Chapter 3 Ground truth survey

3-1 Survey districts and reasons to be selected

Based on the result of the existing data analysis and the satellite image analysis, 31 districts were selected for ground truth survey. The location map of the survey districts is shown in Fig. II-3-1, and the summary and reasons to be selected are listed in Table II-3-1. There were two reasons: the existence of known deposits and the hydrothermal alteration zones extracted by the satellite image analysis. The field survey was intended to comprehend the geology and mineralization in the known deposit areas and in the hydrothermal alteration zones. Especially, in the model mineral deposits area, samples were taken for various laboratory works aiming at clarifying the nature of mineralization and construction of the exploration strategy.

3-2 Survey results for each district

3-2-1 Varvarco district

1) Location

The Varvarco district is located about 40 km to the north of Andacollo town in the northwest of Neuquen province (Fig. II-3-1). Hydrothermal alteration zones, CM004 to CM007, extracted from the satellite image analysis are distributed (Fig. II-2-6). The area is lat. 36° 45' 00" to 36° 53' 24" S, and long. 70° 33' 36" to 70° 41' 24" W (Fig. II-3-2-1a), and about 250 km^2. Its representative coordinate is lat. 36° 47' 32. 3" S and long. 70° 36' 34.6" W at the hydrothermal alteration zone of CM005.

2) Topography and vegetation

Alteration zone of CM004 is located in a gently sloped hill while alteration zones of CM005 and CM006 are located on a relatively steep hillside. The vegetation is thin with sparse grasses of low height. Thus, the rocks are relatively well exposed.

3) Access

It is about 70 km and 1.5 hours drive on No. 43 provincial road to north from Andacollo town to alteration zone of CM004. Though it is unpaved, the road is well maintained up to Las Obejas village in the midway to allow high-speed driving. From CM004 to CM005 and then to CM006 each takes about 30 minutes on foot. Time limit prohibited a survey on CM007.

Table II-3-1 Ground truth survey districts and reasons to be selected.

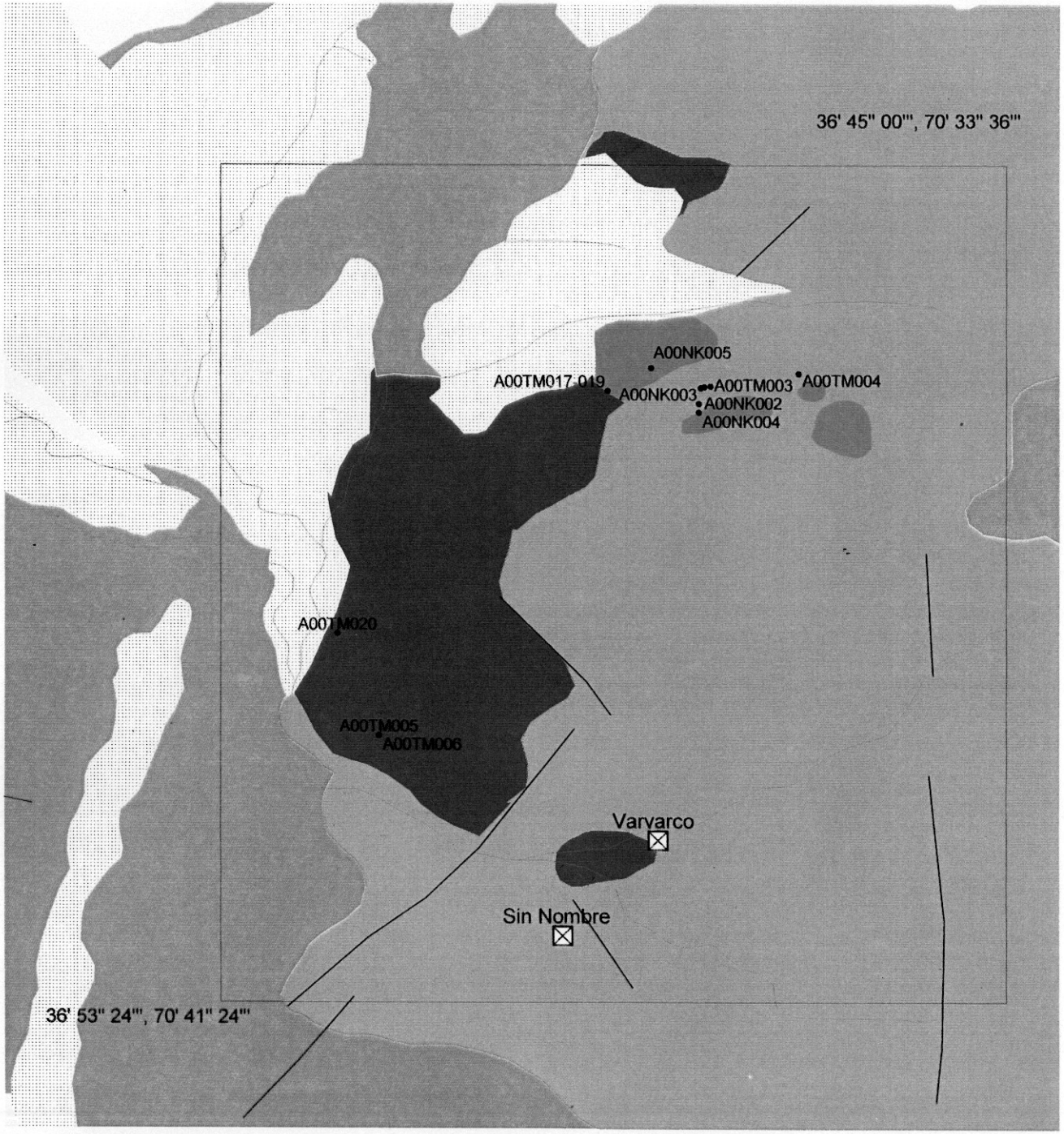
No.	Survey disrict	Survey site	Reason to be selected	Mineralization type	Lineament (TM)	No. of Alt. zones (TM)	Lat.(D)	Lat.(M)	Lat. (S)	Lon.(D)	Lon.(M)	Lon. (S)
1	Varvarco	Alt. zones, Granite area	Known mineral ocurrence, Alteration zones from TM image	Vein (Au, Cu)	NE, NW, N-S	4	36	47	16.0	70.0	36	27.4
2	Butalon Norte	Alt. zones	Known mineral ocurrence, Alteration zones from TM image	Stockwork (Au)	NE	2	36	58	47.3	70	38	49.5
3	Andacollo	Mina Sofia, Sur los Maitenez, Arroyo Huaraco, Cero Colo, Alt. zones	Typical known mineral ocurrence, Alteration zones from TM image	Vein (Au, Pb, Zn)	NE	3	37	11	30.1	70	37	58.5
4	Cerro Caicayen	Quebrada del Bronce, Mina Hierro	Known mineral occurrence	Porphyry Cu, Replacement (Fe)	NE, NW, N-S		37	26	39.3	70	26	35.8
5	Cerro del Diablo	Cerro del Diablo, Barite veins	Known mineral occurrence	Vein (Cu, Barite)	NE, NW		37	38	10.3	70.0	26	20.6
6	Campana Mahuida	Campana Mahuida, Barite veins	Typical known mineral ocurrence, Alteration zone from TM image	Porphyry Cu, Vein (Barite)	NE	N.I.	38	12	48.6	70	32	38.2
7	Palau Mahuida	Palau Mahuida	Alteration zones from TM image		Circular, NE, NW	16	38	53	58	70	49	11.8
8	Carreri Malal	Carreri Malal	Known mineral occurrence	Vein (Cu, Pb, Zn)	NE, NW	1	38	57	50.5	70	36	50.9
9	Nireco	Alt. zones	Alteration zones from TM image		NE, NW, N-S	10	39	2	22.1	70	32	10.7
10	La Voluntad	La Voluntad	Known mineral occurrence	Porphyry Cu	NE, NW	4	39	12	50.2	70	36	22.1
11	Mina Maria	Maria	Known mineral occurrence	Vein (Pb, Zn, Cu)		1	41	40	11.3	71	6	41
12	El Bolson	Rio Azul, Rio Lindo	Alteration zone from TM image		NNW, NE, N-S	3	41	58	10	71	34	24.6
13	Cerro Coihue	Qda. Baya, Qda. Ferreyro	Typical known mineral occurrence	Porphyry Cu	NW		42	8	35.7	71	18	25.1
14	Condorcanqui	Condorcanqui	Typical known mineral occurrence	Irregular vein (Cu)	NE, NW		42	9	9.9	71.0	24	13.9
15	Cushamen	Cushamen	Known mineral occurrence	Irregular vein (Mo)			42	9	40.7	70	30	33.2
16	Epuyen	A. Pedregoso de Epuyen	Known mineral occurrence, Alteration zones from TM image	Placer Au	NE, NW, N-S	3	42	13	51.9	71.0	25	17.7
17	Lago Cholila	A. Pedregoso de Lago Cholila	Alteration zones from TM image		NE	8	42	28	3.8	71	35	53.2

N.I. : Not interpreted although color anomaly of hydrothermal alteration is generated on TM ratio image.

Table II-3-1 Ground truth survey districts and reasons to be selected.

No.	Survey disrict	Survey site	Reason to be selected	Mineralization type	Lineament (TM)	No. of Alt. zones (TM)	Lat.(D)	Lat.(M)	Lat. (S)	Lon.(D)	Lon.(M)	Lon. (S)
18	Huemules	Huemules Sur	Typical known mineral occurrence	Vein (Pb, Au, Ag)	NNW～NNE	2	42	47	32.1	71	29	45.9
19	Joya del Sol	Joya del Sol	Typical known mineral occurrence, Alteration zones from TM image	Vein (Au, Ag)	NE, NW, N-S	3	42	52	43	71	12	19.5
20	Cerro Gonzalo	Cerro Gonzalo-A. Luque	Known mineral occurrence	Porphyry Cu	NE		43	18	54.4	71	2	22.8
21	Arroyo Cascada	A. Cascada	Known mineral occurrence	Vein (Au)	NW		43	30	17	71	6	10.1
22	Gabros de Tecka	Gabros de Tecka	Known mineral occurrence	Orthomagmatic (PGM)	NE, NW, E-W		43	42	32.1	70	33	57.2
23	Poz. de Navarro	Poz. de Navarro, Ea. el Triunfo	Known mineral occurrence	Vein (Cu)	NW, N-S		43	10	38.2	71	40	51.4
24	Las Mentas	Las Mentas	Known mineral occurrence	Vein (Pb)	NE		43	24	9.3	71	32	33.1
25	Poncho Moro	A. Pedregoso	Alteration zone from TM image		NE, NW	1	43	37	55.1	71	25	30.7
26	Cerro Colorado	Co. Colorado, Co. Rinon	Typical known mineral ocurrence, Alteration zone from TM image	High sulfidation Au		N.I.	43	57	47.1	71	34	13.6
27	Estrella Gaucha	Estrella Gaucha	Known mineral ocurrence, Alteration zone from TM image	Kaolin	NE, NW	N.I.	44	41	23.0	71.0	7	12.5
28	Mina Gato	Mina Gato	Known mineral ocurrence, Alteration zone from TM image	Kaolin	NW		44	50	13.6	71	8	30.6
29	Ea. Arroyo Victoria	A. Huemul	Alteration zone from TM image		NE, NW	N.I.	44	54	11.1	71	14	43.6
30	Ferrocarrilera	Ferrocarrilera	Known mineral occurrence	Vein (Pb, Zn)	E-W～WNW		44	56	21.8	71	35	5.4
31	Cerro Blanco	Cerro Blanco	Known mineral ocurrence, Alteration zone from TM image	Vein (Pb, Ag)	NW, Circular	N.I.	45	0	13.7	71	27	28.2

N.I. : Not interpreted although color anomaly of hydrothermal alteration is generated on TM ratio image.



Known deposit
Sampling point
Lineament
Circular structure
River
Lake

Legend

Quaternary sediments
Pliocene to Pleistocene basalt
Tertiary sedimentary rocks
Tertiary volcanic rocks
Tertiary granitoids
Jurassic to Cretaceous sedimentary rocks
Jurassic to Cretaceous volcanic rocks
Jurassic to Cretaceous granitoids
Permian to Triassic igneous rocks
Carboniferous sedimentary rocks
Proterozoic metamorphic rocks
Alteration zone

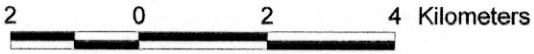


Fig. II-3-2-1a Geologocal map with sampling points of the Varvarco district.

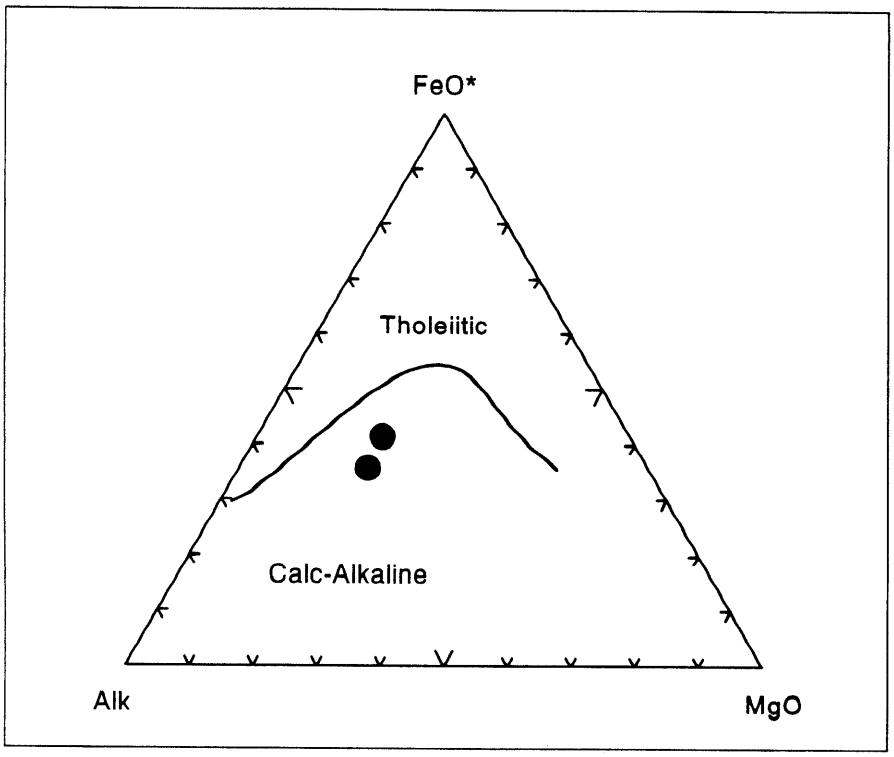


Fig. II-3-2-1b Ternary variation diagram of AFM plot for granitic rocks of the Varvarco district. Alk = Na_2O+K_2O, FeO^* = Total Fe in FeO.

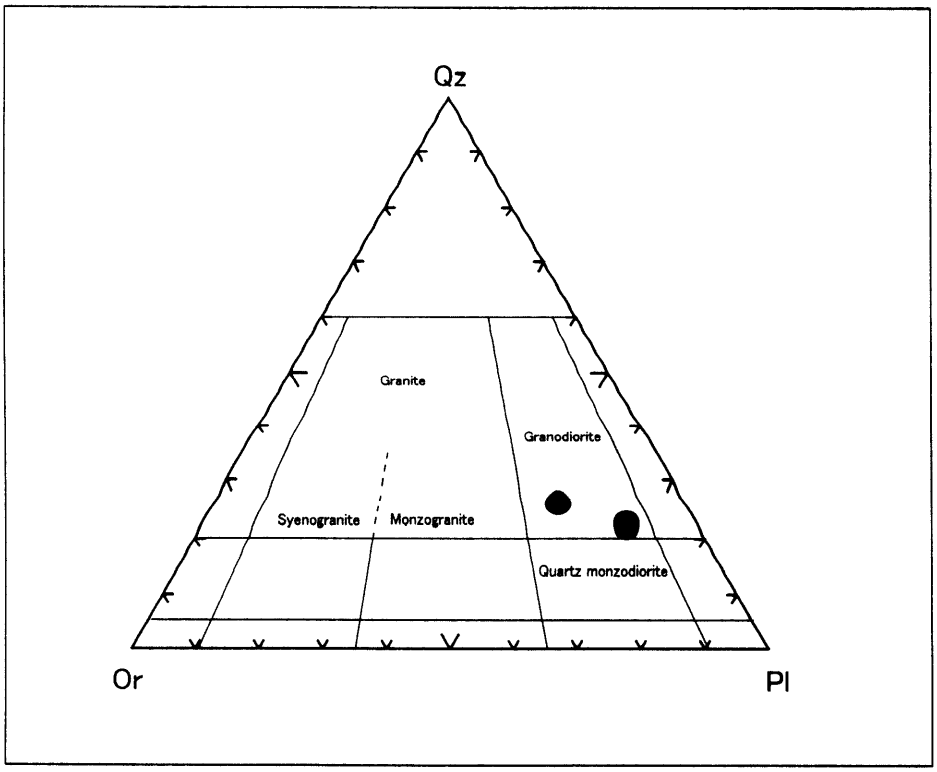


Fig. II-3-2-1c Ternary variation diagram of Qz-Or-Pl CIPW normative compositions for granitic rocks of the Varvarco district.

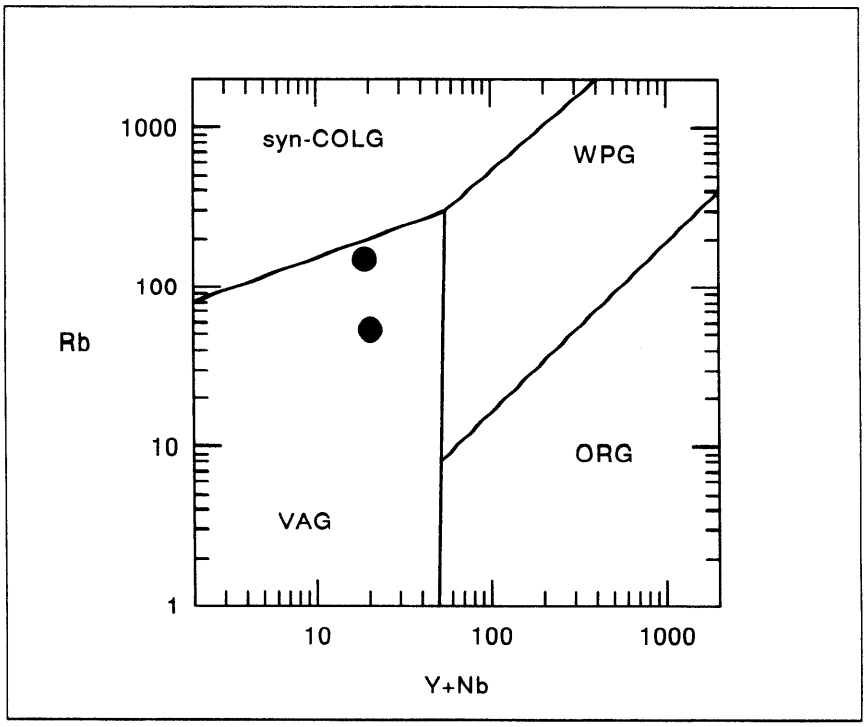


Fig. II-3-2-1d Rb - (Y+Nb) diagram for granitic rocks of the varvarco district. VAG : volcanic arc granites, syn-COLG : syn-collision granites, WPG : within-plate granites, ORG : ocean ridge granites, (Pearce et al. 1984).

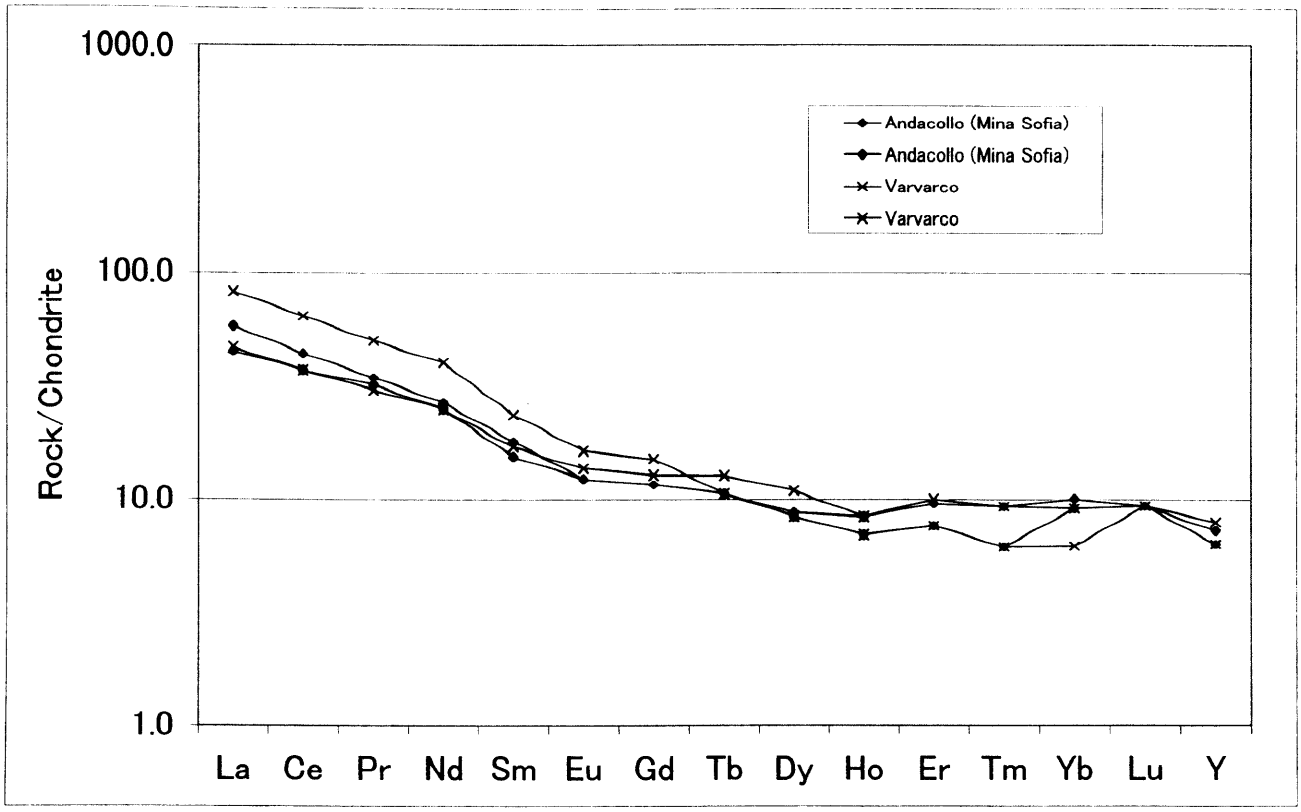


Fig. II-3-2-1e Chondrite normalized paterns for granitic rocks of the Varvarco district compared with the Andacollo district.

4) Previous surveys

The district covering the hydrothermal alteration zones of CM004 to CM006 is called Varvarco area and was surveyed by SEGEMAR and CORMINE in the past.

5) Mining properties

CORMINE S.E.P., the public mining corporation of Neuquen province, owns the mining property.

6) Geology and geological structure

This district is located at the northwestern end of the Cordillera Viento ranging about 60 km from north to south, and about 20 km from west to east, at about 3,000 m above sea level. The geology of the Cordillera Viento has a anticline structure. The geology of the district comprises Carboniferous slate, phyllite and quartz schist of Huaraco formation of Andacollo group, and unconformabaly overlying Permian to Triassic rhyolitic volcanics of Choiyoi group (Fig. II-3-2-1a). These are intruded by granite stocks and fine grained granodiorite dykes which are called the Varvarco granite. A stock of the Varvarco granite is distributed in a range of 4 km x 12 km to the east of Varvarco village.

7) Mineralization and alteration

The Varvarco deposit reported by CORMINE (1996) is located in a stream about 7 km to the east of Varvarco village. It is polymetal veins and disseminated deposits hosted in the Varvarco granite and volcanics of the Coiyoi group, containing pyrite, chalcopyrite, chalcocite, bornite, oxide copper, magnetite, hematite, goethite, tetrahedrite, tennantite, galena, sphalerite, native gold and silver minerals. As the average of six ore samples, 16.97 g/t Au, 302.25 g/t Ag, 20,389 ppm Cu, 1,148 ppm Pb and 2,142 ppm Zn were reported. The strike and dip of the veins are N30° E, 30° NW. Alteration zones area propylite, phyllic, potassic and argillization. Similar mineralization are known nearby besides Varvarco deposit, but they were not surveyed in Phase 1 survey.

The alteration zone of CM004 forms a hill with a comparative differential height of 10 m and tending to the E-W. It is made up of whitened and argillized schist of Huaraco formation of Andacollo group which shows N20° W, 50° E and the Varvarco ganite intruded into them. The granite is distributed to the western end of the hill. Silicified rocks form a lens-shaped ledge of 5 to 50 meters wide tending to the N40° W at an angle somewhat inclined to the schistocity of the Huaraco formation. Limonite is concentrated in around of the silicified rocks. As the results of POSAM measurement, pyrophyllite was identified in the silicified rock. Montmorillonite was identified in the white clay from the center of the hill. Kaolinite was identified in the sample of argillic alteration zone around the hill. No sulfide mineral was

observed in these alteration zones. Although the veins of tourmaline and epidote developing in the Varvarco granite in contact with the western end of CM004, their relations with the surroudning argillic alteration zones are not apparent.

8) Characteristics of the satellite image

The alteration zones of CM004 to CM007 are part of the alteration zones scattered to the north of Andacollo district, show reddish purple color on ratio image as mentioned in Chapter2, and form an elliptic shape with a maximum size of about 0.5 km x 1.5 km in the Choiyoi group and the Varvarco granite. Lineaments tending to the N-S, NE-SW and NW-SE are extracted in this district, but their relations with mineralization and alteration are not clearly defined.

9) Laboratory work results

It was verified by powdery X-ray diffraction that the samples of A00NK006 and A00TM003 were composed of quartz and pyrophyllite. The chemical analysis of silicified rock of A00NK002, A00NK003, A00TM003 and A00TM004 showed from less than detection limit to 0.02 ppm Au and from less than detection limit to 0.2 ppm Ag. K-Ar radiometric dating for the plagioclase of A00TM020 from the Vavarco granite revealed 64.7 ±3.2 Ma. It was observed microscopically that the sample of A00TM020 is tonalite and very weakly altered that biotite is slightly replaced by chlorite. Also, bulk chemical analysis of Varvarco granite of A00TM018 and A00TM020 showed that these are calc-alkaline series granodiorite and have volcanic arc granite composition (Fig.II-3-2-1b to e).

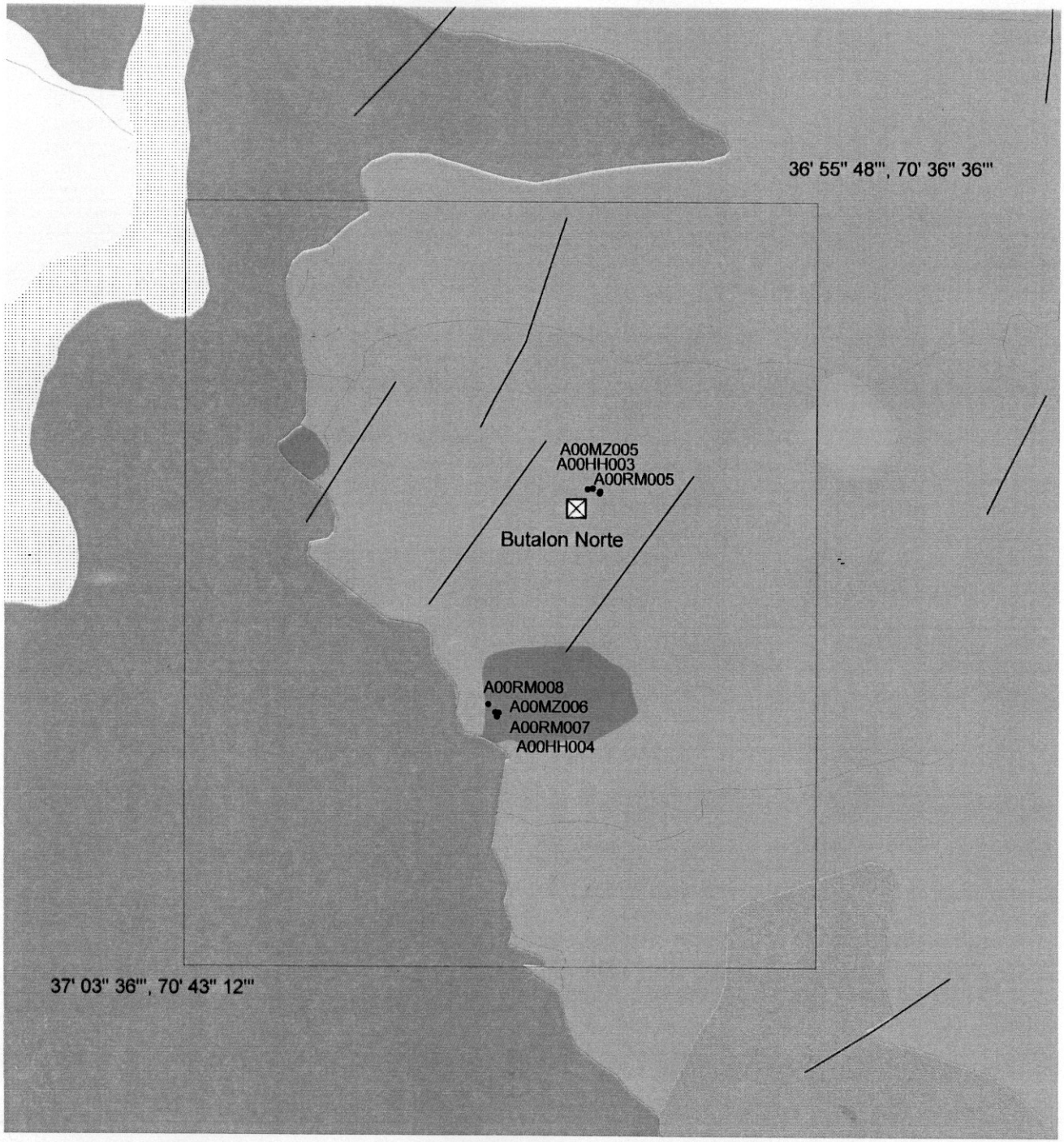
10) Assessment

In the alteration zones of CM004 to CM005, the presence of a pod-shaped silicified rock ledge accompanying pyrophyllite was confirmed, which indicates a high possibility of high-sulfidation hydrothermal system or advanced argillic alteration. Besides that, Varvarco auriferous polymetallic deposit is distributed. Consequently, it is desired to unveil the nature of hydrothermal alteration of this district by means of classification of alteration zones and isotopic study of oxygen and sulfur in order to verify the possibility of prophyry Cu deposits, high-sulfidation epithermal Au deposits and auriferous polymetallic deposits.

3-2-2 Butalón Norte district

1) Location

The Butalón Norte district is located about 20 km to the north of Andacollo town in the northwest of Neuquen province (Fig. II-3-1). The hydrothermal alteration zones of CM009 and



Known deposit
Sampling point
Lineament
Circular structure
River
Lake

Legend

Quaternary sediments
Pliocene to Pleistocene basalt
Tertiary sedimentary rocks
Tertiary volcanic rocks
Tertiary granitoids
Jurassic to Cretaceous sedimentary rocks
Jurassic to Cretaceous volcanic rocks
Jurassic to Cretaceous granitoids
Permian to Triassic igneous rocks
Carboniferous sedimentary rocks
Proterozoic metamorphic rocks
Alteration zone

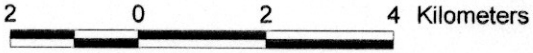


Fig. II-3-2-2a Geologocal map with sampling points of the Butalon Norte district.

CM0010 extracted from the satellite image analysis are distributed here (Fig.II-2-6). The area is lat. 36° 55' 48" to 37° 03' 36" S, and long.70° 36' 36" to 70° 43' 12" W (Fig. II-3-2-2a), and about 170 km^2.

2) Topography and vegetation

This district is located on the western slope of Cerro Panta in the north of the Cordillera Vient. At an elevation of 1,200 to 1,800 m above sea level, it forms a relatively gentle hillside. Rio Neuquen runs on the west side to south and its branch Rio Butalón Norte flowing on the north side. Valleys are cut near the riverside but the land on top of the hill is relatively flat. The vegetation is sparse and the surface soil is not deep.

3) Access

From Chos Mala town, it is about 1 hour drive on No. 43 provincial road to Huinganco, then it is 1.5 hours drive on No. 39 provincial road, then turn eastward into a byroad and run on a farm road for about 30 minutes. There are no roads for two to three kilometers before getting to the district, so considerable walking is necessary. Totally, It takes about three hours to the district from Chos Malal town. Field survey is possible between the middle of September and the end of April.

4) Previous surveys

In 1988, the CORMINE S.P.E. and the Dirección General de Minería of Neuquen province executed the geochemical survey and hydrothermal alteration zones were described. 176 rock chip sampls were taken and values of 0.1 to 0.3 ppm Au were obtained. The fluid inclusion study showed relatively high salinity contents.

In 1989, CORMINE S.P.E. and DGFM took 60 rock samples from the hydrothermal alteration zones for atomic absorption analysis.

In 1993, CORMINE S.E.P. and Minera Placer Dome Argentina S.A. discovered a silicified zone of 50 cm width at N75° E, showing limonite lamination, and a fractured zone of 2 cm width nearby.

Placer Exploration Inc. (1995) reported the results of analysis of the 14 samples taken in Rio Butalón Norte. It was 6 to 96 ppm Cu; for gold, only one sample showed 0.08 ppm Au, and the rest gave <0.02 ppm Au.

Minamérica S.A. (1995) analyzed 7 rock samples for gold and copper. It was between 5 and 82 ppm Cu (six samples), 0.011 ppm and 0.025 ppm Au for two samples, and <0.005 ppm Au for the rest.

5) Mining properties

CORMINE S.E.P. owns the mining property named Butalon. Its area is 6,580 ha.

6) Geology and geological structure

The geology of the district, in ascending order, consists of upper Permian to Triassic volcanics of Choiyoi group, Tertiary Molle volcanic rocks and Quaternary basaltic rocks, piedmont sediments and alluvium. And intrusive rocks of unknown ages are distributed.

Volcanic rocks of the Choiyoi group are made up of rhyolitic ignimbrite and andesitic rocks with interbeds of tuff. Ignimbrite shows flow structure with porphyritic texture, but tuff shows more homogeneous crystal grain sizes.

The Molle volcanic rocks are composed of andesitic rocks and distributed in the western part of the district. Outside the district, they are distributed to the west of Rio Neuquen and the north of Rio Butalon Norte.

The intrusive rocks comprise granodiorite, tonalite and quartz andesitic porphyry. Based on the chemical compositions of these rocks, Casé et al. (1999) reported that these rocks are the sub-alkaline to calc-alkaline and rich in Fe and Al.

(7) Mineralization and alteration

No significant alteration zones were found in the sampling points of A00RM005 in this area that were surveyed in the past. The surface volcanic rocks of the Choiyoi group were fresh not subjected to alteration and contain the primary phenocrysts of quartz, albite and alkali feldspar (Appendix 5). Numerous veinlets of magnetite were observed at the site. Although hydrothermal breccia or pebble dyke into the Choiyoi group were witnessed, no clay mineral was identified by the powdery X-ray diffraction of the sample A00MZ004.

In the southern alteration zone of CM010 (Fig. II-2-6), silicified dacite porphyry with limonite is distributed. As the result of powdery X-ray diffraction, sericite and kaolinite were identified for sample A00RM007. And kaolinite was identified for silicified volcanic rock of sample A00MZ006 by the POSAM measurement.

8) Characteristics of the satellite image

The area of the Choiyoi group was classified as TRiv (lower Triassic, volcanic rocks) and intrusive rocks were classified as αJm (middle Jurassic, igneous rocks). The color tone of the false color is pale yellowish green to brown to whitish brown. The structure due to topographical undulations is rough, and the water system is dendritic and crisscross with moderate to high densities. The ridges are clear with high resistance. It is massive without bedding planes. Five lineaments of NNE-SSW to NE-SW can be extracted. In the ratio image, the alteration zones of CM009 and CM010 assuming a reddish purple color were extracted.