Chapter 5 Ground truth

5-1 Selection of survey zones

5-1-1 Selection of potential zones based on analysis of the existing data on geology and ore deposits

First, in the selection of survey zones, among 46 zones dense with deposits as shown in Table II-5-1-1, the following 20 zones that had little relationship with porphyry copper or copper/gold deposits, epithermal gold deposits, polymetallic vein deposits or SEDEX lead/zinc deposits, all of which had been selected as the targets for the reasons mentioned above, were excluded from the survey.

① Zones dense with the Ordovician sedimentary phosphate deposits: Zones 06 and 25

② Zone dense with REE (rare earth element) deposits in carbonatite dikes: Zone 20

③ Zones dense with borate / salts in evaporite : Zones 21, 29 and 30

④ Zones dense with uranium / vanadium deposits existing in the Cretaceous Yacoraite Formation : Zones 35, 36 and 37

⑤ Zones dense with deposits of rare metals such as Nb, Ta and Be in pegmatite: Zones 32, 33 and 40

⑥ Zones dense with placer deposits: Zones 04 and 19

⑦ Zones dense with Sn or W deposits that were generated at relatively high temperature and are expected to have little relationship with porphyry copper deposits: Zones 13, 14 and 44.

⑧ Zones dense with Pb/Zn/Ag vein deposits with Precambrian/Cambrian wall rock before the generation of SEDEX lead/zinc deposits: Zones 16, 23 and 41

From the remaining 26 zones, 21 zones, or a total of 36 places (of mineral showings), were selected as zones to be covered by the field survey of this fiscal year.

5-1-2 Extraction of highly potential zones based on the analysis of satellite images

Fig. I-5-1-2-1 shows distribution obtained by making a buffer zone that covers the place within 3 km from the alteration zone discriminated by the ASTER and the LANDSAT TM to emphasize this distribution area, and, then over this emphasized one, putting the major tectonic line and distribution of the known deposits (epithermal deposits and porphyry-type deposits). As a result of this operation, it is found that the outlined alteration zones are distributed more in four zones where Tertiary volcanic rocks extend NE and SE and in the extension of these zones. The major tectonic line is also along these NE-SW tending zones of Tertiary volcanic rocks and in their extension. The distribution of these zones is considered important as a zone with active igneous activity and also important because it can serve as a hot water passage tectonically. It is hoped that this area will be surveyed in detail in the next stage.

5-1-3 Selection of high-potential zones based on the analysis of aerial physical exploration data

In the analysis of airborne geophysical exploration data, some processings were carried out regarding airborne magnetic data (total magnetic force (M), reduction to the pole (RTP), and airborne radioactive data (the total count, potassium (K), thorium (T) and uranium (U)). Pprocessing type for RTP (reduction to the pole) are first vertical derivative, second vertical derivateive and horizontal first derivative, and those for radioactivity are the K/T ratio, the K/(K+T+U) ratio and color composition (RGB = KTU).

From characteristics of the results of these analyses, consideration was made regarding guides for extraction of places with a high potential for epithermal and porphyry-type deposits in the present stage. As a result, relatively good consistency with distribution of the known deposits is shown in the distribution range of short-wavelength structures found in magnetic data, and places with a high ratio of potassium to thorium (Fig. II-5-1-3-1) and those with a high ratio of potassium to potassium plus thorium plus uranium (Fig. II-5-1-3-2) found in the radioactive data. Therefore, these have a possibility as a guide to show high-potential area. The short-wave length structures in magnetic data correspond almost entirely with the distribution of Tertiary volcanic rocks.

In addition, what is interesting as a high-potential place from the viewpoint of the possibility of prospecting is zones that are ranges of short-wavelength structure found in the magnetic data and where distribution of Tertiary volcanic rocks does not exist or is not known, and zones where, in spite of the presence of gravity structure of a long cycle conversely, distribution of intrusive rocks on the surface layer does not exist or is not known. In particular, the latter is considered important partly because the existence of the rock body in the deep part is expected as a source supplying mineralization.

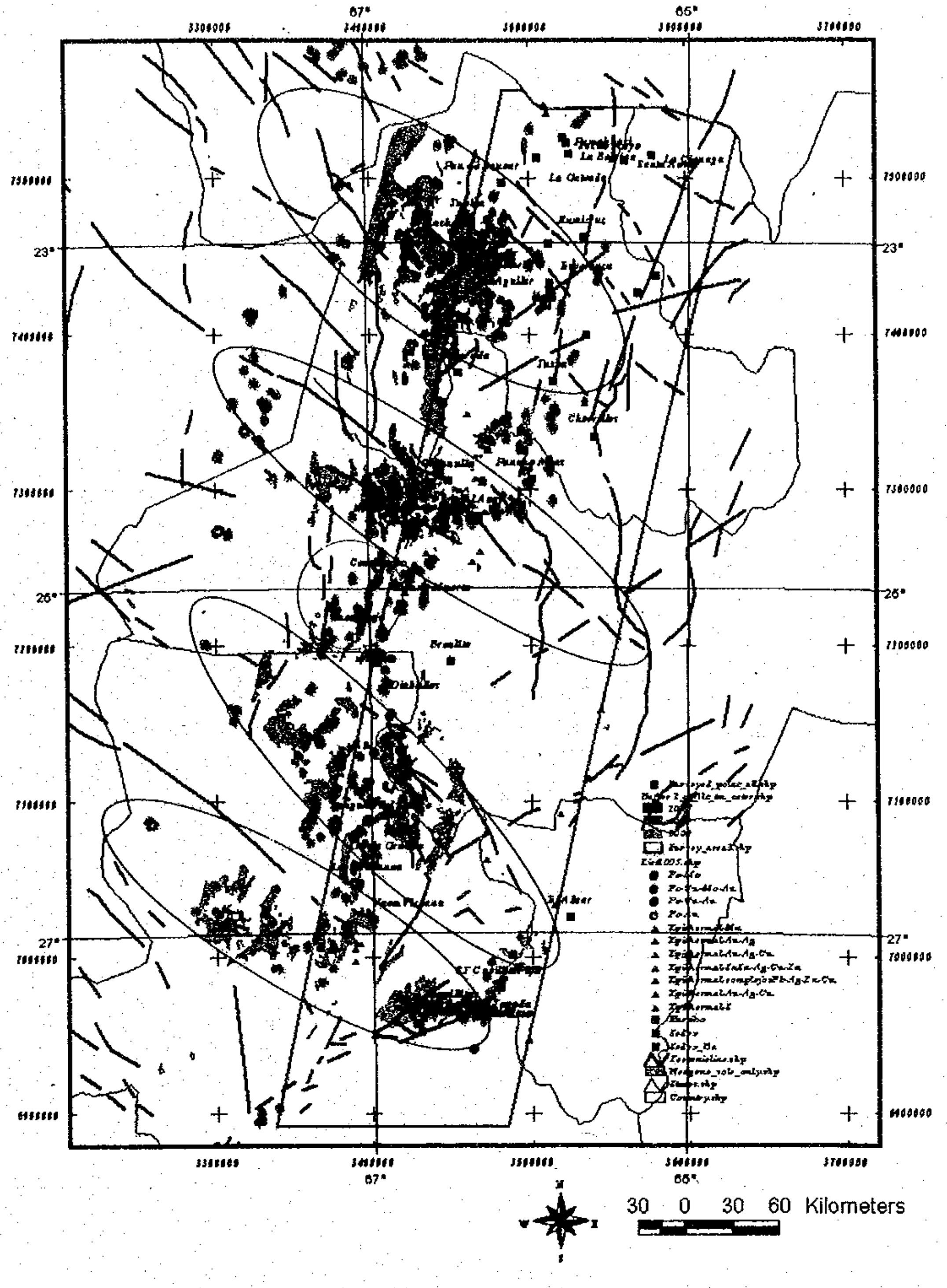


Fig.II-5-1-2-1 Alteration zone, Neogene Volcanics and promising area

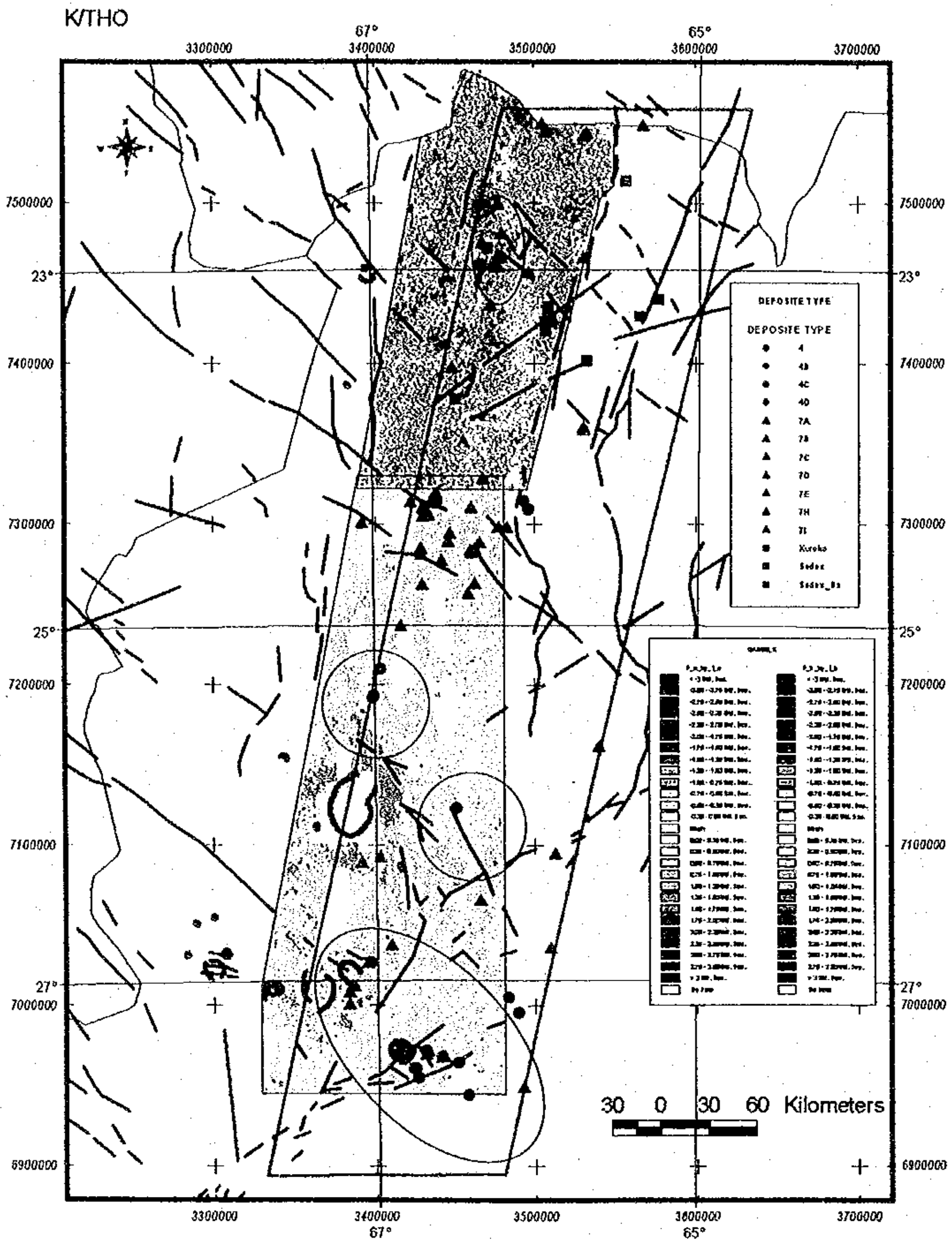


Fig.II-5-1-3-1 Promissing area outlined by airborne geophysical data (radiometoric K/T image)

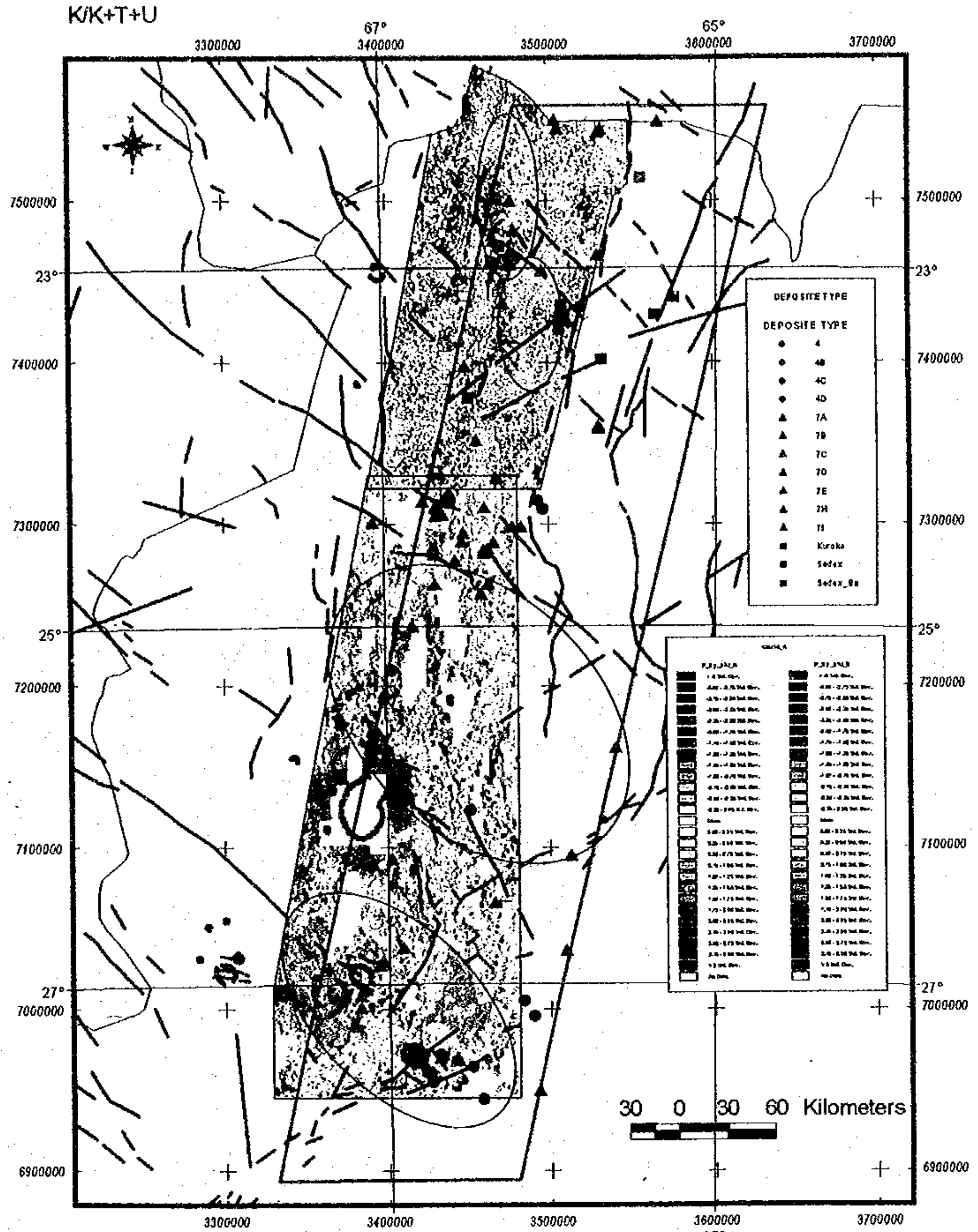


Fig.II-5-1-3-2 Promissing area outlined by airborne geophysical data (radiometoric K/(K+T+U) image)

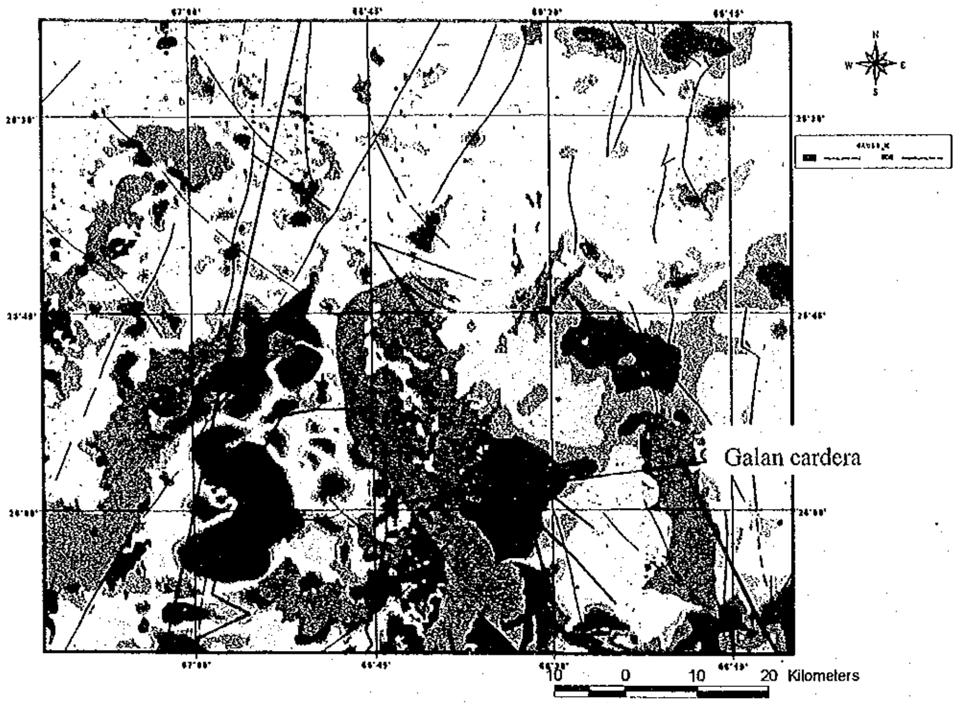


Fig.II-5-1-3-3 RTP image and Neogene Volcanics (Galan cardera area)

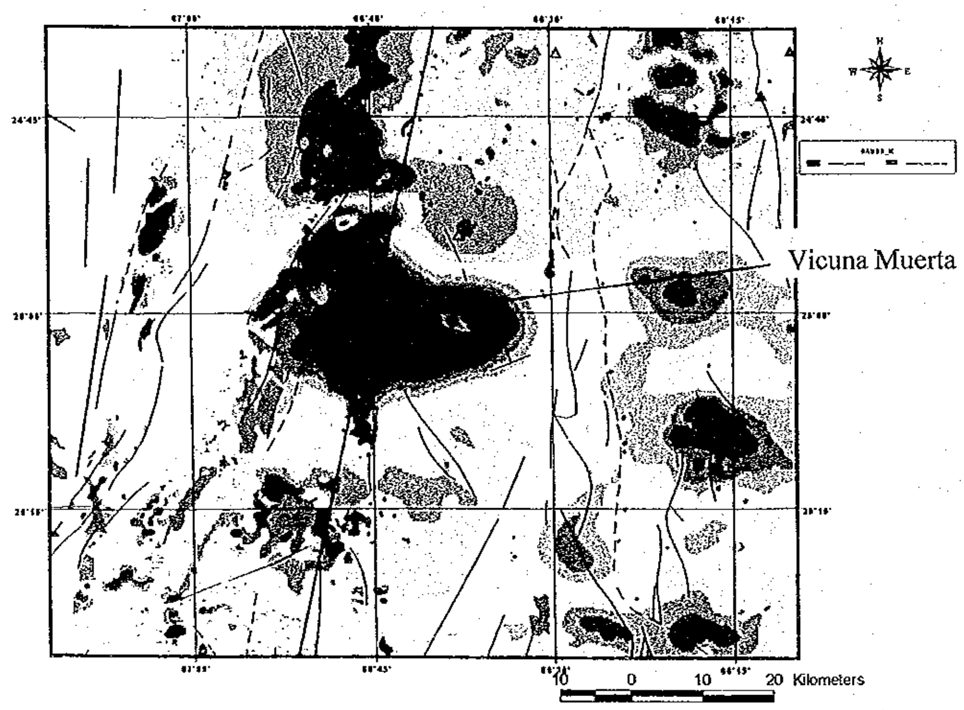


Fig.II-5-1-3-4 RTP image and Neogene Volcanics (Vicuna Muerta area)

5-2 Survey results for each district

5-2-1 La Gateada mineral showings (Zone 1)

1) Location

At 22°22' 23.5" S. Lat. and 65°49' 44.7" W. Long.

La Gateada abandoned mine is located south-southwest of La Quiaca, a town bordering Bolivia, and about 40 km north-northwest of Abra Pampa.

2) Access

After going southward from La Quiaca on National Road 9, driving about 20 km from La Intermedia on Provincial Road 69 and going about 10 km southward on a bad mountain path from the vicinity of the top part of Cochinoca mountains to the end point of the moutain path. It takes a further 30-minute walk to get to the entrance of the adit.

3) Past surveys

1970: The Mining Bureau of Jujuy Province carried out a geological survey. In the report of this survey, there are descriptions of the presence of quartz, pyrite, chalcopyrite, zincblende, galena, chalcocite, covelline, hematite, limonite and psilomelane.

4) Geology and tectonics

According to the geological map "La Quiaca," with a scale of 1 to 250,000, in the whole vicinity there is wide distribution of composite rocks of Cochinoca-Escaya magma and sedimentary rocks of the Upper Ordovician system. The main trend of mineral showings near this place shows approximately a N - S.

Around abandoned adits and in the downstream area, bedded black shale or shale is observed. These shale and shale were collected and analyzed for geochemical study (described later).

5) Mineral showings and alteration

There are abandoned adits on the opposite side of the valley. The adit along the valley shows the direction of S65° E, and bedded shale is exposed near the entrance of the adit. In the upper part of the adit, a quartz and chlorite vein with a width of approximately 30 cm is found developing almost in parallel to bedding of the bedded shale (Fig.II-5-2-1-1(b)). Near the vein, silicification of wall rock is recognized. Abandoned adits located further in the upper part than this adit was used to prospect the same vein.

Microscopic observation of ore sample (A01RT069) shows that it is a part of galena – zincblende – chalcopyrite – pyrite – quartz vein cutting siliceous mudstone. The quartz vein contains siliceous mudstone and cherty wall rock (?) chips that have possibilities of receiving silicification due to mineralization and xenoliths of silicified rock. Recognized ore minerals are anhedral granular zincblende containing liquefied chalcopyrite in addition to coarse anhedral galena, a very small

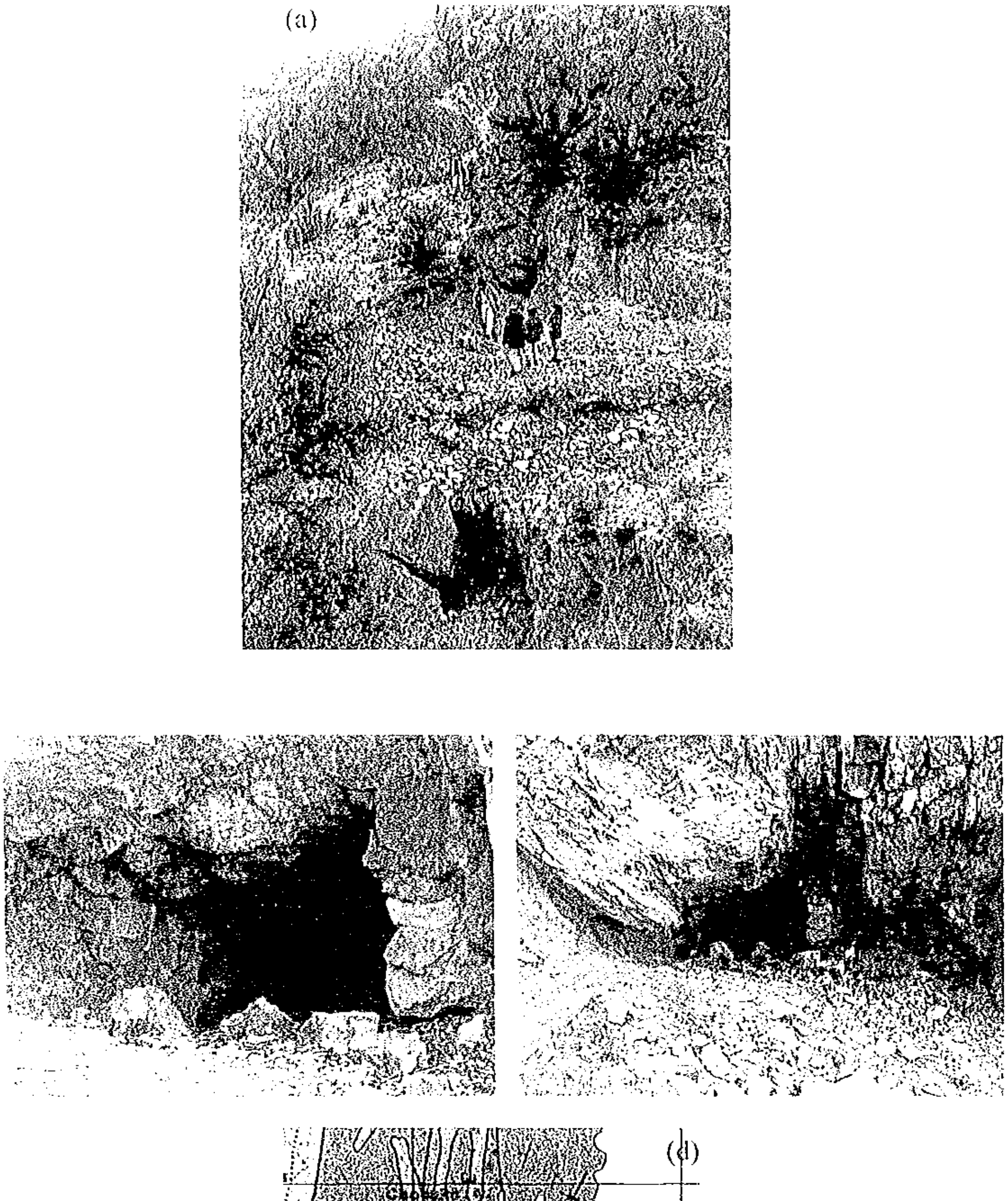


Fig.II-5-2-1-1 La Gateada mineral occurrence

(a) Overview of the occurrence (b) Chlorite-quartz vein (w:30cm) is observed on the entrance of the lower gallery (c) The entrance of upper gallery (d) Geology around the occurrence (Dirección Nacional del Servicio Geológico, 1999) amount of anhedral or semi-automorphic granular pyrite and granular chalcopyrite. Automorphic pyrite of fine to midium grain tends to be distributed in wall rock (?) in an impregnating manner.

6) Characteristics of the satellite image

On the false color image, the main N -S trend can be read near the mineral showings in the extension of Cochinoca mountains, but characteristics to specify Gateada mineral showings cannot be recognized.

7) Comment

Because of the small amount of the waste near the adits, it can be estimated that large-scale mining has not been executed. It is judged that there is not a possibility of the presence of vein-type deposits with sufficient economic effect, scale and grade.

8)Reference materials

* Internal report of Dirección Provincial de Minería, Jujuy (1970?)

5-2-2 La Bélgica mineral showings (Zone 2)

1) Location

At 22°22' 16.7" S. Lat. and 65°36' 40.6" W. Long.

La Bélgica abandoned mine is located south of La Quiaca, and about 35 km north-northeast of Abra Pampa.

2) Access

La Bélgica abandoned mine is reached by driving northward from Abra Pampa on National Road 9, entering Provincial Road 69 from La Intermedia, going eastward, and then driving further northward on a mountain path. It takes about 30 minutes from Abra Pampa by car.

3) Past surveys

* 1978 - 1994: The DGFM (Dirección General de Fabricaciones Militares) carried out a geological survey, geophysical exploration (electromagnetic, IP and resistivity) and drillings in Pumahuasi Mining District (PMD) including La Bélgica. As a result of the geophysical exploration, 4 drill holes were made. At three of them, zincblende impregnation was captured (DGFM, 1980b).

* 1993 - 1994: Argentina Mineral Development S.A. generalized Pb-Zn-Ag mineralization in the PMD and hypothesized that this mineralization could represent a northern extension of Aguilar SEDEX zinc and lead deposits. In order to prove this hypothesis, they carried out detailed geological, geochemical and IP electrical explorations. As a result of the detailed geological and the electrical explorations, it was judged that vein-type deposits in the PMD had been generated by movement of massive sulfide deposits. It was also found from the geochemical exploration that the best impregration and

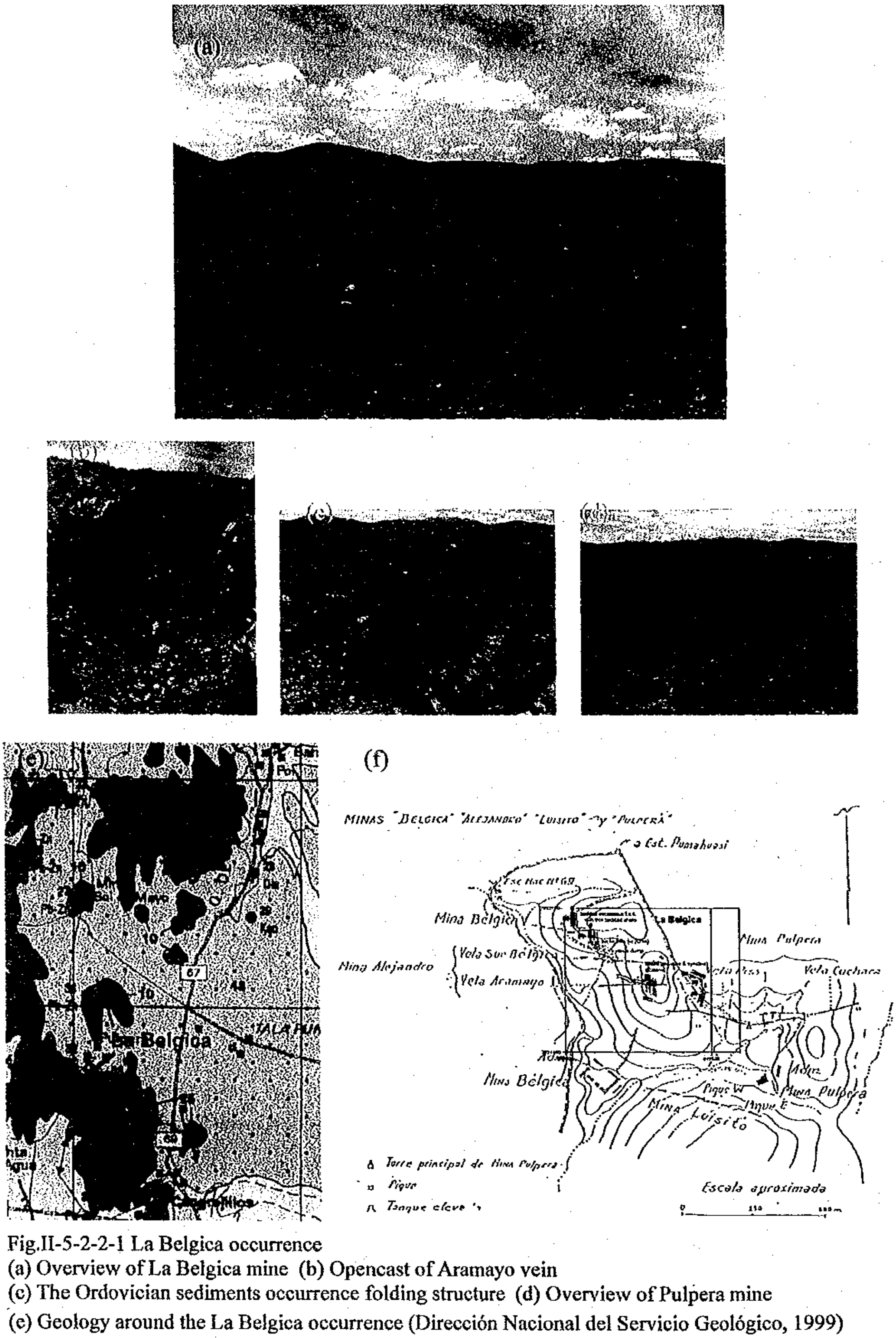


Fig.II-5-2-2-1 La Belgica occurrence
(a) Overview of La Belgica mine (b) Opencast of Aramayo vein
(c) The Ordovician sediments occurrence folding structure (d) Overview of Pulpera mine
(e) Geology around the La Belgica occurrence (Dirección Nacional del Servicio Geológico, 1999)
(f) Survey results added to the sketch diagram of Argentina Mineral Development S.A.(1994)

mineralization on the ground surface is consistent with IP anomaly in the deep part. It was proposed that the only method to confirm the presence of these massive sulfide deposits is drilling. (Argentina Mineral Development S.A., 1994)

4) Geology and tectonics

According to the geological map "La Quiaca" with a scale of 1 to 250,000, in the whole vicinity, there is distribution of an Acoite Formation of the Lower Ordovician that is widely covered by the Pliocene - Pleistocene alluvial sediments. The main trend of the Acoite Formation in the vicinity of the mineral showings shows a N-S direction. Fig. II-5-2-2-1(f) is a deposits sketch attached by Argentina Mineral Development S.A. (1994) with the results of this survey added. As is clear in this figure, geology in the vicinity is formed by bedded fine-grain sandstone and siltstone accompanied by a thin bedded shale, and fine-grain sandstone near Mina Bélgica vein is micaceous. Segal et al. (1999) considers that the geology in the whole vicinity is the Acoite Formation of the Ordovician. Generally, the strike is N - S and the dip is vertical but, toward the southwest, near Aramayo vein in Mina Alejandro, the dip changes and shows an anticline or syncline with an axis in the N - S direction (Fig. II-5-2-2-2(e)).

5) Mineral showings and alteration

According to the DGFM (1980b), Bélgica mine and adjoining Alejandro mine exist in a zone with an area of about 0.3 km^2. The main minerals are galena, zincblende, pyrite, chalcopyrite, limonite, cerussite and anglesite. Barite, ankerite, quartz and limonite exist as gangue mineral. It is described that the total production of lead concentrate at Bélgica mine was 18,000 t and 20,000 t in the period between 1914 and 1921 and the period between 1927 and 1937, respectively.

In this survey, an abandoned mining place for Aramayo vein in Alejandro mine was observed, in addition to a small-sized abandoned mining place for the main vein in Bélgica mine (Fig. II-5-2-2-1(a,b,c,d)). Both veins show an E - W direction and perpendicular to the bedding plane of the host rock. Wall rock (A01RT064) is siltstone and mudstone, which present a clearly striped structure, and is composed of very fine fragmental grains of quartz, plagioclase, etc., and authigenic illite (schistose). A very small amount of fragmental anhedral very-fine grain pyrite is observed. In addition to these, there is coarse-grained pyrite, which forms pool-like or pocket-like irregular and granular aggregates. Surrounding the pyrite, coarse-grained quartz, calcite and coarse-grained sericite are generated, although the amount is small.

6) Characteristics of the satellite image

On the TM false color image, the Ordovician sediments trending N - S and alluvials covering the sediments can be read, but it is difficult to specify places of mineral showings.

7) Comment

It is judged from the existing materials, mineral showings in the abandoned mining places on the ground surface and conditions of debris piling sites that this mineral showings itself is not worthy of evaluation.

8) Reference materials

5-2-3 La Pumahuasi mineral showings (Zone 2)

1) Location

At 22°17' 12.5" S. Lat. and 65°36' 13.4" W. Long.

La Pumahuasi abandoned mine is located about 16 km south of La Quiaca.

2) Access

It takes about 30 minutes to drive southward about 20 km on National Road 5 and Provincial Road 12 from La Quiaca to an abandoned mining place beside the road. Access is good.

3) Past surveys

* Early in the 20th century: Mining activities were started.
* - around 1937: Production
* 1978 - 1979: The DGFM carried out geological, geophysical (electromagnetics, IP and resistivity) and drilling explorations in the area including La Pumahuasi mineral showings.
* 1993 - 1994: Argentina Mineral Development S.A. carried out detailed geological, geochemical and IP electrical explorations in the PMD.

4) Geology and tectonics

According to Segalet et al. (1999), wall rock of the ore deposits in the PMD is oceanic sedimentary rocks in the Ordovician Aconite Formation and a single sequence of alternation of lutite and sandstone strata with a width of 0.10 to 1 m (Pancetti, 1980). Although most of the ore deposits concentrate in a zone with a width of 3 - 4 km and with a total length of 20 km, which stretches in the N - S direction, according to Sureda et al. (1986), no relation to neighboring intrusive rock bodies and effusive rock bodies is seen.

According to the geological map "La Quiaca" with a scale of 1 to 250,000, geology of Mina Pumahuasi zone is composed of the Ordovician Acoite Formation with the Pliocene to the Pleistocene alluvial sediments covering this formation. The detailed structure of the Ordovician system is not clear because outcropping is not observed.

5) Mineral showings and alteration

According to the DGFM (1980b), Mina Pumahuasi is composed of two main veins. Pumahuasi Viejo vein has been mined to the extent of 250 m from the outcrop and down to a depth of

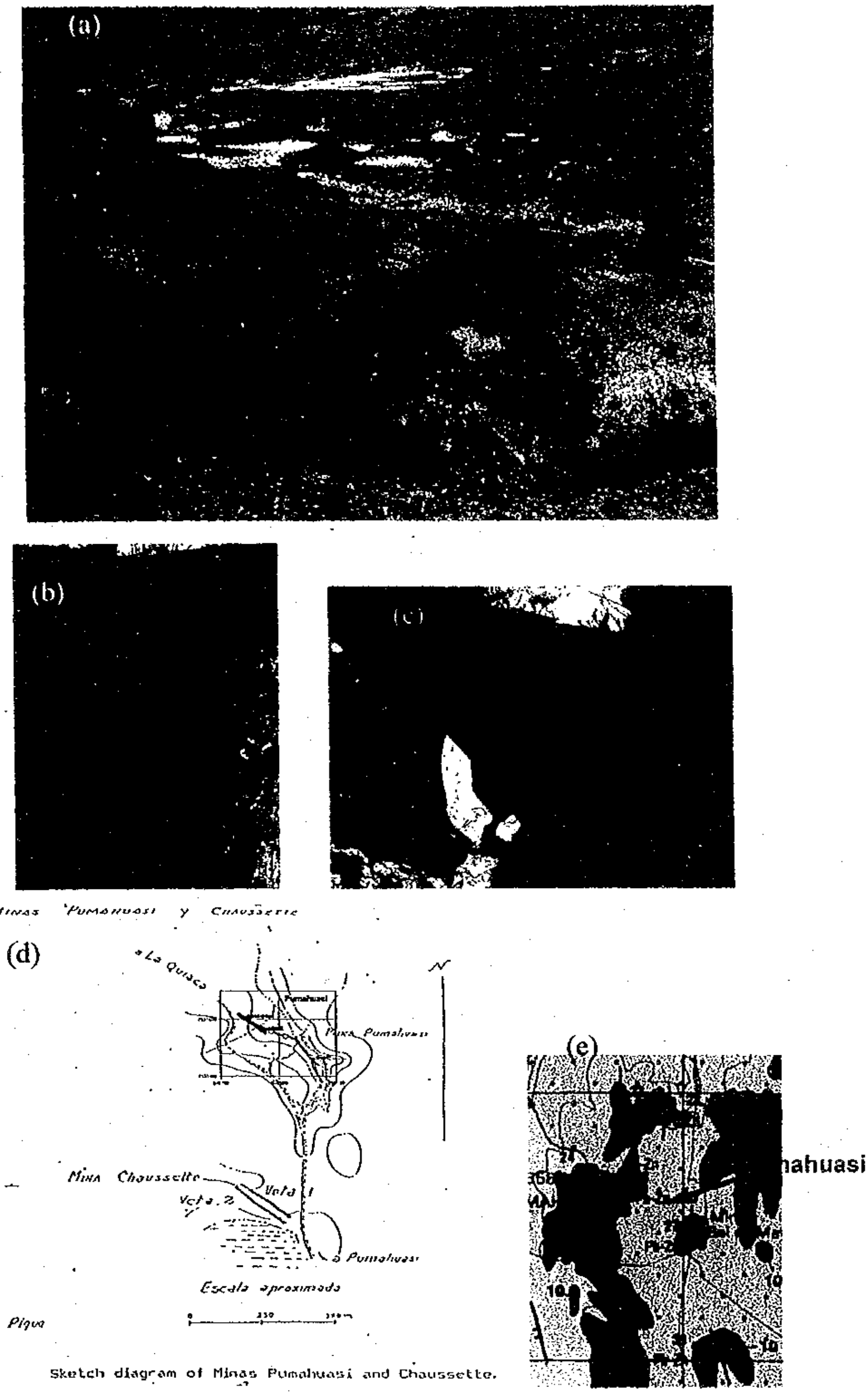


Fig.II-5-2-3-1 Pumahuasi mineral occurrence
(a)Northwest part of the Pumahuasi occurrence (b) Highly weathered host rock observed on the wall of opencast (c) A shaft at the northwestern part of the vein (d) Locations of opencast and shafts on the sketch diagram (Argentina Mineral Development S.A., 1994) (e) Geology around the occurrence (Dirección Nacional del Servicio Geológico, 1999)

350 m. This vein has a strike of N80° W, dip of 80 - 85° NE, and an average vein width of 0.6 to 1.0 m with the maximum width of 3 m. This vein can be confirmed with a vertical shaft. Ores collected from the place near the ground surface are cerussite, anglesite and limonite. In the lower part, galena is dominant (Pb: 14%, Zn: 1%); Pb starts to decrease at the depth of around 250 m, and accompanies Zn of 35% at maximum near the place at a depth of around 350 m. Pumahuasi Nueva vein, located on the west side of a fault in the N - S direction, is relatively lowered due to this fault. It is presumed that this enables the whole oxidized zone to be maintained, and it is said that there is good potential.

Mina Pumahuasi is along the river flowing in flat Pampa, and it only has survival of a vein trench, two vertical shafts, a building foundation and a large-sized debris piling site (Fig. II-5-2-3-1(a,b,c)).

Samples (A01RT065) are sandy mudstone and siltstone where clastic quartz, feldspar and authigenic illite (smectite?) are arranged showing clear lamination. Among these, there is a scattering of pyrite presenting an authigenic or semi-authigenic aggregate cutting this lamination. Some coarse ones form aggregates with the largest diameter of 3 mm. The outer edge of a crystal is characteristically surrounded by illite and seems to be composed of authigenic pyrite generated by a kind of diagenesis.

6) Characteristics of the satellite image

On the false color image, the Ordovician sediments trending N - S and alluvials covering the sediments can be read similarly to La Bélgica mineral showings, but it is difficult to specify places of mineral showings.

7) Comment

It is judged from the existing materials, abandoned mining places on the ground surface and condition of debris piling sites that this ore indication is not worthy of evaluation.

8) Reference materials

5-2-4 Sol de Mayo mineral showings (Zone 2)

1) Location

At 22°18' 8.4" S. Lat. and 65°36' 17.1" W. Long.

Sol de Mayo abandoned mine is located about 20 km to the south of La Quiaca and several kilometers to the south of La Pumahuasi abandoned mine.

2) Access

The Sol de Mayo abandoned mine is reached by going from La Quiaca to Pumahuasi abandoned mine on Provincial Road 12 and then going several kilometers further southward.

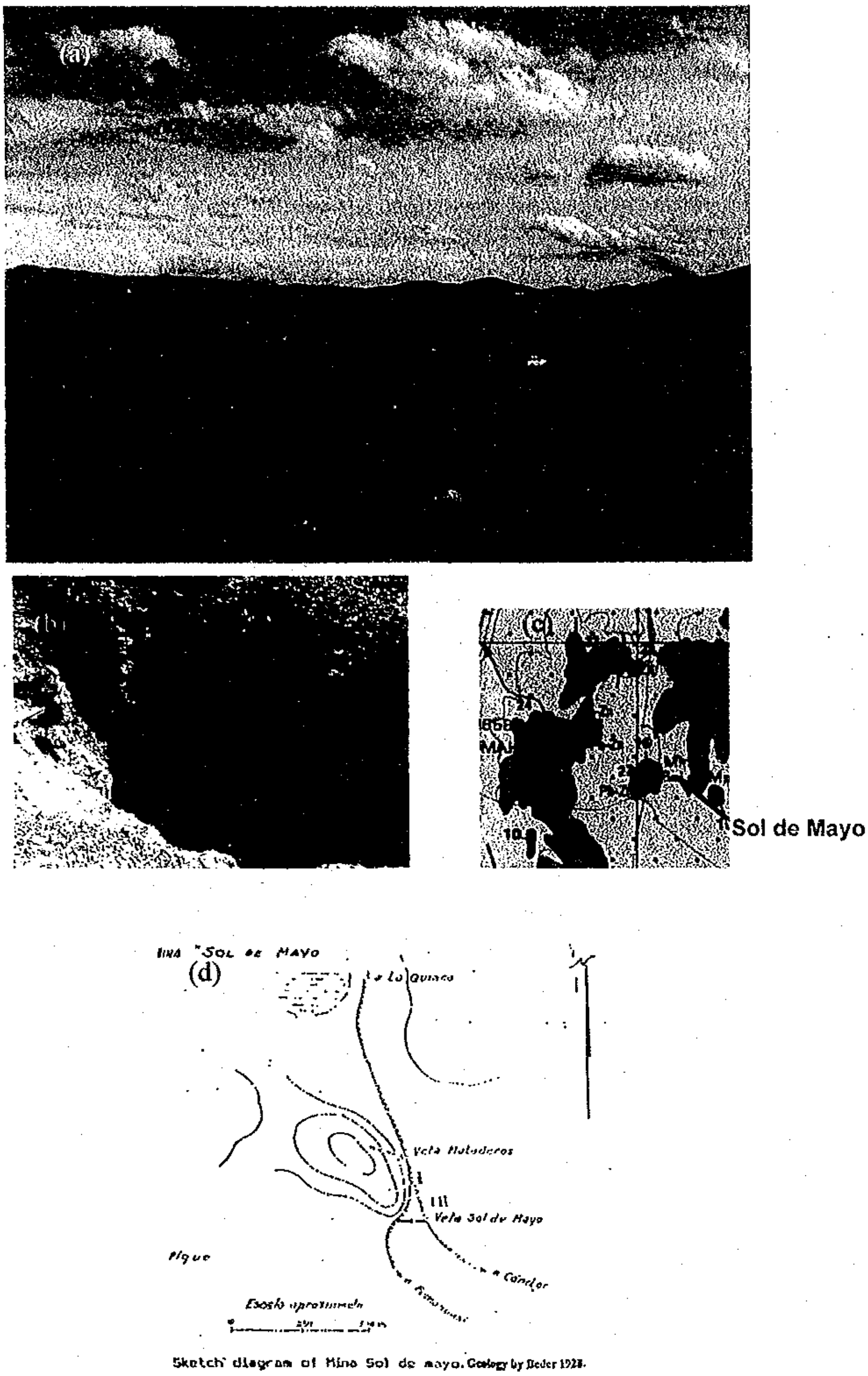


Fig.II-5-2-4-1 Sol de Mayo mineral occurrence
(a)Overview of Sol de Mayo occurrence (b) Bedded Ordovician sediments observed in a pit
(c)Geology around the occurrence (Dirección Nacional del Servicio Geológico, 1999)
(d)Sketch diagram of Sol de Mayo mine (Argentina Mineral Development S.A., 1994)

3) Past survey

* 1920: Mining was started.

* 1940 - 1941: Lead concentrate of 6,000 t was produced.

* 1978 - 1979: The DGFM carried out geological, geophysical (electromagnetic, IP and resistivity), and drilling explorations in the PMD including Sol de Mayo mineral showings.

* 1993 - 1994: Argentina Mineral Development S.A. carried out detailed geological, geochemical and IP electrical explorations in the PMD.

4) Geology and tectonics

According to the geological map "La Quiaca," the geology of the vicinity of this mineral showings is the Ordovician Acoite Formation. There is no deposits outcrop except that in a vertical shaft described later. At the point about 400 m to the northwest of the vertical shaft, there are small-scale outcroppings of bedded siltstone and fine sandstone with a strike of N60° E and dip of 45° NW (Fig.II-5-2-4-1).

5) Mineral showings and alteration

Two almost parallel veins about 250 m apart are observed: Matadero vein in the north part and Sol de Mayo vein in the south part. As underground mining was carried out for both of these veins and they are submerged in water now, it is impossible to investigate. For descriptions and assessment of the ore deposits, there is no way other than to depend on information from the existing literature. Matadero vein has a total length of 120 m, and the main vertical shaft reaches a zone with shift from galena to zincblende at a depth of 150 m (DGFM, 1980b). The most dominant mineralization is shown in zincblende and galena followed by chalcopyrite. Although Sol de Mayo has a vertical shaft to a depth of 280 m, it has fallen in. Probably, mining ended in the place at the depth of around 250 m, which is presumed to be the part with shift from galena to zincblende. There are pyrite, chalcopyrite, cerussite in barite gangue material, ankerite and limonite (DGFM, 1980b).

The presence of a small-sized vein (brecciated barite vein?) cutting bedded and striped fine sandstone and siltstone could be confirmed on the side wall of the vertical shaft. In addition, a small amount of galena was recognized in a barite mass in a neighboring stock pile site (?).

6) Characteristics of the satellite image

On the TM false color image, the Ordovician sediments trending N - S and alluvia covering the sediments can be read similarly to Pumahuasi mineral showings, but it is difficult to specify places of mineral showings.

7) Comment

Judging from the existing materials, and condition of abandoned mining places and waste dump on the ground surface, this ore indication is not worthy of evaluation.

8) Reference materials

5-2-5 Santa Rosa mineral showings (Zone 3)

1) Location

At 22°37' 54"S. Lat. and 66°2' 55" W. Long.

Santa Rosa abandoned mine is located about 50 km southeast of La Quiaca and about 40 km east of La Pumahuasi abandoned mine.

2) Access

Agua Chilca, a colony at the western foot of Santa Victoria Range, is reached by going from La Quiaca on National Road 5 and on an unpaved road along Quebrada de Casti. The Santa Rosa abandoned mine is then reached by going on Provincial Road 69, which runs through Abra del Condor. It takes one hour and forty-five minutes in total by car.

3) Past survey

Details are unknown.

4) Geology and tectonics

According to the geological map "La Quiaca" with a scale of 1 to 250,000, there is distribution of Santa Rosita Formation of the Lower Ordovician, which presents synclinal structure of the NNE -SSW direction in the vicinity.

There is an abandoned trench-like mining large scale near the top part of a gently inclined hill in this mineral showings. Wall rock of ore deposits observed around the trench is bedded phyllite-like rock. As weathered alteration is remarkable, the details are not clear.

5) Mineral showings and alteration

The abandoned mining place shows an inverted-L-shape where a trench with the total length of 60 m in the direction of N50° E crosses a trench with a total length of 50 m in the direction of N30° W. As weathered erosion is remarkable, conditions of the existence of veins in the abandoned mining place are unknown (Fig. II-5-2-5-1).

6) Characteristics of the satellite image

On the false color image, the structure of the Lower Ordovician sediments with a NNE-SSW trend can be read, but it is difficult to specify places of mineral showings.

7) Comment

Judging from the existing materials, and condition of abandoned mining places and remaining minerals in stock pile on the ground surface, this ore indication is not worthy of evaluation.

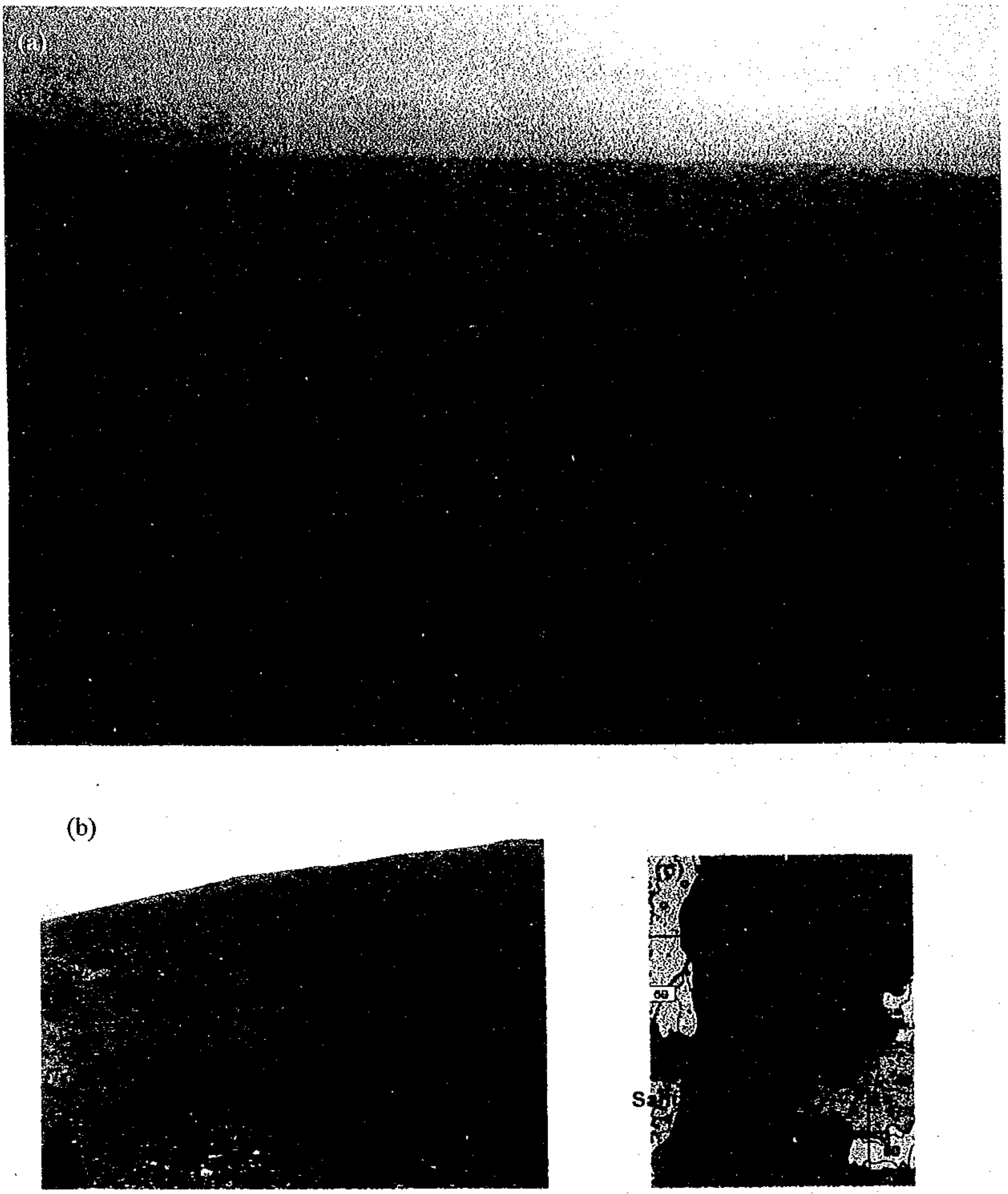


Fig.II-5-2-5-1 Santa Rosa mineral occurrence
(a)Overview of the occurrence located on a gentle hill (b) A large ruin of surface exploitation
(c) Geology around the occurrence (Dirección Nacional del Servicio Geológico, 1999)

8) Reference materials

5-2-6 La Cienaga mineral showings (Zone 5)

1) Location

At 22°23' 17.5"S. Lat. and 65°4' 25.7" W. Long.

La Cienaga abandoned mine is located about 20 km south-southwest of Santa Victoria town, about 25 km east of the Santa Rosa mine and about 70 km southeast of La Quiaca.

2) Access

It takes about two hours to get to this place from the Santa Rosa abandoned mine mentioned above on a bad mountain road 4,000 m above sea level. Access is extremely difficult.

3) Past survey

Details are unknown.

4) Geology and tectonics

According to the SEGEMAR (1999), La Cienaga mineral showings (Index No. 105) are located in Santa Rosita Formation, the lower part of the Santa Victoria Group of the Ordovician. There is volcanic rocks of the Cretaceous Hornillos Formation, which is bordered by a fault in the NE-SW direction, about 1 km to the northwest. Intrusive rocks of the same age are also distributed in the NNW to SSE direction in the vicinity.

The abandoned mining place and the surrounding area are comprised of bedded fine sandstone accompanied by thin siltstone layers, and the periphery of veins received silicification.

5) Mineral showings and alteration

According to the SEGEMAR(1999), the ore deposit is formed of a vein with a strike of N10° W, a dip of 75° W and a width of 20 to 60 cm within a tensile fault in the anticlinal east wing of the Santa Rosita Formation composed of lutite and sandstone. The total length of its outcrop is 150 m. Results of mineralization are galena, a small amount of zincblende, and chalcopyrite and its oxidized minerals. Gangue minerals are barite and quartz only. Silicification and kaolinization are observed in the wall rock near the vein. Reserves of 27,000t (Pb: 4%, Zn: 3.5%) are shown as the result of calculation.

Three entrances of adits were confirmed at two on the south side and at one on the north side of the valley (Fig. II-5-2-6-1). With consideration given to the fact that all adits show similar direction of almost N - S and all veins show similar inclination of westward, it is assumed that these adits were used for mining one plate of the vein. In a adit on the south side along the valley, stringers (with a width of about 20 cm) of barite accompanied by a small amount of malachite are exposed in a small range (Fig. II-5-2-6-1(a,b)).

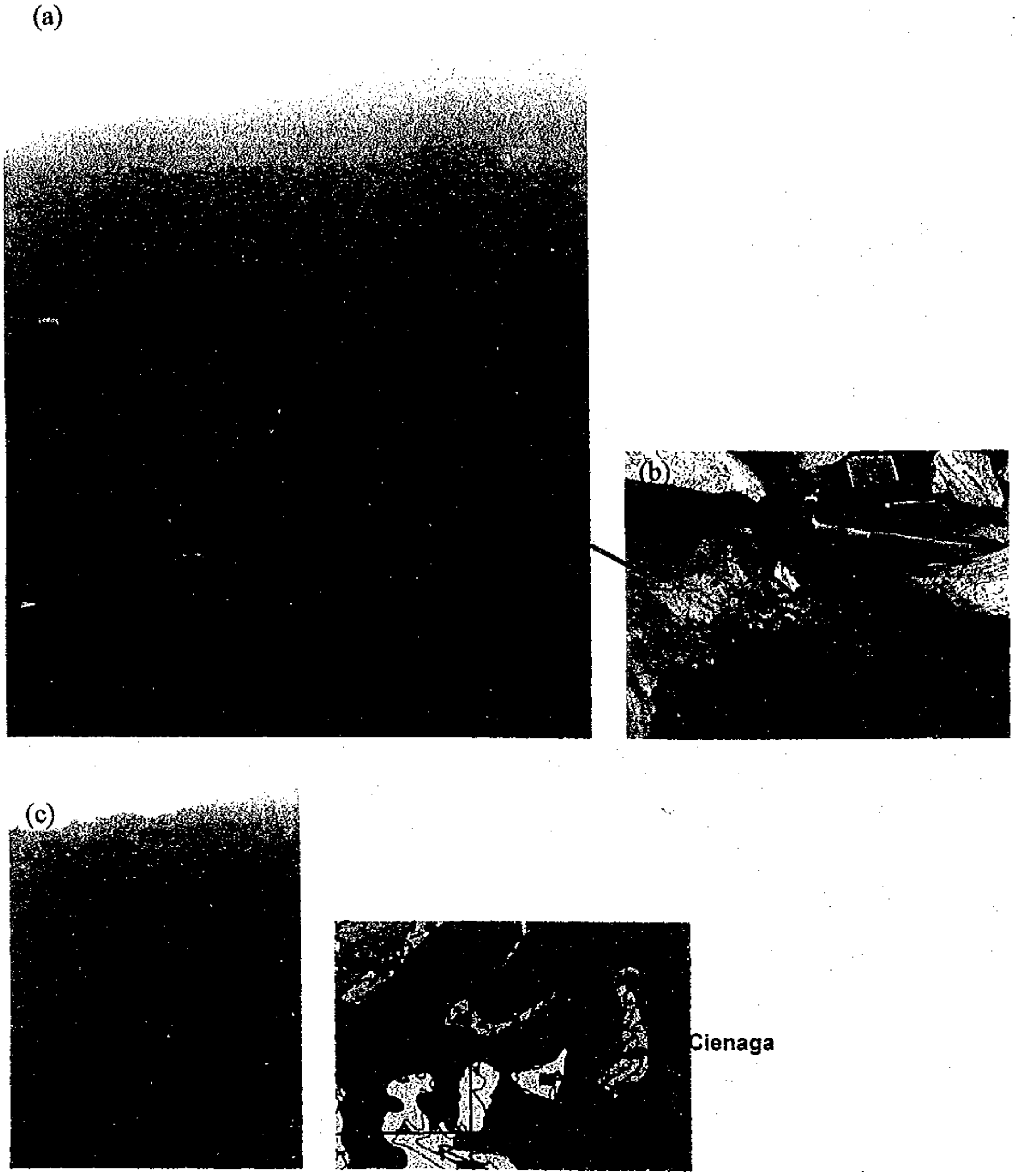


Fig.II-5-2-6-1 La Cienaga mineral occurrence
(a)View of La Cienaga occurrence (b) Quartz vein (w:20cm) with malachite is observed at the entrance of the lower gallery (c) An open gallery occurrence a vein trend (d) Geology around the occurrence (taken from Dirección Nacional del Servicio Geológico, 1999)

The results of microscopic examination of ore sample (A01RT067) collected near the adits show that gangue minerals are made up of siderite (ankerite?) forming a coarse anhedral mosaic aggregate. Although sulfide minerals look replacing in the vein-like form, there is a possibility that these minerals form ores (veins?) on the whole. Pyrite is distributed along veins and often receives fracture, or replacement by chalcopyrite. A large amount of chalcopyrite is produced by fracturing / replacing pyrite, and its production is almost the same as pyrite. A small amount of galena and zincblende are produced in the anhedral irregular amoebic form in chalcopyrite. The order of crystallization is "siderite > pyrite > chalcopyrite > galena > zincblende" and is divided into three stages.

6) Characteristics of the satellite image

On the false color image, a general trend of the Lower Ordovician sediments can be read, but it is difficult to specify places of mineral showings.

7) Comment

Judging from the existing materials and the condition of the abandoned mining places on the ground surface, the ore indication is not worthy of evaluation.

5-2-7 Pan de Azúcar mineral showing (Zone-7)

1) Location

At 22°37' 4.3" S. Lat., 66°3' 16.5" W. Long. and 3,820 m above the sea level (in shaft) This zone is located about 35 km west-northwest of Abra Pampa and about 25 km south of Laguna de Pozuelos.

2) Access

The distance from Abra Pampa on Provincial Road 7 is 61 km, which takes one- and -a-half hours by 4-wheel-drive car.

3) Past surveys and development

* Volume of production in 1975: 33 t, Pb: 7.3 t, Zn: 5.6 t, Ag: 461 g/t (daily output)

* In 1990: The mine was closed (La Empresa Rio Cincel had operated it.). There are records of remaining ore reserves of 59,000 t of the following grade:

Pb: 4.62%, Zn: 6.58%, Ag: 0.224 g/t, Sb: 0.88%.

4) Geology and tectonics

In the northwestern part of Jujuy Province near the Chilean border, there is wide distribution of Neogene Miocene volcanic rocks accompanied by huge resurgent calderas of Pozuelos Depression (12 -14 Ma), Pairique (11.2 Ma), Villama-Coruto (10.7 Ma) and Coranzul (6 - 7 Ma). Caldera

(a)

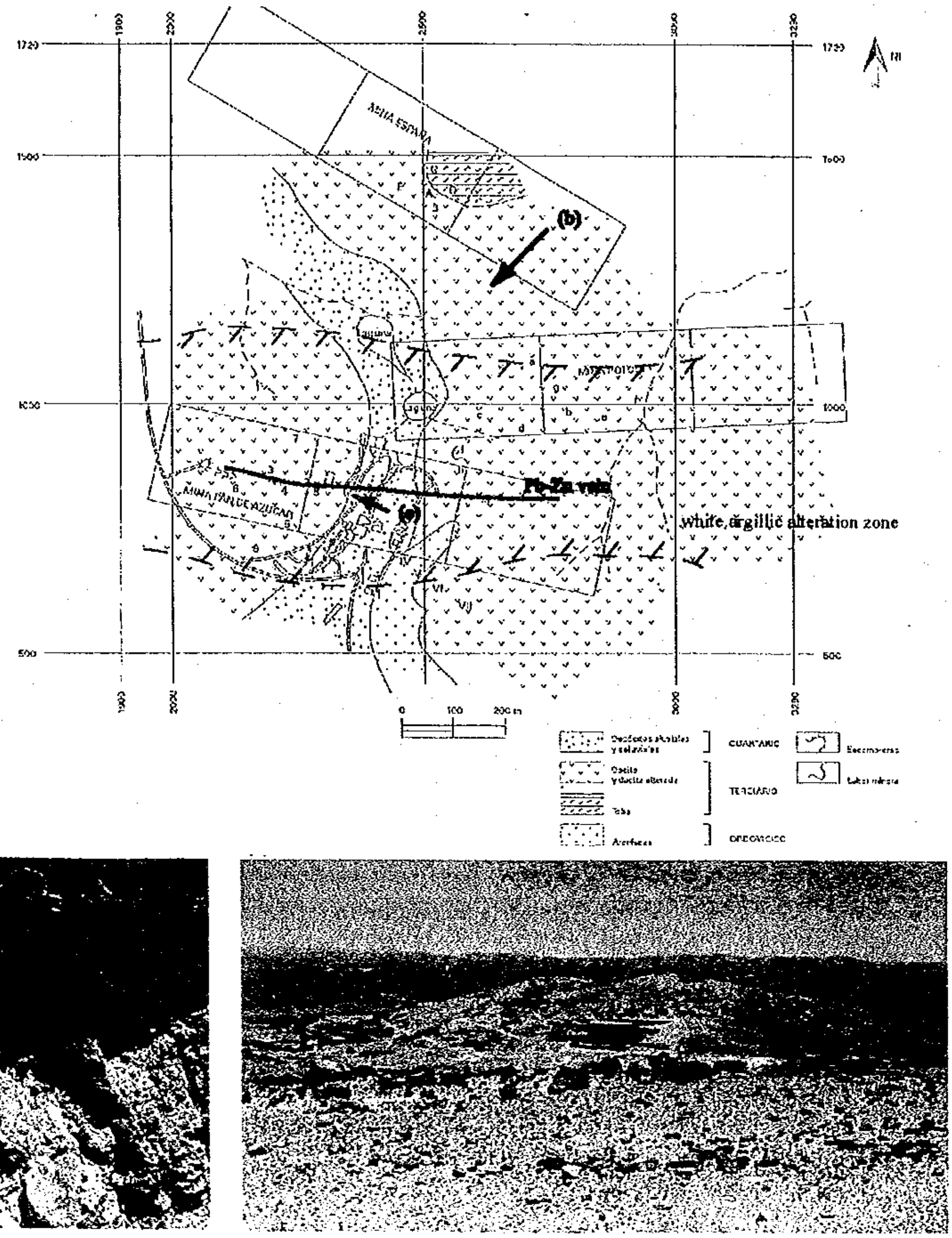
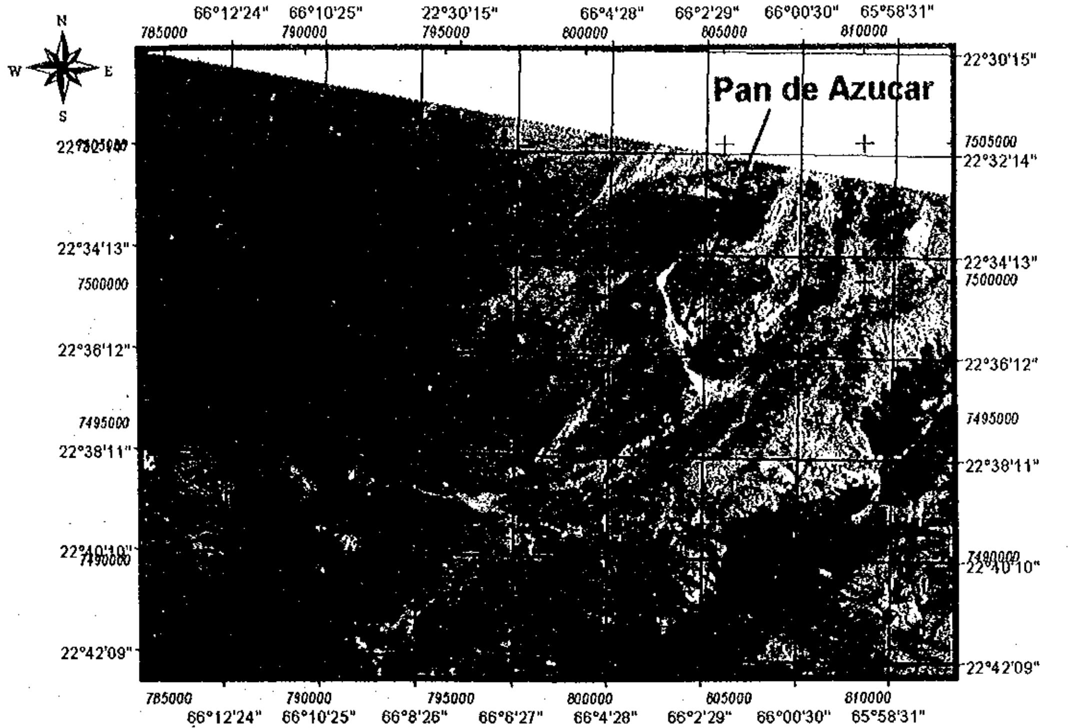


Fig. II-5-2-7-1 Pan de Azucar mineral occurrences

(a)Geological map around Mina Pan de Azucar (taken from Segal and Caffe, 1999)

(b)Overview of Mina Pan de Azucar (c) Goethite vein hosted in quartz-sericite clay



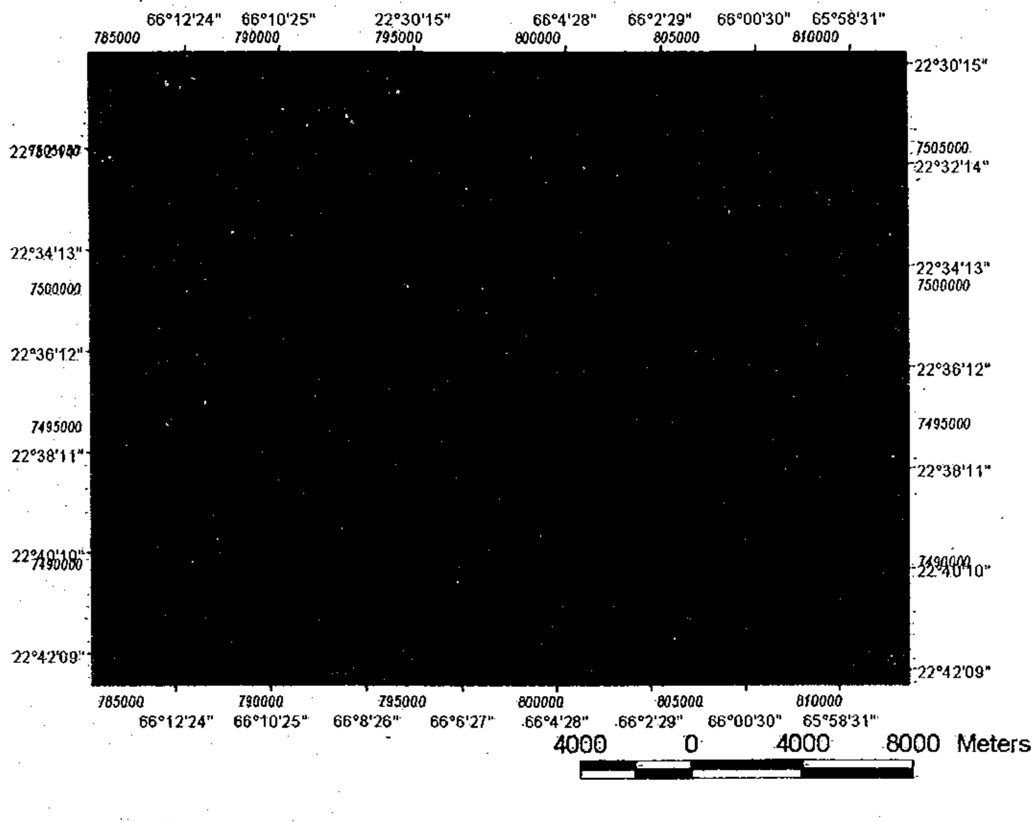


Fig.

Fig. II-5-2-7-2 ASTER image around the Pan de Azucar mineral occurrence

(a)Fales color image (b) IGM image

eruptions are calc-alcali ignimbrite that are rich with K, have a few rock fragments and are crystalline. There are no changes in chemical composition of these volcanic rocks, and they are considered to have been formed from one magma (Coira, 1999). This mineral showings is located at the eastern end of the distribution of Neogene Miocene volcanic rocks and at the southern end of Pozuelos Depression extending south and north from the Bolivian border.

Pozuelos Depression has a graben shape of about 25 km in width and is sandwiched by Sierra de Cochinoca on the eastern side and Sierra de Rinconada on the western side. Both of these mountainous districts are mainly made up of Acoite layer of the Ordovician. In this mineral showings, there is distribution of small-scale andesite/dacite crystalline volcanic rocks (effusive rocks and intrusive rocks) of the post-caldera period. These form Puna at 3,600 above sea level and dome-like projections with a difference in elevation of 100 m named León Cumbre, León Chico, Pan de Azúcar, Curzu and Potosí, which is generally called "Complejo volcanico domico Pan de Azúcar." According to Coira (1999), 12±2 Ma is the age value. This composite rock body intrudes along the annular structure called "Fractura anular del borde austral de la depression de Pozuelos" (Chernicoff et al., 1996). Volcanic stratigraphy corresponds to the lower part of ignimbrite of the Coranzuli volcanic period related to Rachaite mineral showings in the southern part described later (Coira et al., 1998).

5) Mineral showings and alteration

Accompanying Neogene volcanic rocks distributed in the northwestern part of Jujuy state, there are a) epithermal Ag-Au-Sb-Sn-Bi deposits, b) exhalant Sn-Fe deposits, c) exhalant sulfur deposits and d) low-sulfide Ag-Au deposits. Particularly, deposits containing tin exist at the southeastern end of the tin deposit zone which extends from Bolivia and includes Rachite mineral showings described later (Zappettine et al., 2001). In the place about 40 km to the west-southwest of Pan de Azucar, Pirquitas deposits, which are Sn-Zn-Ag deposits, are located. In the distribution area of "Complejo volcanico domico Pan de Azúcar", Mina Pan de Azúcar, Mina Espana and Mina Potosi exist.

Alteration and mineralization in deposits in this zone have been studied in detail, and the following characteristics have been proven. Homogenization temperature of fluid inclusion is 260℃to 280℃, and salt concentration is divided into three types, 1.8%, 17% and 33 % NaCl eq. Enargite, highly sulfureted minerals of luzonite, and tin minerals such as cassiterite, stannite, hexastannite are produced, and the grade of tin is high (the highest: 1.1%). Telescoping is not observed. Because of this, alteration and mineralization have a characteristic of minerals ranging from those largely associated with magma to those largely associated with meteoric water change.

According to Segal and Caffe (1999), Jesuita Vein, which was dug is 1 to 8 m in width, 600 m (+) in horizontal length and 250 m(+) in vertical length and its bonanza is an assemblage of irregular lens-like ore bodies (See Fig. II-5-2-7-1).

This survey was carried out centering around Pan de Azúcar deposits. Although dacite, which is the wall rock of the deposits, has obvious quartz and plagioclase phenocryst, it is mostly displaced by clay minerals due to alteration, and only quartz remains. Alteration to white clay speads about 800 m from east to west and about 300 m from south to north. White clay is composed of quartz and sericite (A01TK035, A01KN037, A01RT071 and A01RT073) and quartz smectite and sericite mixed-layer minerals (A01TK037 and A01RT072). Quartz veins that could be confirmed on the ground surface exist at the disused pit only. Around Mina Potosi, highly silicified rocks are distributed.Mafic minerals and plagioclase are completely leached and polus structure develop and only silicified matrix and quartz phenocryst remain. Though the cubic spread of these silicified rocks could not be confirmed, it is possible to interpret that the contribution of magma was strong and an acid environment existed. This is consistent with the descriptions made above. The results of analysis of quartz veins accompanied by oxidized copper (A01RT070) are as follows: Ag: 1580 g/t, Cu: 2.83%, Pb: 0.16% and Zn: 0.19%. It was found from the microscopic examination of block galena and zincblende (A01KN074-2) that galena was accompanied by wurtzilite and zincblende, and that the space among quartz grains was packed with the colloform or mosaic. Zinc minerals present clear variole composition and rapid growth composition where zincblende in the early time of growth changes to dendritic or fibriform wurtzilite in the latter period. The oxygen isotopic ratio of quartz in quartz veins (A01KN74-3) is 20.5‰, which is very heavy and indicates participation of magma. We tried to measure fluid inclusion packing temperature and salt concentration using the same sample, but no measurable fluid inclusion was observed.

6) Characteristics of the satellite image

Clear annular structure corresponding to "Fractura anular del borde austral de la depression de Pozuelos" (Chernicoff et al., 1996) is observed. It is considered that intrusion of "Complejo volcanico domico Pan de Azúcar" was controlled by this annular structure. On both the color-ratio composite and the iso-grain model image, abnormality was detected in the part corresponding to the alteration zone around Pan de Azúcar (Fig. II-5-2-7-2).

7) Comments

Pan de Azúcar deposits themselves are developed to the deep part, and it is judged that there is no room for prospecting but probably there is room for examination of the surrounding area where intrusive rocks are distributed, the area covered by new sedimentary rocks and ignimbrite. Mineralization in this mineral showings has the same characteristics as the Bolivian tin zone. We think it is necessary to carry out a survey targeting epithermal gold deposits and polymetallic deposits containing gold in this whole zone including Mina Pirquitas.

8) Reference materials

5-2-8 Tupiza mineral showings (Zone 7)

1) Location

At 22°45' 49.4" S. Lat., 66°5' 54.9" W. Long. and 3,820 m above sea level (in the a disused pit mouth)

This zone is located about 40 km west of Abra Pampa and about 35 km south of Lag. de Pozuelos.

2) Access

The distance from Abra Pampa on unpaved Provincial Road 11 is 56 km, which takes about one- and -a-half hours by 4-wheel-drive car.

3) Past surveys and development

This place seems to have been dug until 1985.

4) Geology and tectonics

The periphery of this mineral showings corresponds to the southern extension of Sierra de Cochinoca and has distribution of sedimentary rocks of Cochinoca-Escaya composite magmatic sedimentary rocks (complejo magmatico-sedimentario) (of the Ordovician).

5) Mineral showings and alteration

Mineralization is seen as polymetallic veins in clayslate. Two veins going straight to a NW-SE oriented small valley seem to have been dug on a small scale. Two drifts and a pit, all of which were disused, remain now. Although the bord on the south side collapses at about 15 m from the entrance and therefore cannot be known well, a stringer of N60E, 80E whose width is about 10 cm seems to be prospected by drift. Zinc ores, galena, chalcopyrite, pyrite and pyrrhotite were observed. On the other hand, the bord on the north side seems to be used to dig a vein sandwiched by a white to reddish brown argillized zone of about 6 m in length which exists in clayslate (Fig. II-5-2-8-1). Ores could not be confirmed. In the periphery, there is development of many quartz veins with strike and dip of N45° E and 80° E. These argillized zones, veins and quartz veins are almost parallel with the fissility of surrounding clayslate.

It was found from the result of the microscopic examination of the mine wastes (A01K076) that the main body of ores and minerals was pyrite forming allotrimorphic granular assemblage, and a medium volume of zincblende and small volume of chalcopyrite exist. Pyrite and chalcopyrite include drop-like silver minerals, and zincblende includes disease-like chalcopyrite. Gangue minerals are composed of a large amount of quartz and coherent quartz. As a result of X-ray diffraction of altered sandstone (A01TK038), quartz, plagioclase, chlorite and sericite were identified.

6) Characteristics of the satellite image

On the false color image, the area where volcanic rocks of Cochinoca-Escaya composite

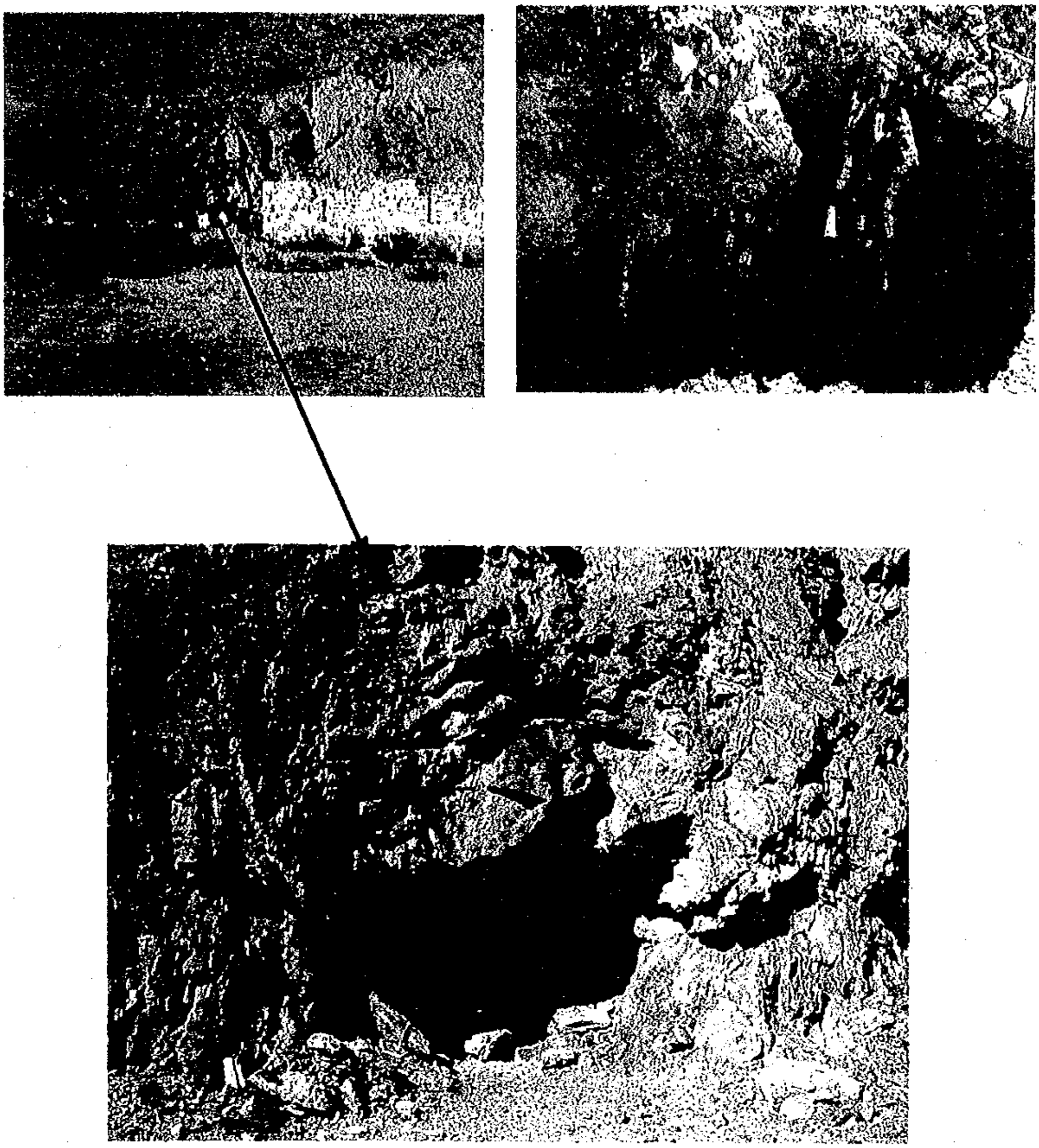


Fig. II-5-2-8-1 Tupiza mineral occurrence

(a)and (c) Occurrence of alteration envelope around sphalerite-chalcopyrite veins

(b)Parallel quartz veins filling cleavages in stale magmatic sedimentary rocks are distributed looks reddish brown, the sedimentary rocks distribution area looks blackish gray and Pirugua Subgrupo of the Cretaceous looks beige. On the border between Pirugua Subgrupo and sedimentary rocks of Cochinoca-Escaya composite magmatic sedimentary rocks located at the north side of Pirugua Subgroup, a lineament showing NE-SW oriented faults is identified. In the distribution area of sedimentary rocks including the mineral showings, the NE-SW system structure reflecting the bedding plane is identified. Alteration zones are not identified on the color-ratio composite and the iso-grain model image.

7) Comments

As far as we could observe, this is a small-scale polymetallic vein of the Ordovician system. The vein itself is small, and the alteration zone is also small. Therefore, it is judged that there is no possibility that deposits with economic effectiveness will be developed.

8) Reference materials

5-2-9 Rachaite mineral showings (Zone 9)

1) Location

At 22°52' 20.1" S. Lat., 66°7' 58.5" W. Long. and 3,950 m above sea level (at the north end of the alteration zone on the east side)
This zone is located about 40 km south of Pan de Azúcar mineral showings.

2) Access

It is accessible by driving a 4-wheel-drive car from Abra Pampa on unpaved Provincial Road 74 and going southward 4 km along Quebrada Liviara. The distance is 58 km, which takes about one-and -a-half hours by car.

3) Past surveys and development

There is a record that lead and zinc were produced in 1950.

4) Geology and tectonics

This zone is located about 25 km northeast of Coranzuri Composite Caldera. According to Seggiaro (1994), Coranzuri volcanic activities are characterized by effusion of dacitic ignimbrite, and a caldera of about 5 km in diameter was formed by the third effusion of ignimbrite. Rachite Volcano was formed in the early time (8-9 Ma) of a series of volcanic activities and is located at the northeast end of the caldera. This survey was carried out in the north half of the alteration zone in the southern part of Mt. Rachite. The survey point was located south of Cerro Rachaite and comprises dacitic lava. The whole southwest part from Rachaite mineral showings to Cerro Coranzuli is widely covered by ignimbrite.

5) Mineral showings and alteration

There are two alteration zones extending south and north which are parallel to Quebrada Liviara. The alteration zone on the west side has a length of about 1.3 km from south to north and width of 4 to 500 m.

The alteration zone on the east side has length of about 3 km from south to north and a maximum width of about 700m from east to west. It forms a steep rise reaching a difference in elevation of about 200 m which is between the south and north valleys. This alteration zone is characterized by alteration to white clay and alteration to limonite. Rocks altered to white clay and surrounding dacite and andesite separate relatively obviously. Andecite with no or weak alteration is melanocratic and has obvious "plagioclase>quartz>amphibole phenocryst." White dacite became breccia and the matrix is filled up by limonite. Survival of dark minerals is not visually confirmed, and plagioclase phenocryst altered to clay is observed. As a result of X-ray diffraction of altered dacite, it can be divided into two groups: one with survival of plagioclase and the other without it (Fig. II-5-2-9-1). The former comprises quartz and plagioclase (plus potassium, chlorite, and sericite/montmorillonite mixed-layer minerals) and is distributed at the north end of the alteration zone. The latter is composed of quartz, potassium, sericite, sericite/montmorillonite mixed-layer minerals, kaolin and dickite. There is intrusion of andesite dikes looking dark to green. This andesite contains chlorite. Dacite has development of N-S oriented fine fractures that are filled up by limonite veins. Around the top of the rise, a limonite layer that seems to be of the present age is formed, and iron leached by acid hot water accumulates. At the north end of the alteration zone on the east side, an abandoned pit (the past prospecting) remains. The direction of the pit is N10° W. It seems that lead and zinc stringers were prospected by drift, galena and zincblende-bearing quartz veins were observed in the remaining slag. What was observed in a microscopic examination of these menerals are automorphic and semi-automorphic crystals of pyrite and automorphic and semi-automorphic corse zincblende, both of which show impregnated or netted production, as well as a small amount of galena showing an allotriomorphic form and automorphic arsenopyrite. Gangue minerals are calcite and a small amount of quartz. The following values were obtained as the results of grade analysis: Au of 0.04 g/t, Ag of 142 g/t, Pb of 1.71% and Zn of 2.5% in A01KN089, and Au of 0.025 g/t, Ag of 2.5 g/t, Pb of 0.18% and Zn of 1.22% in A01YH050.

On the other hand, the alteration zone on the west side is exposed on the cliff along a small valley. It is characterized by strong alteration to white clay. As a result of grade analysis of opaline quartz veins (A01TK042), both Au and Ag were under the detection limit.

6) Characteristics of the satellite image

On the false color image, these alteration zones are located immediately inside horseshoe-shaped ring structure opening to the west which seems to be a caldera wall. Four ring structure of about 1km in diameter exist adjacently to the southeast of this horseshoe-shaped ring structure (outside of the caldera). There is a possibility of existence of intrusive rocks. In particular,

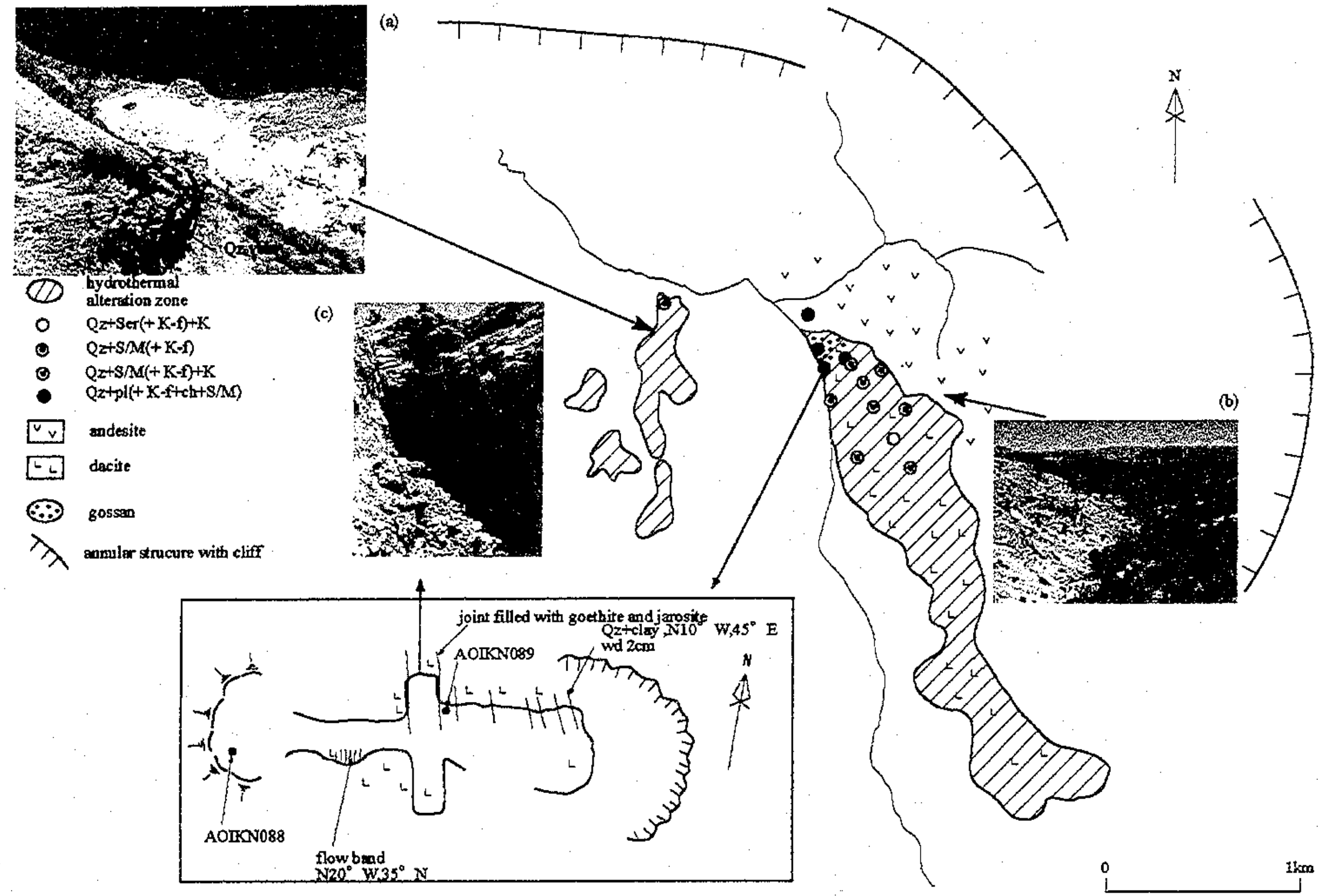


Fig. II-5-2-9-1 Rachaite mineral occurrence.

(a) White argillic alteration and quartz vein in the western alteration zone (b) boundary between altered dacite (whitish) and less altered andesite (c) Old drift

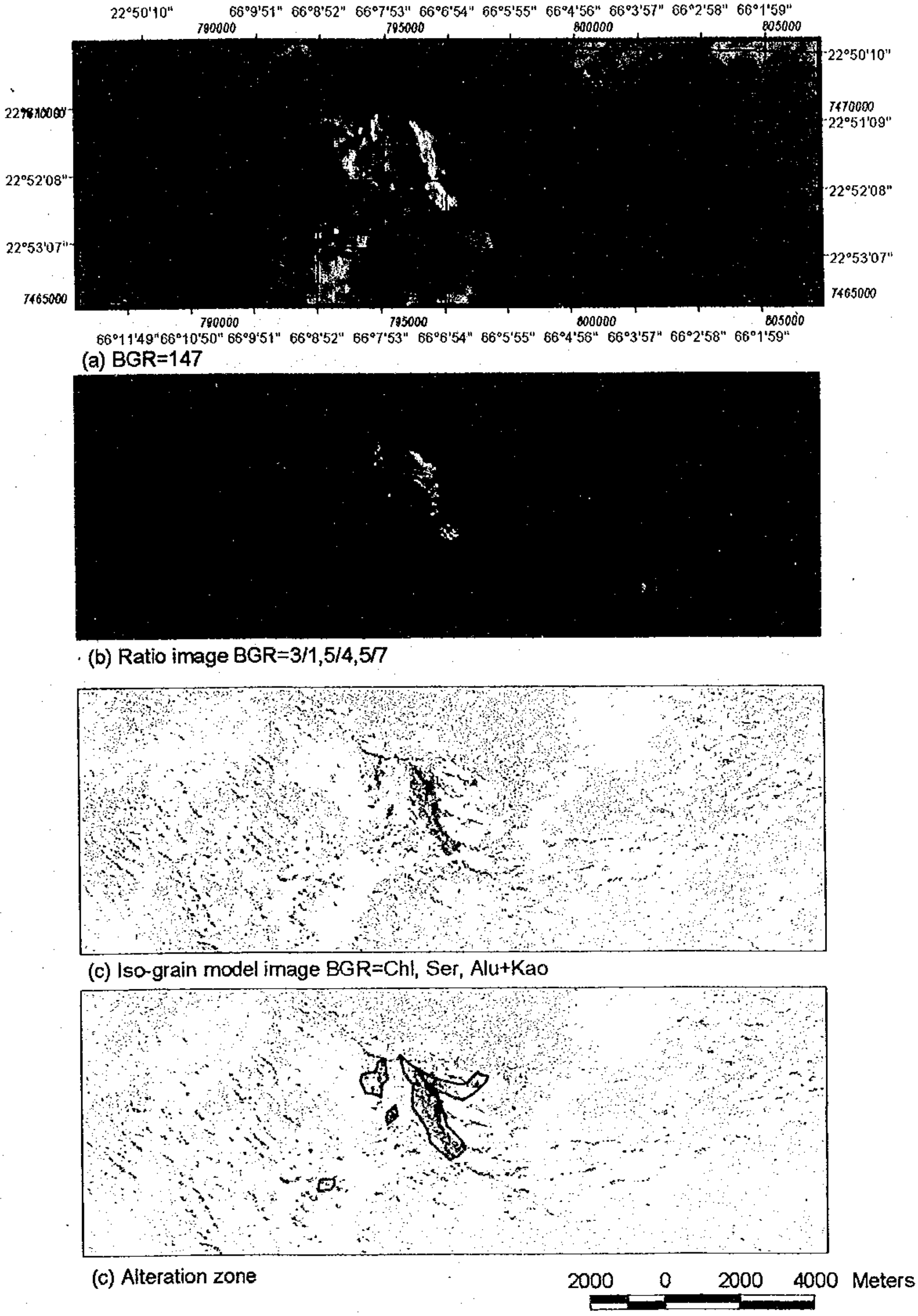


Fig. II-5-2-9-2 Satellite image around the Rachaite mineral occurrence the alteration zone on the east side presents a slightly curved shape along the caldera wall. Both of these alteration zones are white, but the white is stronger on the east side. On the color-ratio composite, strong abnormal areas corresponding to the white part on the false color image are extracted. On the iso-grain model image, an acid alteration zone and a sericite alteration zone are extracted in the same place (Fig. II-5-2-9-2).

7) Comments

Judging from the above, these alteration zones are neutral ones formed by the volcanic hydrothermal system of Coranzuri composite caldera. They are located on the wall of the caldera structure, and it is assumed that hydrothermal activities occurred along the caldera wall. In the alteration zone on the west side, kaolin minerals are observed characteristically and are considered to be those overprinted on neutral alteration. As opaline quartz is observed, it is assumed that this zone represents the shallow part of the hydrothermal system. As silica sinter has been confirmed (Coira et al., 1990), although it was not confirmed in this survey, we may see the ground surface part of hydrothermal activities. Regarding the degree of alteration, neutral altered minerals are smectite, smectite and sericite mixed-layer minerals, and acid mineral is kaolin. Considering together with this, it is assumed that the shallow part of a low-sulfide hydrothermal system is presented. With gold deposits as a target, it is presumed that the level of precipitation of gold is somewhat deep. It is desired to assume places where gold precipitates by grasping the hydrothermal system from the detailed characteristics of alteration zones.

8) Reference materials

5-2-10 La Candelaria mineral showings

1) Location

At 22°52' 35.6" S. Lat., 65°43' 42.6" W. Long. and 3,820 m above sea level (in the a disused pit).

This zone is located about 15 km south of Abra Pampa.

2) Access

It is accessible by going southward from Abra Pampa on National Road 9 by 4-wheel-drive car and crossing the source of flooding around the fork to Provincial Road 40. The distance is 19 km, which takes about 30 minutes by car.

3) Past surveys

4) Geology and tectonics

This zone is located at the north end of Sierra del Aguilar and is composed of clayslate of

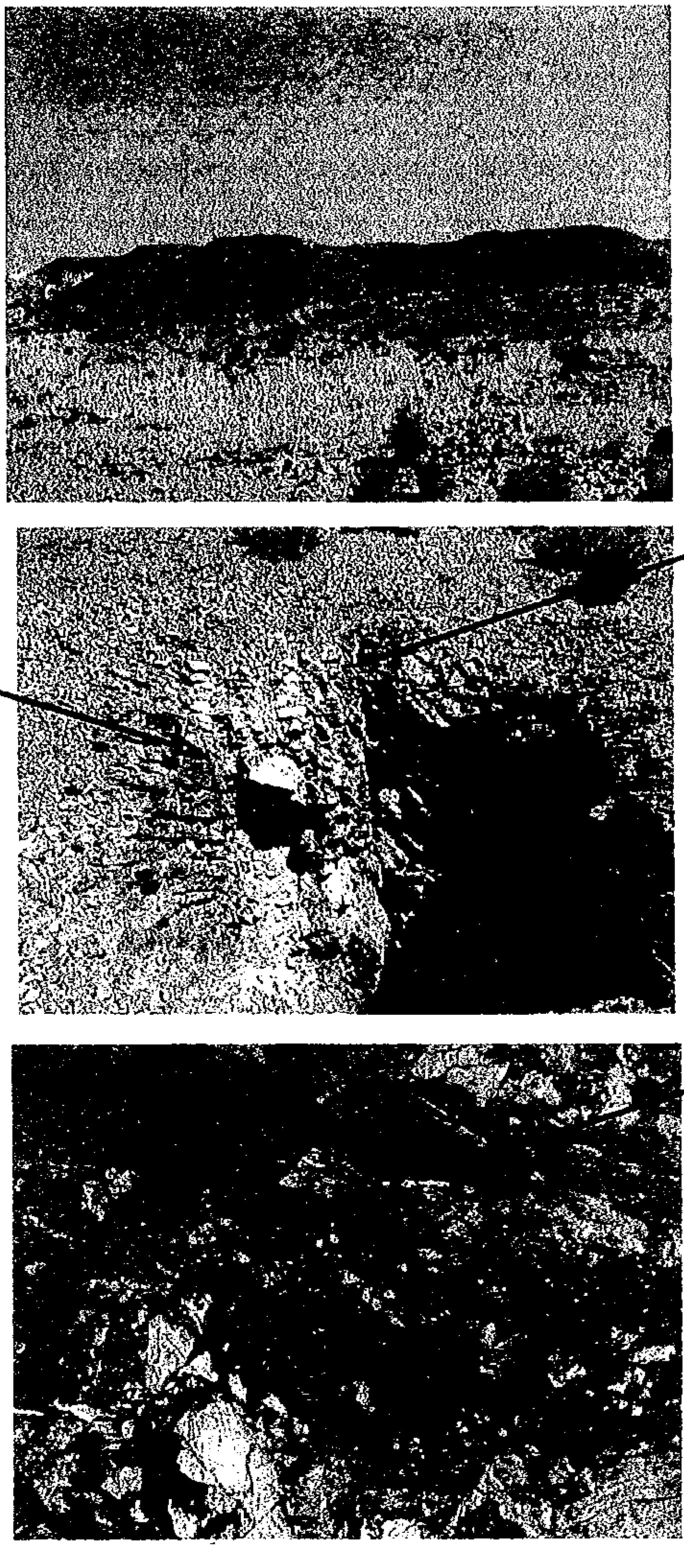


Fig.II-5-2-10-1 La Candelaria mineral occurrence.

(a) Waste dump of the mine (b) Mode of occurrence of galena and spharelite bearing quartz vein

(c) Quartz vein in the gossanic fault breccia

Acoite Layer.

5) Mineral showings and alteration

Clayslate that is wall rock is black to blackish gray, forms rhythmical alternation of strata with the sandy part, and shows strike and dip of N60 to 70E. Ores are galena and a zincblende quartz vein, and two terrancs, N14-20° W and N° 0E, were confirmed. At Point 1, there are those that pack fractures almost crisscrossing the bedding plane of clayslate as shown in Fig. II-5-2-10-1, and those that develop while cutting fault breccia. It is estimated that the maximum width of veins is around several tens of centimeters. Only alteration to white by sericite is observed as vein-edge alteration over several tens of centimeters. The result of a microscopic examination of ore samples (A01KN083) shows that zincblende is the main component and a small amount of galena accompanies. Zincblende is impregnated with or accompanied by quartz veins. Zincblende of both types has permeability, and the content of FeS seems to be low. Mineralized wall rock is quartzose sandstone altered to sericite, presents mosaic aggregate texture of detrital quartz grains, and has development of schistose sericite among the grains. The oxygen isotopic ratio of the quartz veins (KN82) is 12.6%.

6) Characteristics of the satellite image

No remarkable characteristics are found.

7) Comments

The deposits are vein small-sized deposits of the fissure filling type that consist of quartz, galena and zincblende. It is judged that there is no possibility that these will develop to deposits with economic effectiveness.

8) Reference materials

5-2-11 Rumicruz-La Pricima mineral showings (Zone 11)

1) Location

At 22° 49' 34.8" S. Lat., 65°32' 24.9" W. Long. and 4,100 m above sea level (at abandoned pit at the southmost end). This zone is located about 20 km southeast of Abra Pampa.

2) Access

It is accessible by driving a 4-wheel-drive car from Abra Pampa on unpaved Provincial Road 72. The distance is 2 km, which takes about one hour and fifteen minutes by car.

3) Past surveys and development

4) Geology and tectonics

(c)

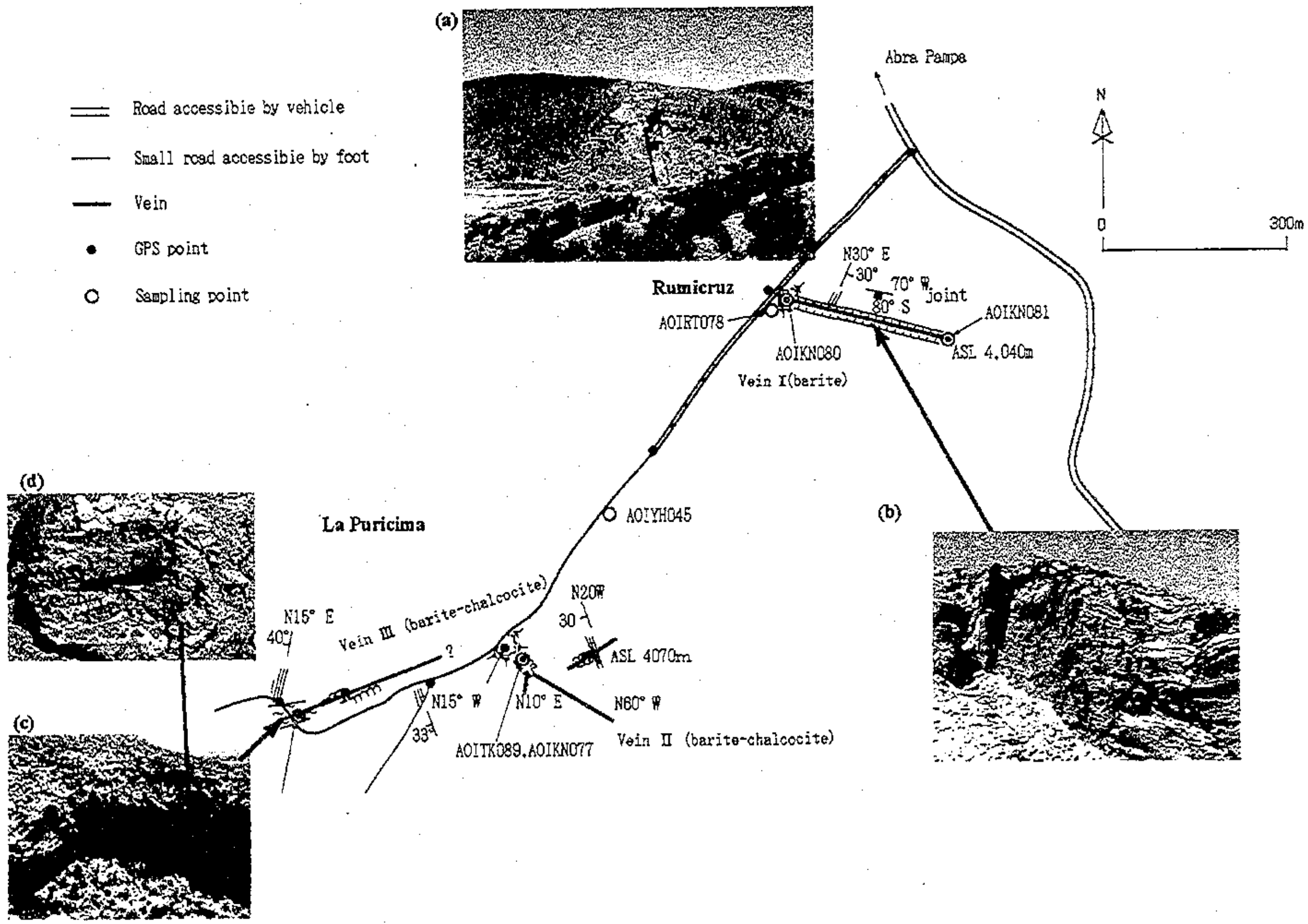


Fig. II-5-2-11-1 La Puricima-Rumicruz mineral occurrence

(a) Old excavation of barite vein (b) Folded Santa Victoria formation (c) fault zone hosting barite-chalcocite veins (d) Occurrence of barite network in the fault gauge

This zone is located in the south extension of Pumahuashi and is made up of Santa Victoria layer of the Ordovician and Pirugua multiple seams of the Cretaceous which cover this formation unconformably. The relation between them is a fault in some cases. Santa Victoria layer has a strike of south and north and has a folding axis parallel to this. Folding tectonics with a long wavelength is shown.

5) Mineral showings and alteration

In the whole area of Rumicurz, there are many places of mineral showings. Deposits checked this time were Pricima Deposits, polymetallic vein deposits, and Rumicruz Deposits, barite deposits on the north side of the former. Pricima Deposits are located along a valley that was opencut in the direction of S60° W from the local road. Three veins in two directions were confirmed (Fig. II-5-2-11-1). For convenience, these veins are referred to as Vein-I (in Rumicruz Deposits), Vein-II (in Pricima Deposits) and Vein-III (in Pricima Deposits) from the east.

In Vein-I, a trench of about 800 m was opencut along a barite vein extending in the direction of N80W, and barite seems to have been collected for a while. As far as is observed now, this vein is a vein of the fissure filling type that fills a fault showing N70° W, 80° S which almost crisscrosses stratification plane schistosity of N30° E, 30° E of clayslate, as shown in Fig. II-5-2-11-11.

Vein-II can be known from a pit that was opencut southward from the valley line. This vein of about 1m in width, which extends in the direction of N60° W, comprises barite, limonite, oxidized copper and clay.

Vein-III has a strike of N70° W to N80° E and dip of 90°, and develops almost in parallel to a valley. In the part where it crosses the valley, there are several barite and chalcocite veins in the fault argillization zone of about 7 m in width. A drift was opencut eastward from this part. Cross cuts were opencut toward the vein extension in the lower valley and also opencut from the surface. Extensions of the veins are estimated to be 300m or longer. The veins do not displace the fault itself but are produced in a netted or veinlike shape in the fault zone. It is assumed that the veins were generated in the period of fault activities. Probably, there was no vein whose width exceeds 1 m. Only alteration to white by sericite is observed as vein-edge alteration over several tens of centimeters. Fig. II-5-2-11-2 shows the state of production of barite netted veins in the fault zone. Ores in Veins-II and -III are barite and chalcocite whose surface has changed to oxidized copper. Those reported by Chomnalcs et. al (in 1960) and Bradtkarb (in 1972) are rammelsbergite, bituminous uranium ore, tetrahedrite, native gold, covelline, barite, pyrite, chalcopyrite, chalcocite, bornite, malachite, galena, zincblende, niccolite and annabergite.

6) Characteristics of the satellite image

7) Comments

The deposits in this zone are small-sized vein deposits of the fissure filling type composed of barite and chalcocite. It is judged that there is no possibility that the deposits will develop to those with economic effectiveness.

8) Reference materials

5-2-12 El Aguilar mine (Zone 15)

1) Location

At 23°12' 46.3"S. Lat. and 65°40' 42.4" W. Long.

El Aguilar mine is located about 60 km south of Abra Pampa.

2) Access

Tres Cruces, where a gate of the El Aguilar mine exists, is reached by driving about 30 km from Abra Pampa on National Road 9 for about 20 minutes by car. The mine office is then reached for about one hour by driving southward from this gate on a private road laid at the foot of the Aguilar Mountains.

3) History of the mine

It seems that the presence of ore deposits in Aguilar Mountains had been already known in the Incan age before Columbus' arrival. In the Spanish colonial age, a missionary living in Yavi attempted collection of silver and constructed a charcoal smelting furnace in Fundicion Valley 7 km to the south of Aguilar mine.

Around 1932: Large-scale deposits prospecting was carried out including excavation of a pit 6,798 m in length.

1936: Operation of Mina El Aguilar was started.

1980s: CMASA (Campania Minera Aguilar S.A.), a national-run lead company, was transferred to Holding FLUOR and then owned by a joint company of COMSUR (66.6 %) and Rio Tinto Zinc Company (33.3 %).

1990: Operation of Mina Espcranza was started.

4) Present situation of the mine

Since the start in 1936, lead and zinc ores of 25 Mt had been produced by 1999 and daily production of 2,000 to 2,200 t (Zn: 8.4%, Pb 5.5%, Ag: 90 - 120 g/t) has been continued. Reserves as of 1999 are 5 Mt, minable ores of which are 3.3 Mt.

Among seven blocks, Mina Tapada, Mina El Aguilar, Oriental, Pirita, Mina Esperanza, Rio Grande and Roco, all of which are held by CMASA, 50% of the total ore production are mined in the underground at Mina El Aguilar, 15% are in the open pit at Mina El Aguilar, and 35 % are at Mina Esperanza.

Fig.II-5-2-12-1 Geological map of the Aguilar mine area(provided by Mineral Aguilar S. A.)

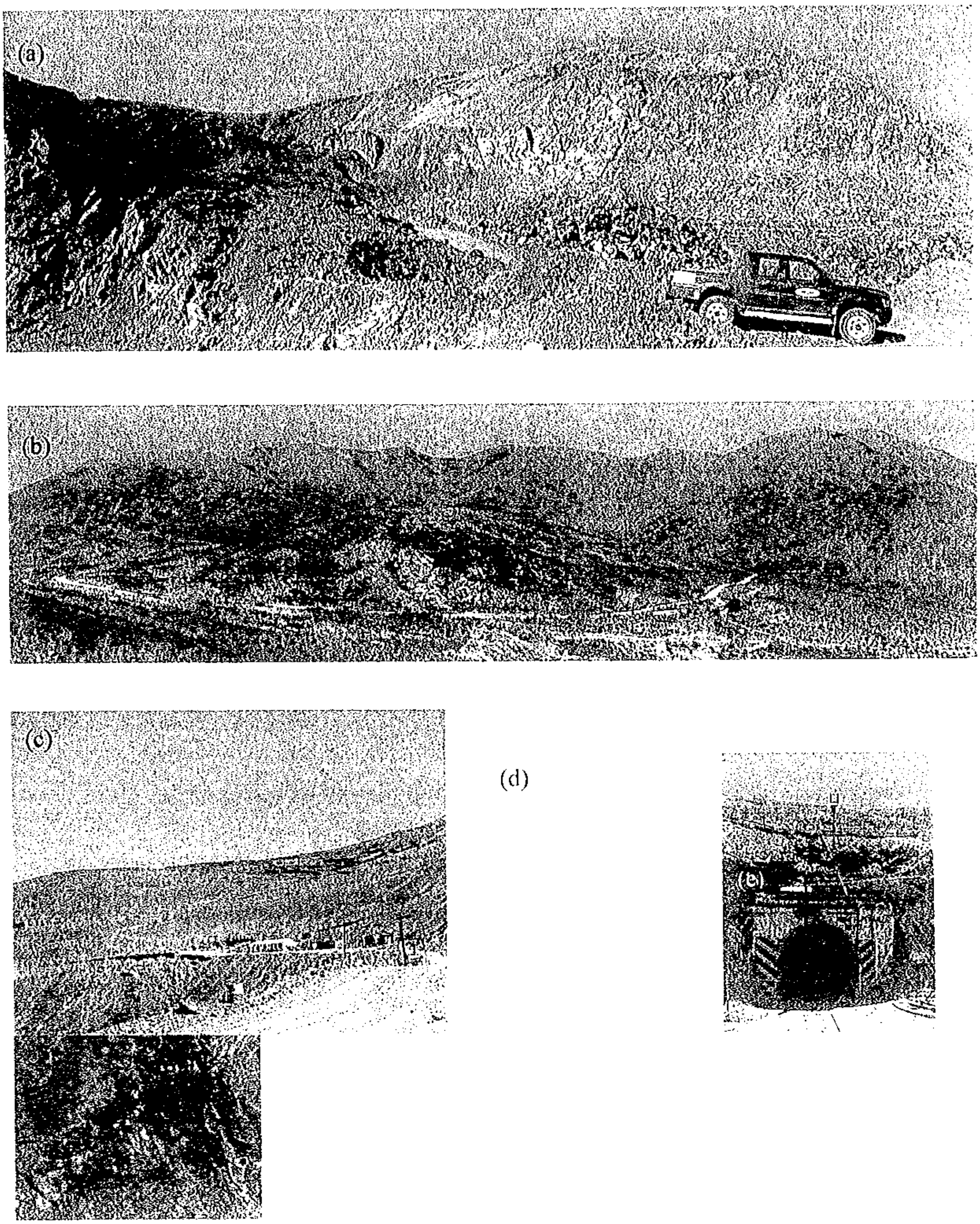


Fig.II-5-2-12-2 El Aguilar mine
(a)El Aguilar open pit exploiting skarn ore (b) An overview between El Aguilar and Esperanza mines
(c) View around Esperanza mine (d) Entrance of the main gallery (4577m level) (e) SEDEX ore zone at side wall of the gallery with 4577m level about 500m from the entrance

5) Geology and tectonics

The geology and tectonics of Aguilar Mountains, including Mina El Aguilar, Mina Esperanza mentioned later and Rio Grande, as described by Sureda, R. J. (1999) is summarized in Table II-5-2-12-1.

6) Mineral showings and alteration

In this survey, only some samples was collected in a portion of the open-cut mining part. The ore deposits at El Aguilar Mine have been summarized by Sereda and Martin (1990) as follows:

"The El Aguilar Mine consists of ten major stratiform Pb - Zn ore bodies, which are hosted in metaquartzites and hornfels in a 200-m-thick section of the Cretaceous Aguilar quartzite. The ore bodies average 150 to 1,000 m in length, 50 to 300 m in width, and 5 to 80 m in thickness. Ore units harmonious with strata extend approximately 2,000 m north-south along the strike in the contact aureole of the Aguilar granite. The Aguilar quartzite unite dips approximately 70° to the west. Intrusion of the Abra Laite and Aguilar granites transformed the Ordovician sedimentary rocks to metamorphic rocks. The protoliths of the Aguilar quartzite should be correlated with the Lower Tremadocian Padrioc layer (Acenolaza 1968; Alonso et al. 1982). According to the recent geological minute investigation, the lateral stratigraphic equivalence between the Padrioc layer and Lampasar layers has been identified (Martin et al. 1986). Most of the main ore bodies narrowly exist in Padrioc and Lampazar layers corresponding to the Lower Tremadocian. Being illustrated in detail, primary layers in the Padrioc sedimentary basin can be further divided into three clear sedimentary deposits horizons. Ordovician stratigraphy units below or above them contain only places of relatively small-scale basemetal indications. These places of mineral showings are prospecting sites in Biancaflor, Fitzhugh, Tapada, Hueco and Zarco. The relation regarding to the origin of small-scale prospecting sites near granite intrusive rocks and dike composite rocks has not been clarified yet."

Results of microscopic examination of samples collected at the open-cut mining site are as follows:

Galena - zincblende (- pyrite - chalcopyrite) - sericite - quartz vein (A01RT060). Sericite - quartz vein is accompanied by sulfide minerals. Sericite forms a long-flake aggregate, and quartz forms a granular and mosaic anhedral aggregate. These minerals are distributed separtely. Some sericite is also generated among quartz grains. Main ore minerals are anhedral galena and granular anhedral zincblende (with low content of FeS). Besides these, a very small amount of anhedral chalcopyrite and automorphic to semi-automorphic pyrite are observed. Ore minerals relatively tend to be accompanied by coarse grained quartz.

Wollastonite (?) - quartz skarn (?). This is a kind of skarn (?) comprising mosaic (amoebic aggregate) quartz grains, and semi-automorphic long-prismatic, single or marquetry-like wollastonite (?) existing among quartz grains. Potassium (?) is also produced to gather with quartz mosaic grains, but it is dusty and easily distinguished from quartz. In addition, anhedral granular diopside is produced accompanying quartz and wollastonite.

Original rock resembles calcareous sandstone (?). Anhedral zincblende and a small amount of galena are sparsely produced, filling the space among quartz grains. An extremely small amount of coarse anhedral pyrite is also produced. Fine anhedral chalcopyrite is produced accompanying zincblende.

Ore deposits in Mina Esperanza are summarized by Sereda et al. (1990) as follows: "Mina Esperanza consists of the main manto of 350 m in total length, 130 m in width in the E-W direction and 18 m in the maximum thickness. The dip is 27° W. " In this direction, two ore bodies accompanying the main manto deposits are hosted in the stratigraphically lower part of the main manto. All ore bodies show the form of a salt lake with plenty of accumulated metal content. This salt lake was formed by effusion of hot water above the sea bottom of the Tremadocian. Deposits made up of extremely fine Zn-Pb ores are accompanied by gangue minerals consisting of barite, carbonate rock, chert, Fe and Mn, and has been substantially deformed together with muddy fine sediments inside the sedimentary basin. Geopetal phenomena, sin-sedimentary pliegues, gravitative fractures, and postdepositional filling after breaking of heavy minerals are frequently recognized. These ores always contact fine clastic sediments such as clay, lutite and limo-pelitite. Influence of hydrothermal alteration in this contact part is extremely small, and good contrast is recognized between the ores and wall rock. The low layers are formed by homogeneous hornfels containing both kinds of mica, and by porphyritic hornfels containing andalusite-cordierite accompanied by a very small amount of disseminated mineralization. On the top part, change to porphyritic clayslate is recognized at the rate of one layer per 10 m, and some unprofitable mineralization comprising pyrite, pyrrhotite and marmatite is observed."

In this survey, the main ore bodies were observed at the adit 4,577 m above sea level (Fig. II-5-2-12-2). The results of microscopic examination of the ore samples collected from the point are as follows:

Bedded sulfide ore (A01RT059). The ore shows the occurrence of strata-bound massive sulphide ore deposit. It mainly comprises automorphic prismatic pyrite, anhedral to semi-automorphic prismatic zincblende, automorphic to anhedral galena and anhedral chalcopyrite, and are arranged presenting a clear lamination structure. Long-flaky (tabular?) sericite is arranged almost harmoniously with sedimentary structure. This indicates it is a sedimentary (syngenetic) ore. The border between ores and mudstone (quartz - illite?) is clear and no alteration is particularly observed near the border. It indicates it is mechanical sedimentation. The combination of minerals and the quantity ratio differ according to layers. Namely, the following relations are shown: ① pyrite >> zincblende >> galena, ② zincblende >> pyrite≒galena > chalcopyrite, and ③ chalcopyrite≒zincblende > galena > pyrite.

7) Results of geochemical analysis with drilling core samples used

In Mina Esperanza area of the El Aguilar Mine, many drillings were carried out in peripheral areas of existing SEDEX ore bodies, and SEDEX ore bodies have been captured (See Fig. II-5-2-12-3). In this survey, with cooperation of the El Aguilar Mine, a total of 77 chip samples, that is,

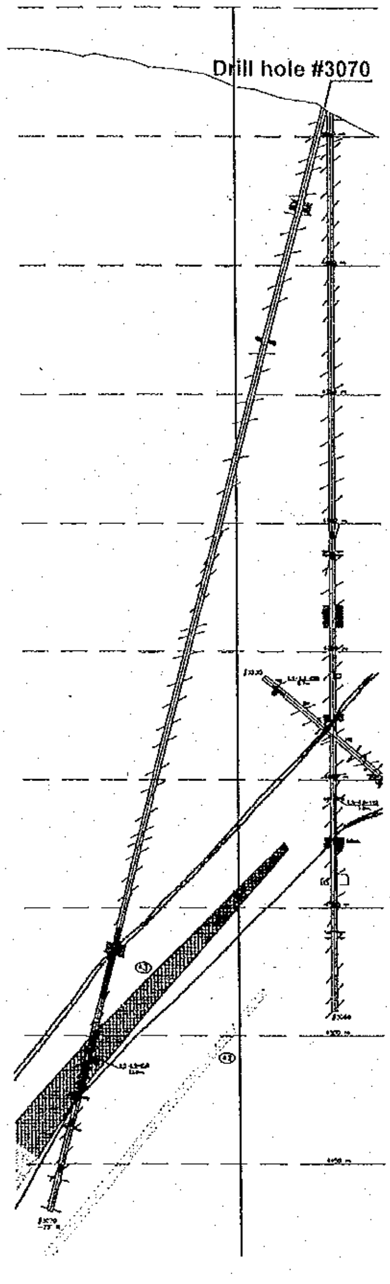


Fig.II-5-2-12-3 Relation between drill hole #3070 and SEDEX mineralized zone (The original figure was offered by Minera Aguilar S.A.)

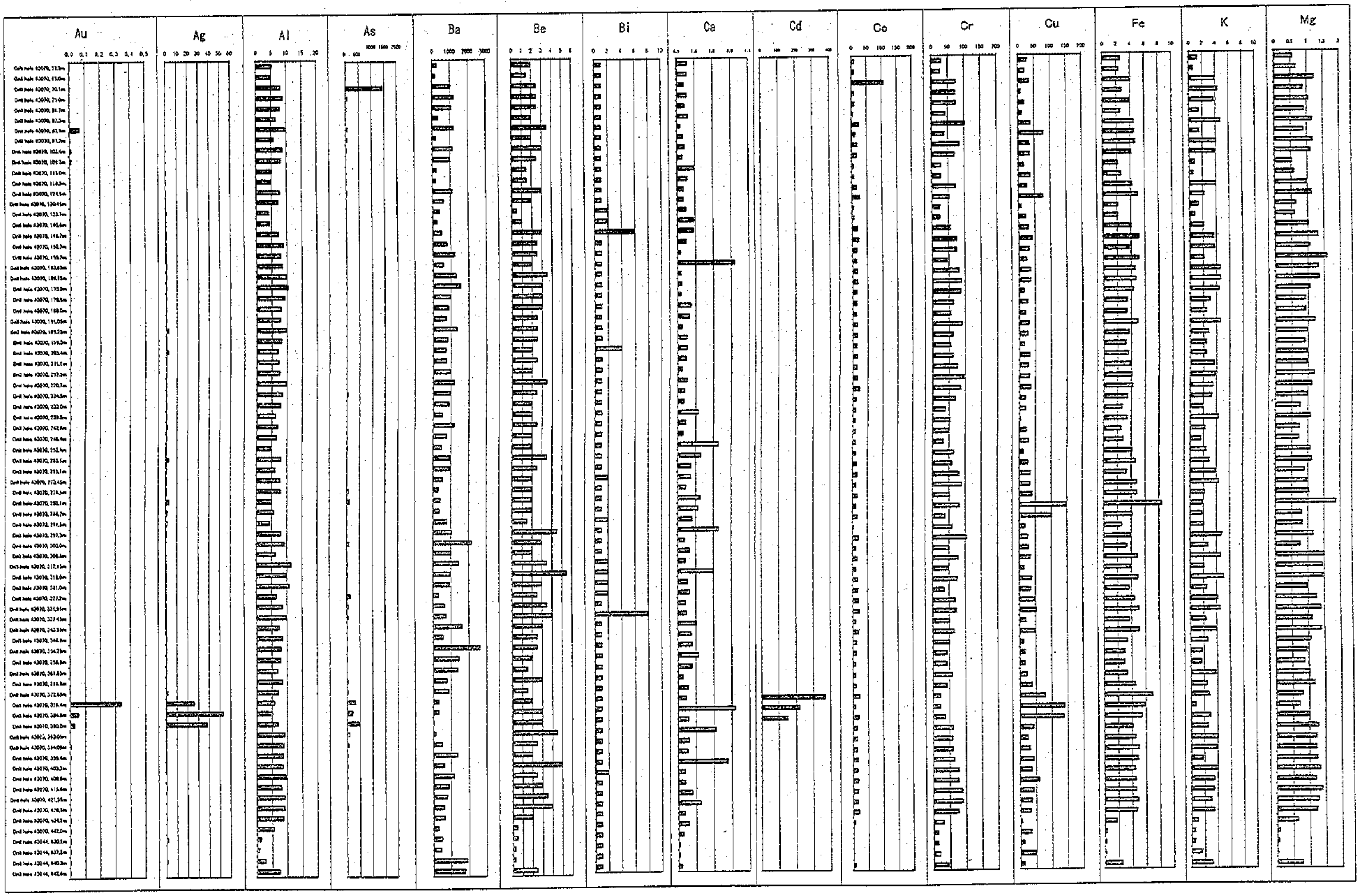


Fig. II-5-2-12-4(1) Geochemical variation diagrams of drill holes #3070 and a lower part of #3244

Fig. II-5-2-12-4(1) Geochemical variation diagrams of drill holes #3070 and a lower part of #3244

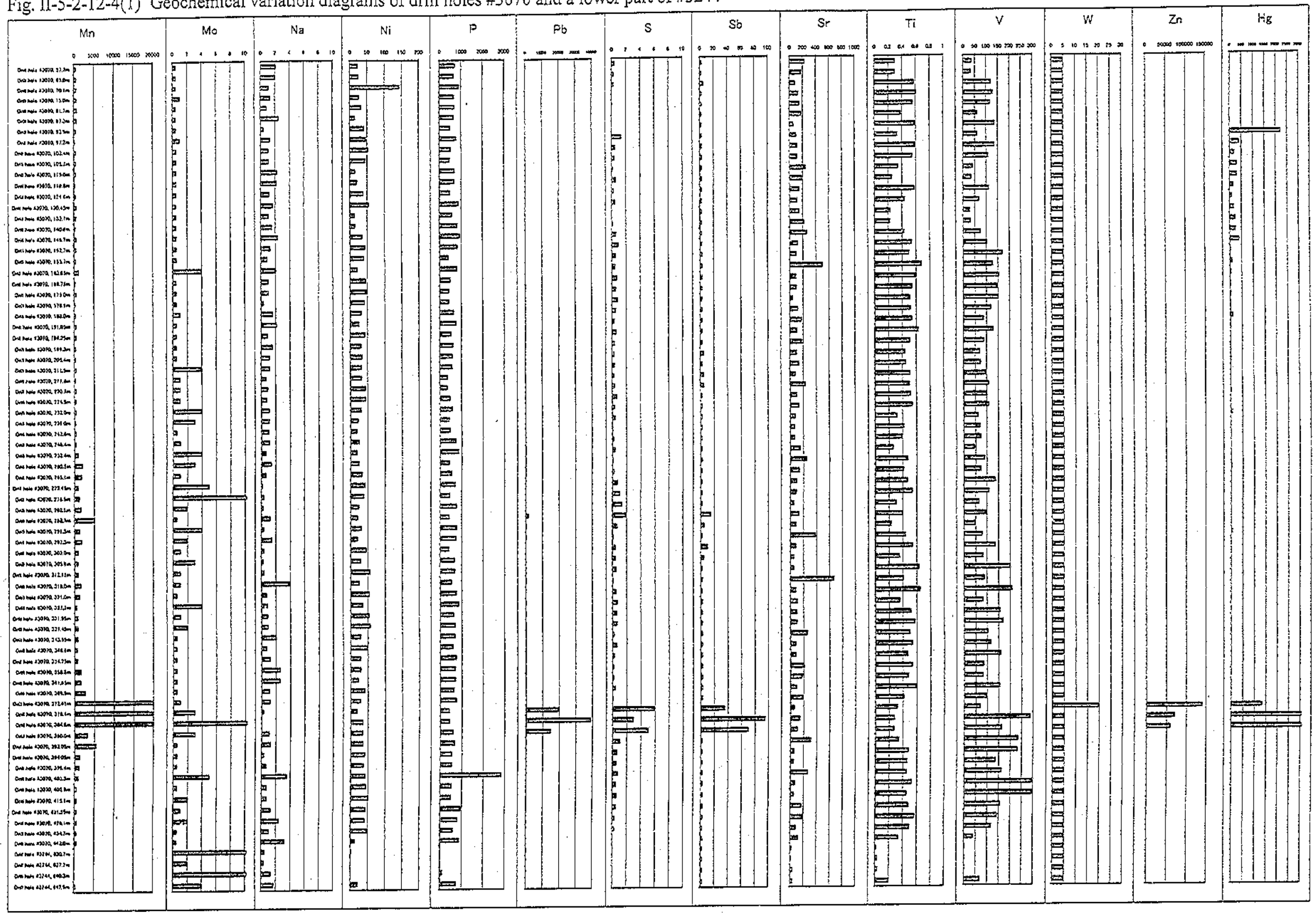


Fig. II-5-2-12-4(2) Geochemical variation diagrams of drill holes #3070 and a lower part of #3244

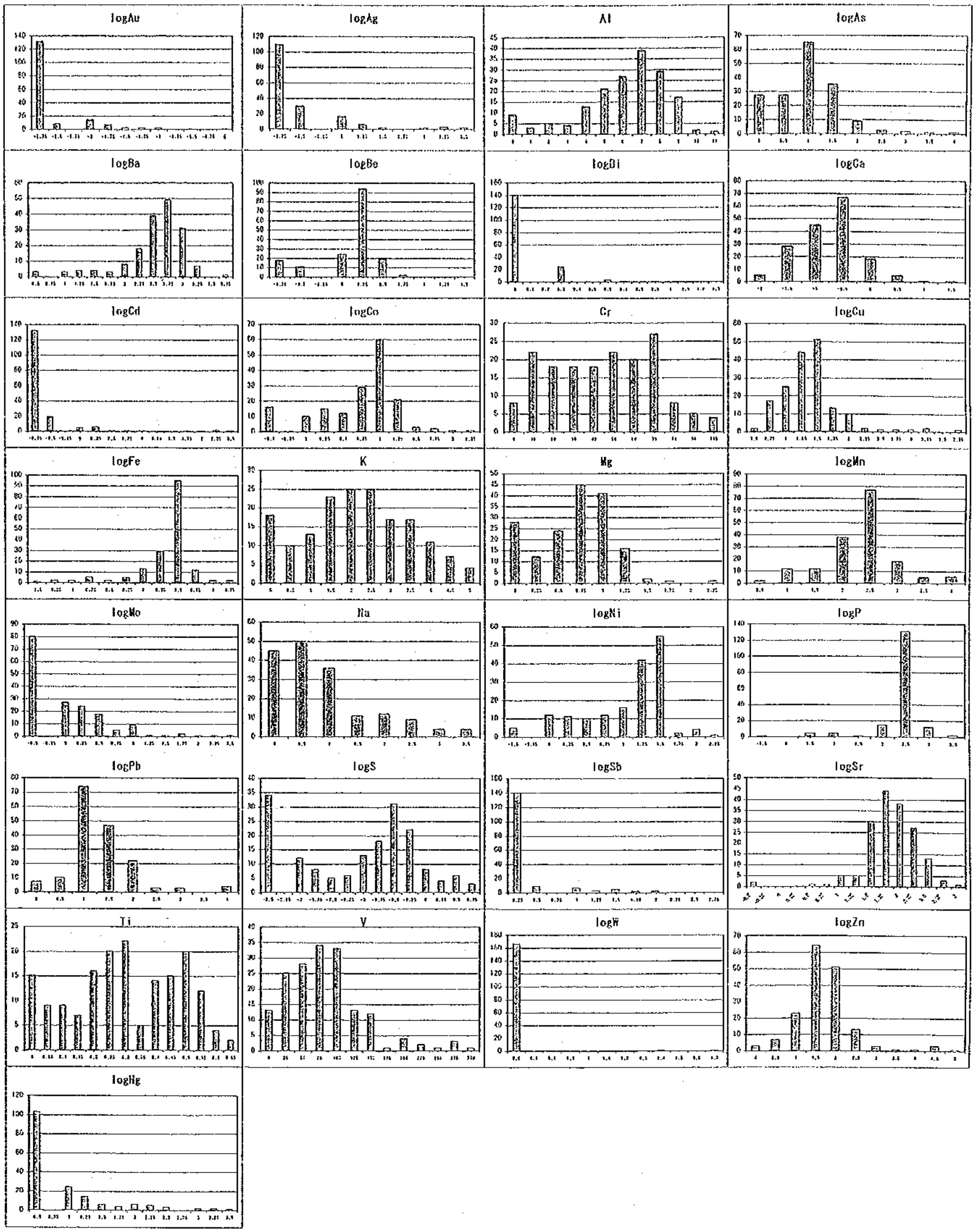


Fig.II-5-2-12-5 Histograms of 29 elements for drill holes #3070 and a lower part of #3244

56 samples from the hangingwall, 7 samples from the mineralized zone and 14 samples from the footwall, were collected from the drill holes #3070 and #3244, where ore bodies have been intersected. Using the results of their chemical analysis, we examined geochemical characteristics of the SEDEX ore zone, the hangingwall and the footwall by the statistical method.

a. Examination of the variation diagram classified by depth for each element

Results of chemical analysis are shown as a list in Table II-5-2-12-2 and as a variation diagram in Fig. II-5-2-12-4(1)(2). It can be seen from the figures that 14 elements - Au, Ag, As, Cd, Cu, (Fe), Mn, Mo, Pb, S, Sb, (W), Zn and Hg - show higher values in the SEDEX ore zone between 358.8 m and 390.0 m of Drill Hole #3070 than in the hangingwall above 354.25 m of Drill Hole #3070 and the footwall below 393.05 m of Drill Hole #3070 and around 630 - 640 m of Drill Hole #3244. However, geochemical characteristics of the hangingwall and the footwall cannot be determined from this diagram.

b. Examination of discriminant analysis (multivariate analysis)

Rough examination of normality was carried out with a histogram for each element prior to discriminant analysis. As a result, excluding Al, Cr, K, Mg, Na, Ti and V from all 29 elements, tendency of logarithmic normal distribution that shows positive asymmetric distribution is recognized in 24 elements. Logarithmic conversion of analyzed values was then carried out as pre-processing.

Fig. II-5-12-5 is the histogram of 29 elements with data after pre-processing was used. In the detailed examination, however, care should be taken because asymmetry has not been improved for 8 elements (Au, Ag, Bi, Cd, Mo, Sb, W and Hg) whose data at or below the detection limit accounts for more than half. Asymmetry could be improved by the logarithmic conversion, however, for 16 elements.

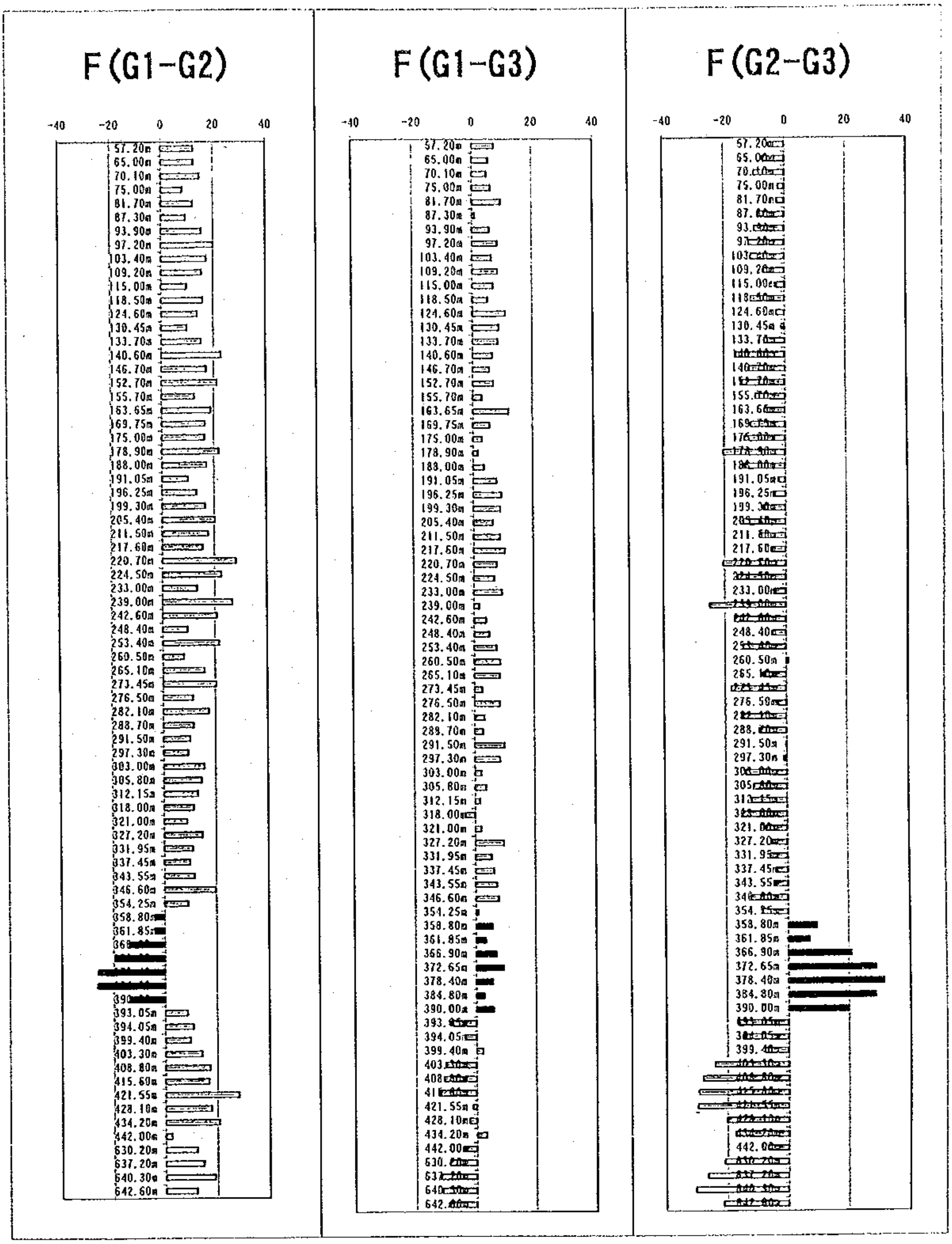
Samples were grouped as follows: 56 samples taken from the hangingwall, which belong to Group 1; 7 samples taken from the ore zone, which belong to Group 2; and 14 samples taken from the footwall, which belong to Group 3.

As a result of discrimination analysis of 77 samples at drilling cores, the following was clarified:

① The variable addition and reduction method was employed as a method of automatic careful selection of a small number of useful variables from 29 variables used in the calculation. As a result, 11 variables, that is, logMn, logFe, V, logCa, Na, logSr, Mg, Ti, logPb, Cr and logW, were used as useful variables for discrimination.

② As a result of grouping obtained by the calculation, the discriminant rate shown was as high as 96.1%. Therefore, it is expected that discrimination of unknown samples will be possible at high accuracy by using the discriminant function with an obtained discriminant coefficient matrix (Table II-5-12-4) used.

③ It has been clarified that both the hangingwall and the footwall are clearly distinguished from the



Remarks;

G1: hangingwall of the mineralized zone
G2: the mineralized zone(SEDEX)
G3: footwall of the mineralized zone

F(G1-G2): Function discriminating between G1 and G2
F(G1-G3): Function discriminating between G1 and G3
F(G2-G3): Function discriminating between G2 and G3

Fig. II-5-2-12-6 Variation diagrams of discriminant values for drill holes #3070 and a lower part of #3244

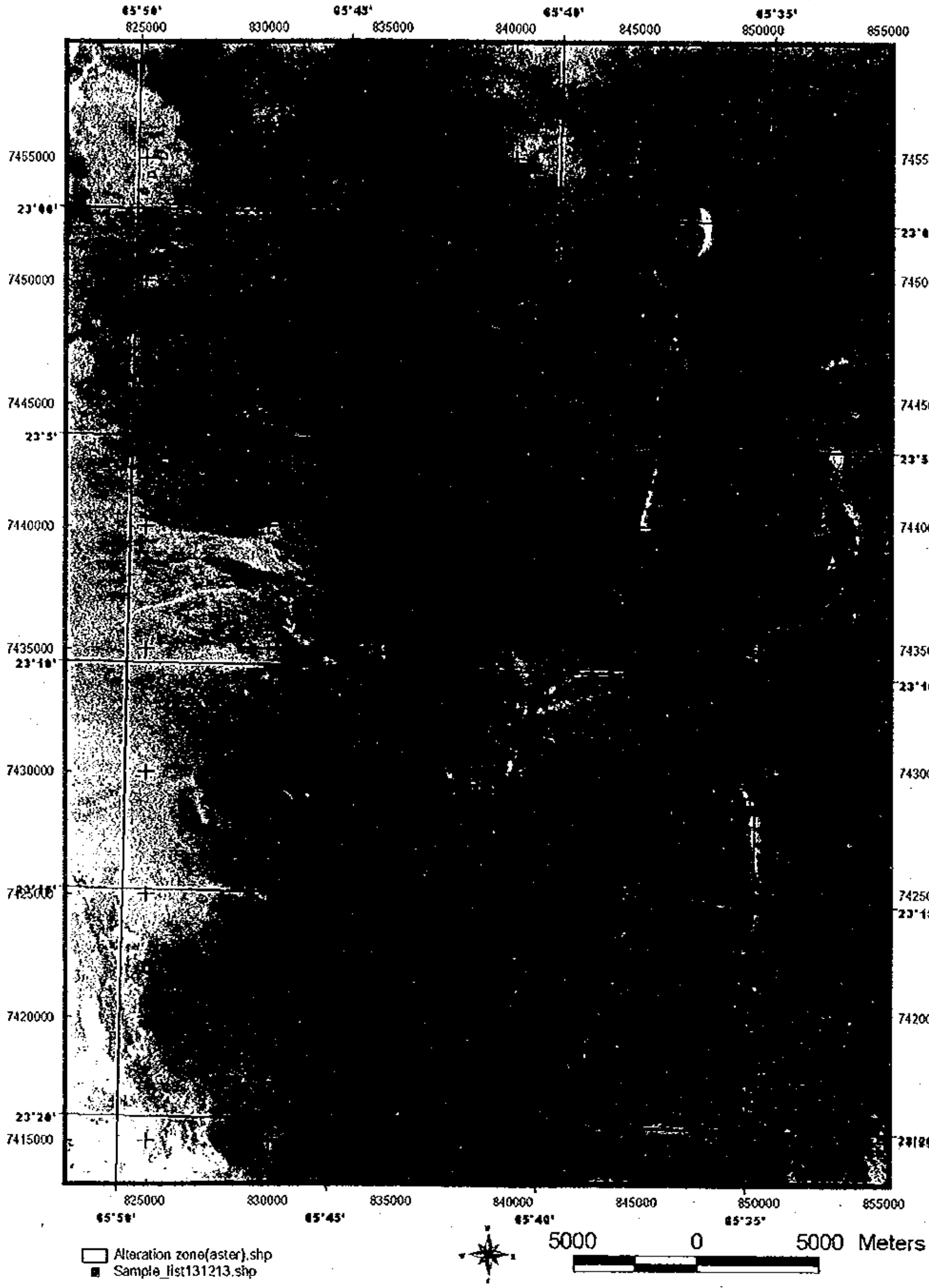


Fig.II-5-2-12-7 El Aguilar deposit(ASTER BGR=147)

Table II-5-12-1 Characteristics of the Ordovician formations in the Aguilar range

Formation	Geological Age	Width	Lithology	Stratigraphical relationship with the underlying formation	Depositional environment	Mineralization	Distribution	Structure
Sepulturas Formation (Harrington y Leanza,1957)		300m	Sandstone and red and dark parple lutite	Conformable and gradual change in the north end of the mountain range			In the north end of the range and in Real Grande and Mocante districts	
Acoite Formation (Harrington y Leanza,1957)	The Lower to Middle Tremadocian age is referred by the fossiliferous registration.	more than 3,000m	Turbidite composed of greywackeand greenish grey mudstone ,intercalated with thin beds of dark limestone and conglomerate	Stratigraphic relationship is not observed in the mining district	Shallow sea (Neritic sea)		Widely distributed as the main Ordovician sedimentary unit in the Aguilar range	
Cardonal Formation (Harrington,1937; Martin et al.,1989)	The Lower Tremadocian age	more than 340m	Yellowish brown and greenish grey sandstone intercalated with a small amount of dark grey, grey and yellowish brown mudstone	It lies concordantly and transitionally on the lower unit.	Shallow sea (Neritic sea)	Small bodies mineralized		
Lampazar Formation (Harrington,1937; Martin et al.,1986)	The Lower Tremadocian age is indicated by the fossil remains.		Pelitic lithofacies are predominant on sandstone and conglomerate in the lowest levels of the Lower Tremadoc.	Intercalated with the underlying Padrioc Formation. There is a lateral change between the top of the Padrioc Formation and the base of the Lampazar Formation.	Shallow sea (Neritic sea) with oxygen free layer		It is cropped out in the both side of Cajas range, in Rio Grande area and golf field of the El Aguilar mine, and to the north and the east of the Aguilar Granite.	In the canyon of the Esperanza mine, it forms a tectonic flake between the Esperanza fault and the Aguilar West fault.
Padrioc Formation (Acenolaza, 1989, emend Alonso et al., 1982)	The Lower Tremadocian age is indicated by the paleontological contents.	more than 560m	It is composed of a dominant succession of very light-colored and coarse grained arkose sandstone, and calcareous sandstone, with thick intercalation of fossiliferous black lutite towards the top of the unit.		Shallow and tidal inland sea	The important unit bearing most stratiform deposits of base-metals in the Quiaquena Metalogenic Province.	It is well exposed in Maray canyons and a stream of Tapada mine	
Despensa Formation (Alonso et al., 1982)	Assigned to the Lower Tremadocian by the existence of Dictyonema sp.	more than 350m	Consisting of bedded greenish grey arenaceous mudstone, arkose and greywacke, intercalated with polymictic conglomerate in paleochannel flowing from proximal river.	The base of the unit is unknown.	Shallow sea to tidal delta	Mineralization of metalic sulphides are observed in the matrix of some conglomerate	Well exposed in the southern section of the range of Aguilar.	Outcrops of the canyon of the Tapada mine show a distinct cleavage of fracture.

After Sureda,R.J.(1999)

Table II-5-2-12-2 Chemical analysis results of drill core samples

Serial	Sample				kg	g/t	ppm	%	ppm	ppm	ppm	ppm	%	ppm	ppm	ppm	ppm	%	%	%	ppm	ppm	%	ppm	ppm	ppm	%	ppm	ppm	%	ppm	ppm	ppm	ppb
No.	No.	Drill hole No.	Depth	Rock	Weight	Au	Ag	Al	As	Ba	Be	Bi	Ca	Cd	Co	Cr	Cu	Fe	K	Mg	Mn	Mo	Na	Ni	P	Pb	S	Sb	Sr	Ti	V	W	Zn	Hg
1	A01AG01	#3070	57.20m	f.s.s.	0.16	<0.005	0.5	5.34	20	290	2.0	<2	0.60	<0.5	11	32	29	2.57	1.35	0.58	420	<1	2.1	23	720	34	0.40	<5	231	0.30	38	<10	58	<10
2	A01AG02	#3070	65.00m	f.s.s.	0.16	<0.005	<0.5	4.73	35	180	1.5	<2	0.57	<0.5	9	27	21	2.42	0.65	0.67	515	<1	2.05	25	670	20	0.27	<5	180	0.30	33	<10	74	<10
3	A01AG03	#3070	70.10m	shale	0.10	<0.005	<0.5	8.27	1440	1030	2.5	<2	0.40	<0.5	107	75	35	4.08	3.94	1.23	565	<1	1.15	144	920	18	0.25	5	86	0.58	121	<10	148	<10
4	A01AG04	#3070	75.00m	f.s.s.	0.14	<0.005	<0.5	8.94	70	1210	2.5	<2	0.58	<0.5	9	73	8	2.77	4.35	0.88	600	1	1.35	27	680	18	0.01	<5	136	0.61	129	<10	78	<10
5	A01AG05	#3070	81.70m	f.s.s.	0.12	<0.005	<0.5	7.98	35	1080	2.5	<2	0.43	<0.5	10	75	19	3.87	3.76	1.06	800	<1	0.87	33	700	24	0.10	<5	151	0.56	118	<10	104	<10
6	A01AG06	#3070	87.30m	f.s.s.	0.16	<0.005	<0.5	6.64	15	340	2.0	<2	0.64	<0.5	5	42	12	2.58	1.45	0.91	690	<1	2.51	15	670	28	<0.01	<5	180	0.38	61	<10	150	<10
7	A01AG07	#3070	93.90m	f.s.s.	0.10	0.065	<0.5	9.59	80	1200	3.5	<2	0.18	<0.5	25	103	39	4.54	4.77	1.16	500	<1	0.38	42	500	18	<0.01	<5	61	0.59	138	<10	124	<10
8	A01AG08	#3070	97.20m	f.s.s.	0.10	0.005	<0.5	5.76	55	210	2.0	<2	0.35	<0.5	13	40	79	4.58	1.55	0.90	305	1	1.27	47	780	28	1.34	<5	101	0.33	62	<10	96	2230
9	A01AG09	#3070	103.40m	f.s.s.	0.20	0.010	<0.5	8.82	35	1150	3.0	<2	0.43	<0.5	18	86	35	4.70	4.13	1.19	480	<1	1.04	53	520	24	0.42	<5	112	0.59	135	<10	112	410
10	A01AG10	#3070	109.20m	f.s.s.	0.24	0.010	<0.5	8.26	15	1010	2.5	<2	0.32	0.5	17	71	36	4.11	3.82	1.10	460	<1	1.08	44	470	16	0.39	<5	112	0.55	109	<10	294	200
11	A01AG11	#3070	115.00m	f.s.s.	0.10	<0.005	<0.5	5.18	15	240	1.5	<2	0.95	<0.5	7	30	17	2.18	0.79	0.53	465	<1	2.24	14	710	42	0.13	<5	239	0.34	42	<10	126	320
12	A01AG12	#3070	118.50m	f.s.s. with py. diss.	0.14	<0.005	<0.5	4.84	10	180	1.5	<2	0.58	<0.5	8	28	37	2.64	0.58	0.59	310	<1	2.23	20	680	34	0.53	<5	201	0.25	36	<10	86	300
13	A01AG13	#3070	124.60m	f.s.s.	0.18	<0.005	<0.5	7.82	40	1110	3.0	<2	0.37	<0.5	16	75	26	4.24	4.04	0.99	405	<1	1.18	40	480	22	0.26	<5	144	0.58	112	<10	100	160
14	A01AG14	#3070	130.45m	f.s.s.	0.14	<0.005	<0.5	7.14	15	620	2.0	<2	0.36	2	25	54	77	5.06	2.20	1.13	635	<1	1.69	55	900	68	0.43	<5	116	0.44	70	<10	360	90
15	A01AG15	#3070	133.70m	f.s.s.	0.14	<0.005	0.5	4.14	<5	400	0.5	2	0.50	<0.5	6	24	8	2.15	1.30	0.64	545	<1	1.05	13	580	46	<0.01	<5	149	0.23	29	<10	82	170
16	A01AG16	#3070	140.60m	f.s.s.	0.18	<0.005	<0.5	4.39	<5	230	1.0	2	0.92	1.5	7	24	22	2.16	0.79	0.61	350	<1	1.48	14	830	36	0.15	<5	221	0.22	32	<10	198	230
17	A01AG17	#3070	146.70m	f.s.s. with py. diss.	0.16	<0.005	<0.5	7.39	10	500	3.0	6	0.91	<0.5	19	55	31	4.07	2.13	1.03	530	<1	2.31	35	930	40	0.59	<5	263	0.43	76	<10	102	250
18	A01AG18	#3070	152.70m	f.s.s.	0.08	<0.005	<0.5	9.04	10	800	2.5	<2	0.50	<0.5	22	76	42	5.12	3.60	1.32	500	<1	1.27	44	830	24	0.92	<5	125	0.54	103	<10	108	390
19	A01AG19	#3070	155.70m	shale with py. diss.	0.20	<0.005	<0.5	8.02	25	1230	2.5	<2	0.17	<0.5	15	75	32	3.76	3.73	1.06	440	<1	0.86	40	430	22	0.56	<5	98	0.50	171	<10	106	30
20	A01AG20	#3070	163.65m	shale with py. diss.	0.12	<0.005	1.0	8.52	25	600	2.0	<2	3.20	<0.5	14	45	24	5.13	2.10	1.59	1140	4	2.05	22	810	36	0.40	<5	500	0.68	128	<10	202	80
21	A01AG21	#3070	169.75m	shale with py. diss.	0.14	<0.005	0.5	9.87	15	1330	3.5	<2	0.18	<0.5	18	81	36	4.56	4.65	1.32	355	<1	1.03	46	500	14	0.70	<5	93	0.60	154	<10	124	60
22	A01AG22	#3070	175.00m	shale with po. diss.	0.18	<0.005	<0.5	10.35	20	1530	3.0	<2	0.22	<0.5	18	90	35	4.65	4.61	1.35	540	<1	1.05	47	440	32	0.57	<5	99	0.54	146	<10	132	20
23	A01AG23	#3070	178.90m	shale with py. diss.	0.18	<0.005	<0.5	9.27	5	1010	3.0	<2	0.16	<0.5	14	87	16	4.33	4.37	1.06	260	<1	0.35	42	430	8	0.74	<5	44	0.51	152	<10	28	50
24	A01AG24	#3070	188.00m	shale with py. diss.	0.14	<0.005	<0.5	8.03	15	860	3.0	<2	0.76	<0.5	14	65	26	3.37	3.00	0.91	325	1	1.62	33	640	24	0.50	<5	122	0.52	119	<10	84	30
25	A01AG25	#3070	191.05m	f.s.s. with py. diss.	0.10	<0.005	<0.5	7.91	15	750	2.5	<2	0.65	<0.5	13	56	20	3.36	2.50	0.93	435	<1	2.15	26	770	28	0.31	<5	181	0.54	87	<10	96	100
26	A01AG26	#3070	196.25m	shale with py. diss.	0.24	<0.005	2.5	9.84	5	1340	2.5	<2	0.24	<0.5	17	91	31	4.98	4.66	1.21	575	<1	0.89	43	530	16	0.59	<5	109	0.63	129	<10	126	40
27	A01AG27	#3070	199.30m	shale with py. diss.	0.10	<0.005	<0.5	8.11	5	810	2.5	<2	0.52	<0.5	15	63	27	3.70	2.84	1.00	390	<1	1.61	32	620	26	0.35	<5	180	0.51	89	<10	92	30
28	A01AG28	#3070	205.40m	f.s.s. with py. diss.	0.10	<0.005	2.0	7.08	<5	710	2.0	4	0.52	<0.5	13	55	15	3.23	2.40	0.91	335	<1	1.19	35	590	16	0.32	5	100	0.44	72	<10	68	40
29	A01AG29	#3070	211.50m	f.s.s. with py. diss.	0.14	<0.005	<0.5	7.34	5	760	2.5	<2	0.50	0.5	16	63	33	3.59	2.41	0.97	440	4	1.18	33	580	38	0.35	<5	136	0.45	74	<10	76	30
30	A01AG30	#3070	217.60m	f.s.s.	0.20	<0.005	<0.5	7.70	<5	980	2.0	<2	0.27	<0.5	14	76	28	3.92	3.70	0.98	335	1	0.64	33	360	46	0.27	5	83	0.51	98	<10	90	10
31	A01AG31	#3070	220.70m	shale with py. diss.	0.22	<0.005	<0.5	9.74	15	1180	3.5	<2	0.52	<0.5	17	96	31	4.06	3.81	1.19	415	1	0.89	44	340	30	0.34	5	238	0.50	109	<10	100	10
32	A01AG32	#3070	224.50m	shale with py. diss.	0.22	<0.005	<0.5	8.55	50	970	2.5	<2	0.38	0.5	22	86	35	4.20	3.51	1.12	375	1	0.79	44	480	20	0.65	<5	97	0.52	101	<10	100	30
33	A01AG33	#3070	233.00m	shale with py. diss.	0.18	<0.005	1.0	7.95	<5	900	2.0	<2	0.36	0.5	12	71	19	3.42	3.28	1.00	425	4	1.11	31	580	34	0.33	<5	136	0.54	109	<10	80	<10
34	A01AG34	#3070	239.00m	shale with py. diss.	0.12	<0.005	0.5	6.27	<5	520	2.0	<2	1.15	0.5	10	40	20	2.70	1.96	0.77	280	3	1.1	22	430	22	0.40	<5	79	0.32	62	<10	56	50
35	A01AG35	#3070	242.60m	shale with veinlets	0.16	<0.005	1.5	6.87	55	1180	2.5	<2	0.45	<0.5	8	54	4	3.35	4.28	1.08	410	<1	1.05	18	490	18	0.07	<5	70	0.42	71	<10	30	10
36	A01AG36	#3070	248.40m	shale with veinlets/py.	0.20	<0.005	0.5	6.58	30	770	2.0	<2	0.32	<0.5	8	50	22	2.53	2.26	0.73	460	1	1.09	26	740	32	0.25	<5	71	0.39	73	<10	68	<10
37	A01AG37	#3070	253.40m	f.s.s.	0.14	<0.005	<0.5	4.62	40	470	2.0	<2	2.30	0.5	9	33	30	2.82	1.66	0.72	945	4	0.61	18	860	90	0.34	<5	147	0.26	45	<10	76	20
38	A01AG38	#3070	260.50m	phyllitic shale	0.12	<0.005	2.5	8.08	25	980	3.5	<2	1.30	2.5	10	66	12	4.14	2.45	1.08	2020	3	1.37	24	430	144	0.11	<5	245	0.47	90	<10	966	10
39	A01AG39	#3070	265.10m	shale	0.26	<0.005	0.5	6.16	5	950	2.5	<2	0.75	<0.5	14	60	27	4.63	2.90	1.12	1775	1	0.6	34	540	32	0.23	<5	136	0.41	74	<10	138	30
40	A01AG40	#3070	273.45m	phyllitic shale	0.16	<0.005	<0.5	7.84	15	540	2.0	2	0.73	<0.5	15	81	36	3.36	3.88	0.90	875	5	0.19	43	700	14	0.72	<5	100	0.47	138	<10	96	10
41	A01AG41	#3070	276.50m	phyllitic shale with a few py. diss.	0.10	<0.005	<0.5	7.95	75	290	2.0	<2	0.47	<0.5	12	90	34	4.82	4.38	0.97	1295	11	0.35	39	460	22	1.06	<5	92	0.54	110	<10	98	20
42	A01AG42	#3070	282.10m	phyllitic shale with a few py. diss.	0.16	<0.005	3.0	5.03	115	400	2.0	<2	1.25	<0.5	16	53	40	4.85	2.20	1.03	1730	2	0.28	24	770	76	1.33	<5	53	0.31	65	<10	158	10
43	A01AG43	#3070	288.70m	shale with veinlets/py.	0.18	<0.005	1.5	5.70	20	370	2.0	<2	1.15	3	10	83	151	8.46	1.91	1.87	5130	<1	1.18	20	430	1366	1.89	15	132	0.40	96	<10	336	10
44	A01AG44	#3070	291.50m	f.s.s.	0.14	0.005	1.5	4.42	35	800	1.5	2	0.83	0.5	16	39	102	4.14	1.75	0.81	1360	4	0.32	31	780	446	0.65	5	84	0.23	48	<10	106	<10
45	A01AG45	#3070	297.30m	shale	0.08	<0.005	0.5	8.16	5	1050	4.5	<2	2.30	<0.5	3	60	18	2.66	2.06	0.83	1895	2	1.47	20	730	120	0.13	<5	382	0.44	78	<10	118	60
46	A01AG46	#3070	303.00m	phyllitic shale with py.	0.12	<0.005	<0.5	9.40	85	2190	3.0	<2	0.39	0.5	20	105	26	3.90	4.79	1.17	1005	1	0.39	46	400	34	0.43	10	80	0.54	137	<10	90	10
47	A01AG47	#3070	305.80m	f.s.s.	0.16	<0.005	<0.5	6.31	20	1020	2.0	<2	0.68	<0.5	11	52	30	3.34	2.72	0.77	810	3	0.3	29	680	40	0.44	5	48	0.35	82	<10	156	10
48	A01AG48	#3070	312.15m	shale	0.10	<0.005	<0.5	11.45	40	1460	3.5	2	0.43	0.5	16	79	35	4.91	4.68	1.51	870	1	0.37	57	680	40	0.55	<5	53	0.64	202	<10	196	<10
49	A01AG49	#3070	318.00m	shale with veinlets	0.14	<0.005	<0.5	9.83	55	960	5.5	2	2.00	0.5	11	49	15	3.84	2.09	1.45	1605	1	3.87	25	540	116	0.12	<5	666	0.41	89	<10	520	<10
50	A01AG50	#3070	321.00m	shale with veinlets	0.14	<0.005	<0.5	10.83	20	940	3.0	2	0.56	<0.5	18	76	39	4.99	5.06	1.46	1225	<1	0.74	55	760	46	0.53	<5	81	0.65	209	<10	150	<10
51	A01AG51	#3070	327.20m	shale with py. diss.	0.14	<0.005	0.5	6.65	160	320	2.5	2	0.66	2.5	18	36	35	3.76	2.49	0.98	535	4	0.85	36	880	148	0.67	<5	104	0.36	82	<10	358	<10
52	A01AG52	#3070	331.95m	shale with py. diss.	0.14	<0.005	0.5	8.64	70	670	3.5	<2	0.45	0.5	20	71	48	4.47	4.14	1.26	770	1	0.83	53	630	122	0.58	<5	101	0.52	157	<10	286	<10
53	A01AG53	#3070	337.45m	phyllitic shale	0.12	<0.005	<0.5	9.74	60	730	4.0	8	0.50	<0.5	21	73	54	5.07	4.55	1.40	825	2	0.93	57	710	154	0.65	<5	104	0.58	169	<10	246	<10
54	A01AG54	#3070	343.55m	f.s.s.	0.10	<0.005	<0.5	7.51	25	1630	3.0	<2	1.05	<0.5	11	53	21	3.78	2.32	1.12	755	<1	2.05	29	690	76	0.25	<5	263	0.50	104	<10	158	<10
55	A01AG55	#3070	346.60m	phyllitic shale	0.10	<0.005	0.5	8.64	20	580	2.5	<2	0.74	0.5	19	66	49	5.19	4.04	1.39	640	<1	0.68	49	590	64	0.61	<5	82	0.54	117	<10	452	<10
56	A01AG56	#3070	354.25m	phyllitic shale	0.08	0.005	<0.5	8.00	35	2640	2.5	<2	0.81	<0.5	13	52	13	3.39	2.64	1.07	690	<1	1.17	29	760	138	0.23	<5	82	0.47	159	<10	110	<10
57	A01AG57	#3070	358.80m	shale	0.10	<0.005	<0.5	7.83	20	1470	2.0	<2	1.15	<0.5	12	44	16	3.02	1.75	0.94	1610	<1	2.61	30	710	60	0.18	<5	209	0.54	85	<10	62	<10
58	A01AG58	#3070	361.85m	shale	0.12	<0.005	<0.5	6.97	10	1370	1.5	<2	0.80	<0.5	9	42	17	3.01	1.63	0.88	1565	<1	2.59	22	710	42	0.20	<5	177	0.48	82	<10	92	<10
59	A01AG59	#3070	366.90m	phyllitic shale with py. diss.	0.10	<0.005	<0.5	8.64	40	770	3.0	<2	0.28	1.5	9	59	23	3.37	3.80	1.03	2670	<1	1.09	41	640	100	0.36	<5	86	0.59	155	<10	1265	<10
60	A01AG60	#3070	372.65m	Pb-Zn ore zone with py.	0.10	<0.005	1.5	7.08	40	870	1.5	<2	0.56	1.5	10	42	38	4.52	2.45	1.18	>10000	1	1.16	28	750	386	0.11	<5	195	0.41	98	<10	758	<10
61	A01AG61	#3070	378.40m	Pb-Zn ore with shale	0.10	0.340	26.0	5.82	330	310	2.0	<2	0.47	369	22	22	80	6.99	2.80	0.82	>10000	3	0.25	18	410	19600	5.95	35	56	0.32	68	20	140500	1330
62	A01AG62	#3070	384.80m	Pb-Zn ore zone with py.	0.14	0.055	53.0	5.11	210	320	3.0	<2	3.20	220	8	23	141	5.95	0.70	0.72	>10000	12	0.04	36	430	39000	2.94	95	141	0.28	286	<10	69800	3290
63	A01AG63	#3070	390.00m	Pb-Zn ore zone with py.	0.16	0.030	38.0	6.99	495	40	3.0	<2	0.58	150	18	38	138	5.49	2.92	1.01	3260	3	1.06	35	600	14600	5.07	70	107	0.27	162	<10	59300	3100
64	A01AG64	#3070	393.05m	shale with veinlets/py.	0.16	<0.005	<0.5	9.24	100	140	4.5	<2	2.10	1.5	14	60	43	4.16	2.61	1.28	5390	<1	1.23	36	680	306	1.06	<5	310	0.34	234	<10	648	20
65	A01AG65	#3070	394.05m	phyllitic shale	0.14	0.010	<0.5	9.06	55	490	2.5	<2	0.63	1.0	15	59	25	4.50	4.08	1.23	1270	<1	0.29	41	550	56	0.64	<5	55	0.48	232	<10	408	<10
66	A01AG66	#3070	399.40m	phyllitic shale	0.10	0.005	<0.5	8.71	30	1370	2.0	<2	0.53	<0.5	14	60	32	4.98	3.88	1.22	1140	<1	0.61	37	520	82	0.52	<5	48	0.46	137	<10	252	<10
67	A01AG67	#3070	403.30m	phyllitic shale	0.14	<0.005	<0.5	8.59	35	600	5.0	<2	2.80	0.5	16	64	44	4.83	1.71	1.24	855	5	3.53	43	2840	92	0.70	<5	269	0.46	162	<10	234	10
68	A01AG68	#3070	408.80m	phyllitic shale	0.12	<0.005	0.5	9.62	25	1180	2.5	2	0.38	2.0	15	79	37	4.45	4.12	1.33	540	<1	0.71	45	530	28	0.49	<5	63	0.53	295	<10	188	<10
69	A01AG69	#3070	415.60m	phyllitic shale	0.18	<0.005	1.0	8.13	20	880	3.0	<2	0.40	6.5	17	77	60	4.52	3.53	1.20	470	2	0.67	51	500	66	0.58	<5	52	0.45	297	<10	712	<10
70	A01AG70	#3070	421.55m	phyllitic shale	0.16	<0.005	0.5	9.22	5	790	3.5	<2	0.78	<0.5	16	89	44	4.58	3.47	1.40	515	1	1.26	43	950	42	0.43	<5	167	0.48	156	<10	172	<10
71	A01AG71	#3070	428.10m	phyllitic shale	0.18	<0.005	<0.5	9.24	20	630	4.0	<2	1.25	<0.5	15	90	37	4.88	3.03	1.28	600	2	2.46	41	810	46	0.35	<5	186	0.57	143	<10	132	<10
72	A01AG72	#3070	434.20m	phyllitic shale	0.14	<0.005	0.5	8.73	15	660	2.0	<2	0.38	<0.5	20	78	33	4.71	3.44	1.23	500	<1	1.05	47	600	18	0.30	<5	90	0.50	118	<10	70	<10
73	A01AG73	#3070	442.00m	f.g.quartzite	0.14	<0.005	<0.5	5.64	5	310	0.5	<2	0.58	<0.5	6	31	6	1.74	0.92	0.63	540	<1	3.23	12	890	20	0.01	<5	126	0.34	40	<10	62	<10
74	A01AG74	#3244	630.20m	f.g.quartzite	0.16	<0.005	1.5	1.27	<5	510	0.5	<2	0.29	<0.5	2	13	34	0.26	0.50	0.08	140	16	0.46	2	<10	190	0.08	<5	24	0.02	3	<10	20	<10
75	A01AG75	#3244	637.20m	f.g.quartzite	0.14	<0.005	<0.5	0.85	<5	440	<0.5	<2	0.08	<0.5	<1	13	12	0.16	0.47	0.05	45	2	0.34	<1	<10	58	<0.01	<5	12	0.03	2	<10	10	<10
76	A01AG76	#3244	640.30m	f.g.quartzite	0.18	<0.005	1.0	2.87	5	1910	<0.5	<2	0.09	<0.5	1	20	48	0.14	1.55	0.03	25	15	1.3	<1	100	74	0.02	<5	37	0.03	1	<10	26	<10
77	A01AG77	#3244	642.60m	f.g.quartzite	0.16	<0.005	<0.5	7.54	5	1790	2.5	<2	0.19	<0.5	6	45	12	2.47	3.17	0.79	400	4	1.72	20	740	26	0.03	<5	33	0.20	68	<10	26	<10

Table II-5-2-12-3 Result of discriminant analysis for 77 core samples collected from the holesdrilled intersecting the SEDEX ore zone

Serial No.	Sample No.	Drill hole #	Depth	Rock	Actual group	Discriminant function values G1-G2	G1-G3	G2-G3	Discriminant group
1	A01AG01	#3070	57.20m	f.s.s.	G1	12.52	7.64	-4.89	G1
2	A01AG02	#3070	65.00m	f.s.s.	G1	12.58	5.61	-6.97	G1
3	A01AG03	#3070	70.10m	shale	G1	14.86	5.04	-9.82	G1
4	A01AG04	#3070	75.00m	f.s.s.	G1	8.35	6.32	-2.02	G1
5	A01AG05	#3070	81.70m	f.s.s.	G1	12.24	9.84	-2.41	G1
6	A01AG06	#3070	87.30m	f.s.s.	G1	9.58	1.07	-8.51	G1
7	A01AG07	#3070	93.90m	f.s.s.	G1	15.45	5.84	-9.62	G1
8	A01AG08	#3070	97.20m	f.s.s.	G1	20.10	8.55	-11.52	G1
9	A01AG09	#3070	103.40m	f.s.s.	G1	17.49	6.63	-10.86	G1
10	A01AG10	#3070	109.20m	f.s.s.	G1	15.51	8.64	-6.86	G1
11	A01AG11	#3070	115.00m	f.s.s.	G1	9.90	7.10	-2.80	G1
12	A01AG12	#3070	118.50m	f.s.s. with py. diss.	G1	16.05	5.20	-10.84	G1
13	A01AG13	#3070	124.60m	f.s.s.	G1	13.87	11.28	-2.59	G1
14	A01AG14	#3070	130.45m	f.s.s.	G1	9.93	9.00	-0.93	G1
15	A01AG15	#3070	133.70m	f.s.s.	G1	15.23	8.68	-6.55	G1
16	A01AG16	#3070	140.60m	f.s.s.	G1	22.97	6.81	-16.16	G1
17	A01AG17	#3070	146.70m	f.s.s. with py. diss.	G1	17.24	5.68	-11.56	G1
18	A01AG18	#3070	152.70m	f.s.s.	G1	21.32	7.09	-14.23	G1
19	A01AG19	#3070	155.70m	shale with py. diss.	G1	12.65	3.09	-9.56	G1
20	A01AG20	#3070	163.65m	shale with py. diss.	G1	18.91	12.28	-6.63	G1
21	A01AG21	#3070	169.75m	shale with py. diss.	G1	16.74	5.72	-11.02	G1
22	A01AG22	#3070	175.00m	shale with po. diss.	G1	16.42	3.15	-13.27	G1
23	A01AG23	#3070	178.90m	shale with py. diss.	G1	21.96	1.69	-20.26	G1
24	A01AG24	#3070	188.00m	shale with py. diss.	G1	17.15	3.78	-13.37	G1
25	A01AG25	#3070	191.05m	f.s.s. with py. diss.	G1	10.20	8.00	-2.20	G1
26	A01AG26	#3070	196.25m	shale with py. diss.	G1	13.36	9.65	-3.71	G1
27	A01AG27	#3070	199.30m	shale with py. diss.	G1	16.49	9.24	-7.25	G1
28	A01AG28	#3070	205.40m	f.s.s. with py. diss.	G1	20.41	6.68	-13.73	G1
29	A01AG29	#3070	211.50m	f.s.s. with py. diss.	G1	17.67	9.18	-8.49	G1
30	A01AG30	#3070	217.60m	f.s.s.	G1	15.46	10.78	-4.68	G1
31	A01AG31	#3070	220.70m	shale with py. diss.	G1	28.33	7.92	-20.41	G1
32	A01AG32	#3070	224.50m	shale with py. diss.	G1	22.71	6.99	-15.72	G1
33	A01AG33	#3070	233.00m	shale with py. diss.	G1	13.32	9.67	-3.66	G1
34	A01AG34	#3070	239.00m	shale with py. diss.	G1	26.90	1.96	-24.93	G1
35	A01AG35	#3070	242.60m	shale with veinlets	G1	20.88	4.17	-16.71	G1
36	A01AG36	#3070	248.40m	shale with veinlets/py.	G1	9.54	5.20	-4.34	G1
37	A01AG37	#3070	253.40m	f.s.s.	G1	21.57	7.67	-13.90	G1
38	A01AG38	#3070	260.50m	phyllitic shale	G1	8.13	8.90	0.77	G1
39	A01AG39	#3070	265.10m	shale	G1	15.94	8.74	-7.21	G1
40	A01AG40	#3070	273.45m	phyllitic shale	G1	20.53	2.72	-17.81	G1
41	A01AG41	#3070	276.50m	phyllitic shale with a few py	G1	11.53	8.68	-2.85	G1
42	A01AG42	#3070	282.10m	phyllitic shale with a few py	G1	17.60	3.40	-14.20	G1
43	A01AG43	#3070	288.70m	shale with veinlets/py.	G1	11.65	2.87	-8.78	G1
44	A01AG44	#3070	291.50m	f.s.s.	G1	10.37	10.16	-0.21	G1
45	A01AG45	#3070	297.30m	shale	G1	9.53	8.62	-0.91	G1
46	A01AG46	#3070	303.00m	phyllitic shale with py.	G1	15.60	2.31	-13.29	G1
47	A01AG47	#3070	305.80m	f.s.s.	G1	14.56	3.84	-10.72	G1
48	A01AG48	#3070	312.15m	shale	G1	13.19	1.80	-11.38	G1
49	A01AG49	#3070	318.00m	shale with veinlets	G1	11.65	-3.14	-14.78	G3
50	A01AG50	#3070	321.00m	shale with veinlets	G1	8.95	2.09	-6.86	G1
51	A01AG51	#3070	327.20m	shale with py. diss.	G1	14.84	9.88	-4.96	G1
52	A01AG52	#3070	331.95m	shale with py. diss.	G1	11.13	5.46	-5.67	G1
53	A01AG53	#3070	337.45m	phyllitic shale	G1	9.99	6.34	-3.65	G1
54	A01AG54	#3070	343.55m	f.s.s.	G1	11.73	7.27	-4.46	G1
55	A01AG55	#3070	346.60m	phyllitic shale	G1	19.81	7.95	-11.87	G1
56	A01AG56	#3070	354.25m	phyllitic shale	G1	9.07	0.93	-8.14	G1
57	A01AG57	#3070	358.80m	shale	G2	-3.70	5.62	9.43	G2
58	A01AG58	#3070	361.85m	shale	G2	-3.62	3.41	7.03	G2
59	A01AG59	#3070	366.90m	phyllitic shale with py. diss.	G2	-13.93	6.95	20.88	G2
60	A01AG60	#3070	372.65m	Pb-Zn ore zone with py.	G2	-19.41	9.47	28.88	G2
61	A01AG61	#3070	378.40m	Pb-Zn ore with shale	G2	-25.78	5.70	31.48	G2
62	A01AG62	#3070	384.80m	Pb-Zn ore zone with py.	G2	-25.90	2.82	28.72	G2
63	A01AG63	#3070	390.00m	Pb-Zn ore zone with py.	G2	-14.00	5.91	19.91	G2
64	A01AG64	#3070	393.05m	shale with veinlets/py.	G3	8.60	-8.03	-16.64	G3
65	A01AG65	#3070	394.05m	phyllitic shale	G3	10.96	-3.89	-14.85	G3
66	A01AG66	#3070	399.40m	phyllitic shale	G3	9.81	2.29	-7.51	G1
67	A01AG67	#3070	403.30m	phyllitic shale	G3	14.08	-10.03	-24.11	G3
68	A01AG68	#3070	408.80m	phyllitic shale	G3	17.23	-10.61	-27.85	G3
69	A01AG69	#3070	415.60m	phyllitic shale	G3	16.70	-12.51	-29.21	G3
70	A01AG70	#3070	421.55m	phyllitic shale	G3	28.34	-1.26	-29.60	G3
71	A01AG71	#3070	428.10m	phyllitic shale	G3	17.80	-2.35	-20.15	G3
72	A01AG72	#3070	434.20m	phyllitic shale	G3	20.76	3.43	-17.33	G1
73	A01AG73	#3070	442.00m	f.g.quartzite	G3	2.47	-4.14	-6.61	G3
74	A01AG74	#3244	630.20m	f.g.quartzite	G3	12.17	-8.65	-20.82	G3
75	A01AG75	#3244	637.20m	f.g.quartzite	G3	14.68	-11.78	-26.46	G3
76	A01AG76	#3244	640.30m	f.g.quartzite	G3	19.07	-11.22	-30.29	G3
77	A01AG77	#3244	642.60m	f.g.quartzite	G3	12.08	-9.17	-21.25	G3

Discriminant rate : 96.1%

Remarks;

G1 : hangingwall of the mineralized zone G2 : the mineralized zone(SEDEX) G3 : footwall of the mineralized zone

Table II-5-2-12-4 Discriminant function coefficients

Varibles	F(G1-G2)	F(G1-G3)	F(G2-G3)
logMn	-20.70426	-2.68431	18.01995
logFe	2.92810	14.49229	11.56419
V	-0.01372	-0.08249	-0.06877
logCa	15.01654	-5.64220	-20.65873
Na	-5.08394	-5.42031	-0.33637
logSr	7.38881	13.32051	5.93170
Mg	18.65202	-6.42426	-25.07628
Ti	-48.23731	42.97103	91.20834
logPb	-7.68627	3.67575	11.36202
Cr	0.13482	-0.12985	-0.26467
logW	18.87701	-24.00090	-42.87791
Constant	60.61629	-3.34555	-63.96184

Remarks;

G1: hangingwall of the mineralized zone
G2: the mineralized zone(SEDEX)
G3: footwall of the mineralized zone
F(G1-G2): Function discriminating between G1 and G2
F(G1-G3): Function discriminating between G1 and G3
F(G2-G3): Function discriminating between G2 and G3