type mineralization observed in the Telimbela area is the largest in scale in the entire Bolivar area, and its strong mineralization extends to the Macuchi Formation.

Centering around each of the seven mineralized locations within this area, pyrite dissemination and veinlets are widely distributed in granitic rocks. Macroscopically, the seven mineralized zones in this area, which are generally arranged in the NE-SW direction, are grouped into the Central, South and North zones.

In the North zone distributed are Mineralized Zones V and VI, which are new and large zones found in the Phase II survey. These mineralized zones are described in the following section.

(2) Northeast zone, Telimbela area

The geology of the area consists of Macuchi Formation and Granites which intruded into the Macuchi Formation. Granites are composed of Hornblende-biotite quartzdiorite, hornblend qurtzdiorite, melanocratic qurtzdiorite dike and coarse quartzdiorite dike. Those rock bodies are distributed and arranged in the NE-SW direction.

Porphyry copper type mineralized zone in the surveyed area is proved to be as a dissemination and metwork zone of chalcopyrite and pyrite.

These mineralized zones are macroscopically lined up in the direction of NE-SW and mineralization is centered in Hornblende quartzdiorite and affects thoroughly such country rocks as Macuchi Formation intensely.

Mineralized outcrops scatter in the area of 1.5 km X 1.0 km in and along Q. Ugshacocha and Q. Ashuaca, high grade ores are notably destributed in an area of 400 m X 600 m close to the Ashuaca achool, where dissemination and network zone of chalcopyrite and pyrite are recognized to exist not only in quartzdiorite but also in Macuchi Formation intensely. Moreover, molibdenite is observed in forms of dissemination and/or films scattered.

The assay revealed that southern mineralized part cropping out along Q. Ugshacocha contains 0.71 to 1.38 % Cu and that northern mineralized part cropping out along Q. Ashuaca 0.78 to 0.89 % Cu.

Outer part of the mineralized zone is to be dissemination and network zone of pyrite only. As a result of IP method electric survey, distinguished were 6 of high FE anomalies. FE anomaly corresponds generally to mineralization, while high resistivity anomaly to silicification and low resistivity to argilization.

Drilling survey was conducted at the west and east of the Ashuaca school, results of which are as follows: On the drill hole core MJE-8, intense dissemination of chalcopyrite and pyrite was observed through the hole (from the surface to the bottom).

Principal mineralized zones encountered by drill hole are interval between 21 to 102 m in depth with 0.02 to 0.72 % Cu (average, 0.468 % Cu). Adding this, several other intervals are recognized to show copper contents more than 0.10 %.

Mineralization tends to be dominant in the parts of angular xenoliths of andesite and in the the parts of auto-brecciated zone of quartzdiorite.

On the drill core MJE-9, intense mineralization of chalcopyrite and pyrite was observed through the hole from the surface to the bottom (205.00 m in depth).

Principal mineralized zones encountered by drill hole are intervals between 80 to 105 m in depth with a grade of 0.10 to 0.33 % cu (average, 0.229 % Cu) and between 124 to 161 m with a grade of 0.08 to 0.55 % Cu (average, 0.207 % cu). Adding those mineraization, several intervals are also recognized, which show copper contents more than 0.10 %.

As a whole, MJE-9 contains less andesite breccias and shows less auto-brecciation. Therefore, average grade of mineralized parts of MJE-9 was relatively lower than that of MJE-8.

To conclude data and information described above following three mineralized zones are delineated as potential zones of mineralization:

1) "Ashuaca mineralized zone"

As a result of geological survey, a number of intense mineralization of chalcopyrite and pyrite have been recognized around Ashuaca school. IP method electric survey disclosed that the deep low resistivity-high FE anomaly "A" which corrresponds to the "Ashuaca mineralized zone".

Moreover, low apparent-resistivity anomaly was recognized at the intense mineralized parts of chalcopyrite-pyrite in and along Quebradas, west and south of Ashuaca.

2) Ugshacocha mineralized zone

Ugshacocha mineralized zone distributes about 500 m southeast of Ashuaca school. Through detailed geological survey, recognized is intense mineralization of chalcopyrite-

pyrite, while this mineralization is confirmed to be corresponded to low resistivity-high FE zone "A" which has been selected as a tangue shape anomalous zone extendiong from the Northeast of the Ashuaca to the Southeast.

3) Las Tres Cruces minerlized zone

Las Tres Cruces mineralized zone is distributed about 600 m western northwest of Ashuaca school.

As a result of geological survey, intense pyrite dissemination accompanying chalcopyrite are recognized. Furthermore, low resistivity-high FE anomaly "B" is delineated as a narrow and elongated zone with the dirrection of NNE-SSW by IP method electric survey.

This anomaly implies that hidden mineralized zone may exist in the depth of Macuchi Formation.

1-4 La Industria-Yatubi area

Mineralization observed in this area is of two types: namely, hot-spring type Au mineralization and porphyry-copper type mineralization. In the former type of mineralization, a white argillized zone (kaolin) and a silicified zone are distributed in the lower and upper parts respectively. Across the two zones, network veins are recognized, which consist of metallic sinter-acicular minerals-hematite-quartz-kaolin. The assay result shows the maximum Au content of 0.3 g/t. The silicified outcrops are recognized only at the top of mountains (Cerro Barranco Amarillo and Caimito South), the silicified zone turns downward to the kaolinized zone which were observed below the mountaintop. The silicified zone is, therefore, considered to be eroded largely, and the silicified parts at the mountaintop to be the relics of the lower part of the silicified zone.

An alteration zone, which consists of sericitization and weak silicification, is also accompanied by pyrite. This alteration is probably associated with the porphyry copper type mineralization in the northern part of the area.

1-5 Las Guardias area

Mineralization of the porphyry copper type is recognized at 12 locations, all of which are distributed along melanocratic diorite intrusive rocks and a fault in the direction of NW-SE. This direction is in a marked contrast to the NE-SW direction of the mineralization zones and intrusive rocks in other areas. Extension of each mineralized zone is less than 100 m, small in scale and discontinuous in surveyed area.

1-6 Other areas

Other areas include following seven areas: Tres Hermanas area; San Miguel area; Sicota area; Tambillo area; Tablas Pamba area; Balaron area; and Chilcales Alto area. Mineralized zone of each area was small in scale and low in grade.

Chapter 2 Recommendation for the future survey

Based on the findings of Phase I, Phase II and Phase III surveys, the following recommendations are made for the future survey.

(1) Osohuayco zone, Balzapamba area (Fig.III-2-1)

The Osohuayco North mineralized zone, mineralized outcrops of which are confirmed through geological survey of Phase III, is extensive in scale and comparatively high grade in copper content.

This mineralized zone occurs in hornblende-biotite granodiorite (Gd). Distribution area of these mineralized outcrops corresponds with the IP anomaly area delineated on the high resistivity-high FE values of Phase II geophysical survey.

Therefore, drilling survey is recommended to disclose the condition and extent of mineralization in detail, the locations of which are shown in Fig.III-2-1. For example, 300 m deep X 2 holes in Osohuayco North mineralized zone.

(2) Northeast zone, Telimbela area (Fig.III-2-2)

"The Ashuaca mineralized zone", which is confirmed thoroughly by Phase III geological, geophysical and drilling survey, is extensive in scale and high in grade of metal (copper) content. This mineralized zone is also peoved to have close relationship of distribution with hornblende quartzdiorite (HQd). Adding this, potential areas have been delineated around "Ashuaca mineralized zone".

Furthermore, through geophysical survey, IP anomlies are distinguished in the depth of "Ashuaca mineralized zone" where recognized are chain of mineralized outcrops.

Therefore, drilling survey is recommended to disclose the condition and extent of mineralization in detail, the locations of which are shown in Fig.III-2-2 . For example, 200 m deep X 3 holes in "ashuaca mineralized zone"; 200 m deep X 2 holes in Ugshacocha mineralized zone; and 200 m deep X 1 hole in Las Tre Cruces mineralized zone.

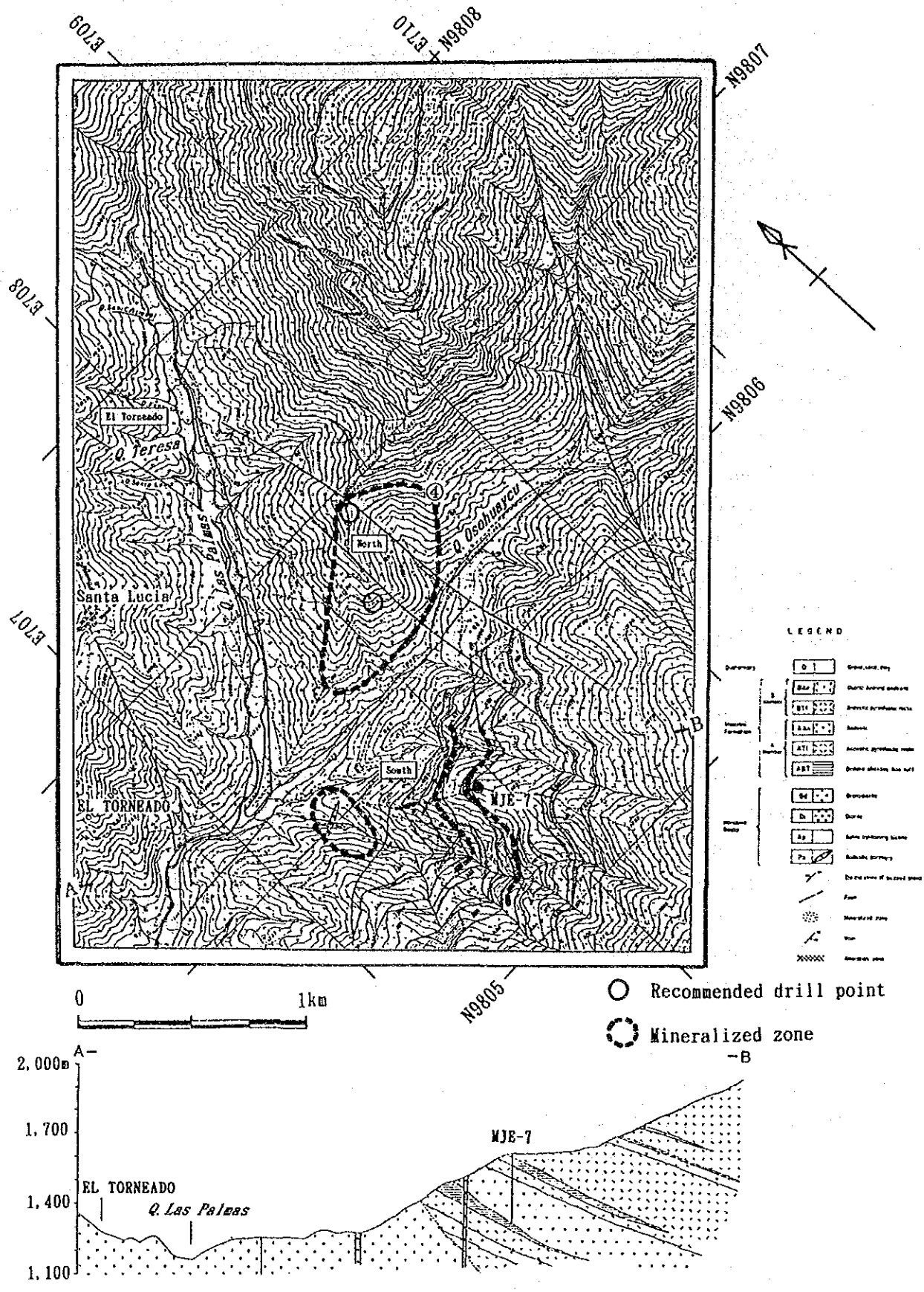


Fig. Ⅲ-2-1 Recommended area for future survey of the Osohuayco zone, Balzapamba area

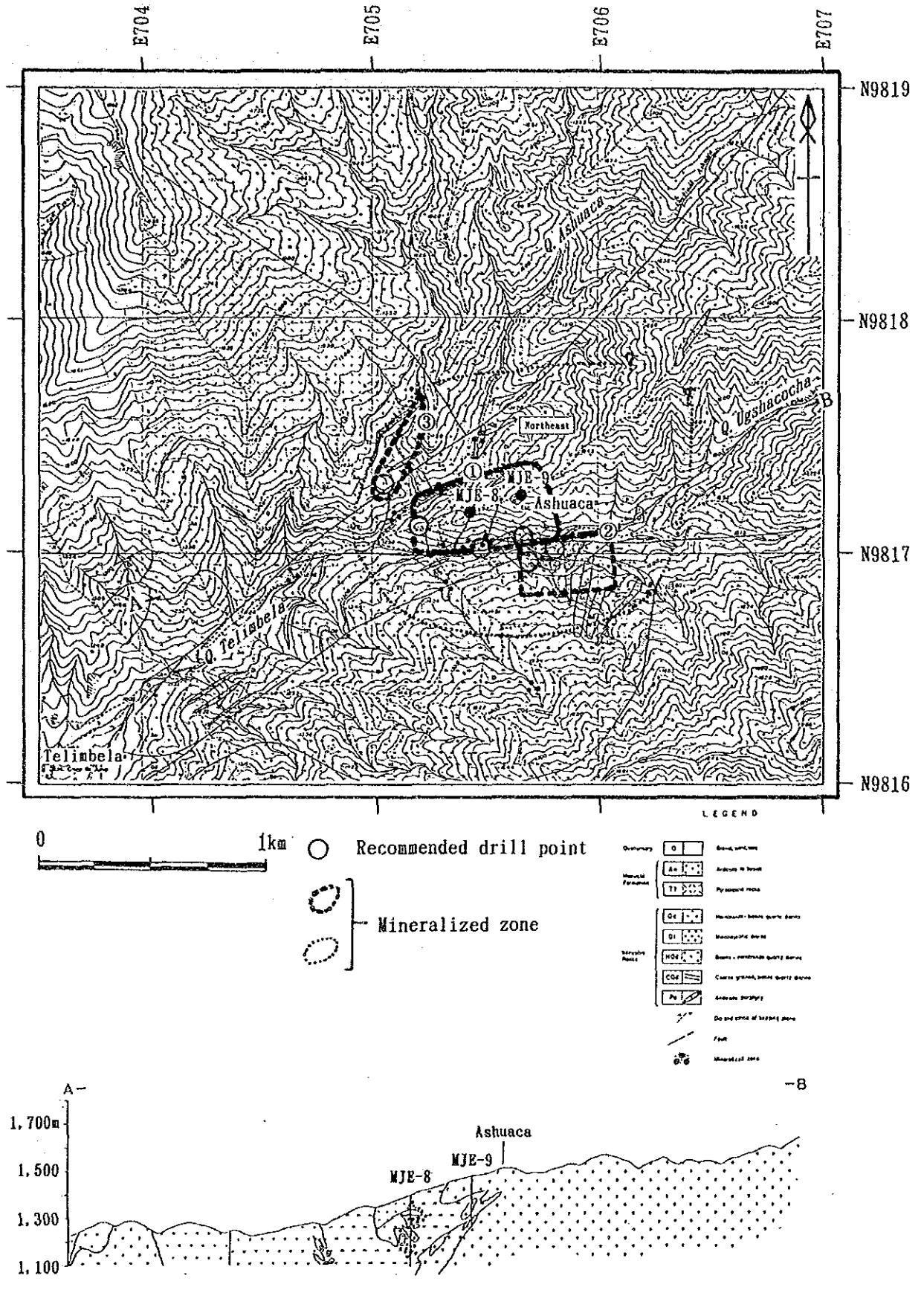


Fig. Ⅲ-2-2 Recommended area for future survey of the Telimbela area

REFERENCES

1. Bamba, T. y Herrera, J. (1966): Perfil Geologico de los Andes Ecuatorianas, Bull. Geol. Surv. Japan, 17, 18-42 (in Japanese with Spanish and English abstracts)
2. Direccion General de Geologia y Minas/Ministerio de Recursos Naturais y Energeticos (1979): Regional Geochemical Exploration in Western Central Ecuador, 1-19
3. Direccion General de Geologia y Minas/Ministerio de Recursor Naturais y Energeticos (1979): Geochemical, Geophysical and Geological Investigations in Telimbela, Bolivar Province, Western Central Ecuador, 1-34
4. Direccion General de Geologia y Minas/Ministerio de Recursos Naturais y Energeticos (1979): Geochemical, Geophysical and Geological Investigations in San Miguel, Bolivar Province, Western Central Ecuador, 1-18
5. Fairbridge, R. W. (1975): The encyclopedia of World Regional Geology, Part 1: Western Hemisphere, Dowelen, Hutch. Ross., 261-270
6. Farrell, C. W. (1978): Report on the Examination of the La Plata Mine, Ecuador, 1-18
7. Feiniger, T. (1977): Simple Bouguer Gravity Anomaly Map of Ecuador (1:1,000,000)
8. Goossens, P. J. (1969): Mapa Indice Mineralogico del Ecuador (1:1,000,000)
9. Goossens, P. J. (1972): Metallogeny in Ecuadorian Andes, Econ. Geol. 458-468
10. Goldstein, M. A. and Strangway, D. W. (1975): Audio Frequency Magnetotelluric with a Ground Dipole Source. Geophysics vol. 40, p. 669-684.
11. Hall, M. L. and Calle, J. (1982): Geochronological Control for the Main Tectonic-Magmatic Events of Ecuador, Ear. Sci. Rev., 18, 215-239
12. Henderson, W. G. (1979): Cretaceous to Eoceoe Volcanic are activity in the Andes of northern Ecuador, JI. Geol. Soc. Lond. vol. 136, 367-378
13. INEMIN: Analisis de los Trabajos de Exploracion Realizados en el Centro Occidente del Ecuador (Proyecto Bolivar), 1-28
14. INEMIN (1986): "resumes of 9 projects"
15. INEMIN (1987): Mining in Ecuador
16. Kürzl, M. (1988): Exploratory Data Analysis: Recent Advances for the Interpretation of Geochemical Data, J. Geochem. Explor. 30, 309-322

17. Lepeltier, C. (1964): A simplified Statistical Treatment of Geochemical Data by Graphical Representation, Econ. Geol. 64
18. Minera Toachi S. A. (1982): Estudio de Factibilidad, Resumen, Volumen 1-4 La Plata
19. Ministerio de Recursos Naturais y Energeticos/Direccion Generl de Geologia y Minas (1969): United Nations Development Programme, Survey of Metallic and Non-metallic Minerals, 1-68
20. Ministerio de Recursos Naturais y Energeticos/Direccion General de Geologia y Minas (1979): Mapa Geologico del Ecuador (1:100,000) (49-Guaranda, 50-San Miguel, 51-Bucay)
21. Ministerio de Recursos Naturais y Energeticos/Direccion General de Geologia y Minas (1980): Mapa Metalogenico del Ecuador (1:1,000,000)
22. Ministerio de Recursos Naturais y Energeticos/Direccion General de Geologia y Minas (1982): Mapa Geologico Nacional del Ecuador (1:1,000,000) (Spanish and English)
23. Ministerio de Recursos Naturais y Energeticos/Direccion General de Geologia y Minas (1982): Geology of Ecuador, 1-69
24. Ministerio de Recursos Naturais y Energeticos/Direccion General de Geologia y Minas (1982): Informativo Geologico Minero
25. Ministerio de Recursos Naturais y Energeticos/Direccion General de Geologia y Minas (1982): Proyecto Chaso Juan, 1-43
26. Ministerio de Recursos Naturais y Energeticos/Direccion General de Geologia y Minas (1982): Proyecto Balzapamba, 1-23
27. Ministerio de Recursos Naturais y Energeticos/Direccion General de Geologia y Minas: Ecuador Hacia el Desarrollo Minero, 1-91
28. Miyako, T. (1974): Characteristics of Chaucha Porphy Copper Deposit, Ecuador, Mining Geol., 24, 129-135 (hn Japanese with English abstract)
29. MME/DNPM (1978): Tectonic Map of South America (1:5,000,000), Explanatory Note 1-21
30. Overseas Technical Cooperation Agency (1963): Report on the Investigation of Ore Deposit at the Macuchi Mining District in Cotopaxi Province of Ecuador, 1-31 (P1.12, Fig. 15)

31. Puig, C. A. (1984): Ecuador-not only oil, but also mining, Mining Magazine, 588-591

32. Sauer, W. (1970): Geologische Karte von Ecuador (1:1,500,000)

33. Servicio Nacional de Geologia y Mineria/Ministerio de Industrias y Comercio (1969): Mapa Geologico del Ecuador (1:1,000,000)

34. Sinclair, A. J. (1974): Selection of Threshold Values in Geochemical Data Using Probability Graphs, J. Geochem. Explor. 3, 129-149

35. Stewart, J. W., Evernden, J. F. and Snelling, N. J. (1974): Age Determination from Andean Peru: A Reconnaissance Survey, Geol. Soc. America Bul. 85, 1107-1116

36. White, W. H., Bookstrom, A. A., Kamilli, R. J., Ganster, M. W., Smith, R. P., Ranta, D. E. and Steininger, R. C. (1981): Character and Origin of Climax-Type Molybdenum Deposits, Econ. Geol. 75th Anniversary Volume, 270-316