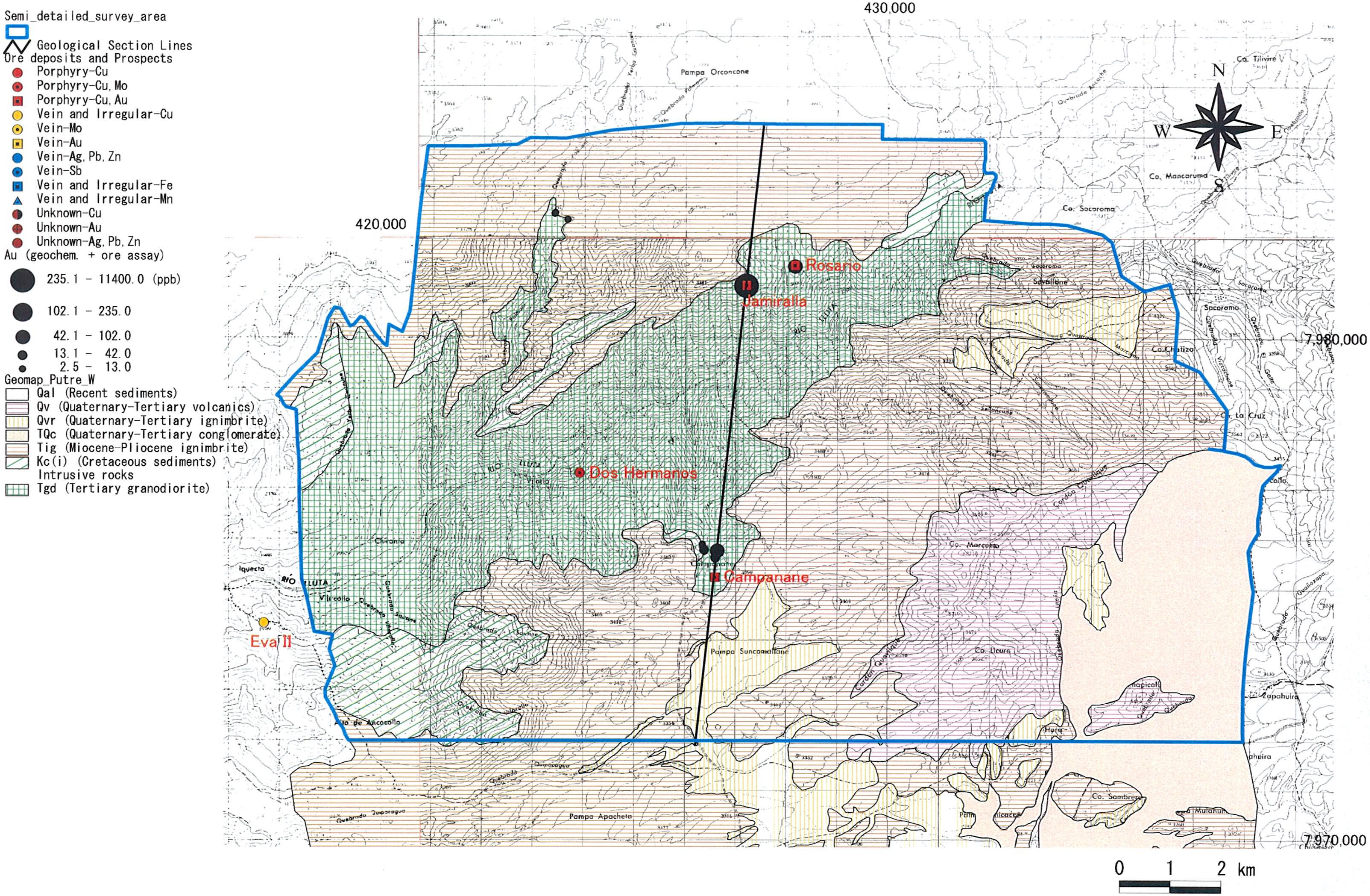

Fig. 2-1-65 (1) Geochemical Anomaly Map in the Area to the West of Putre (Au)

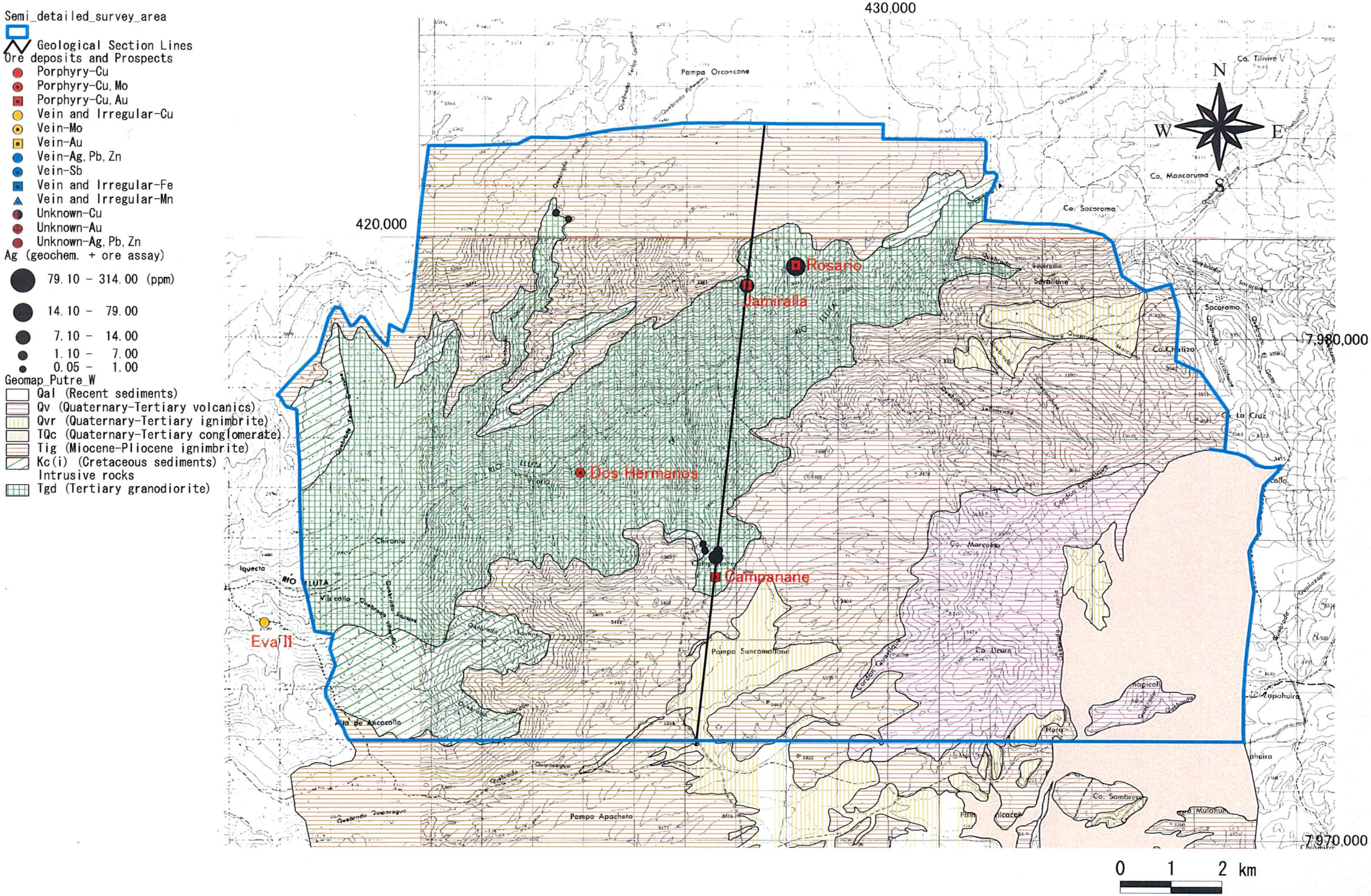

Fig. 2-1-65 (2) Geochemical Anomaly Map in the Area to the West of Putre (Ag)

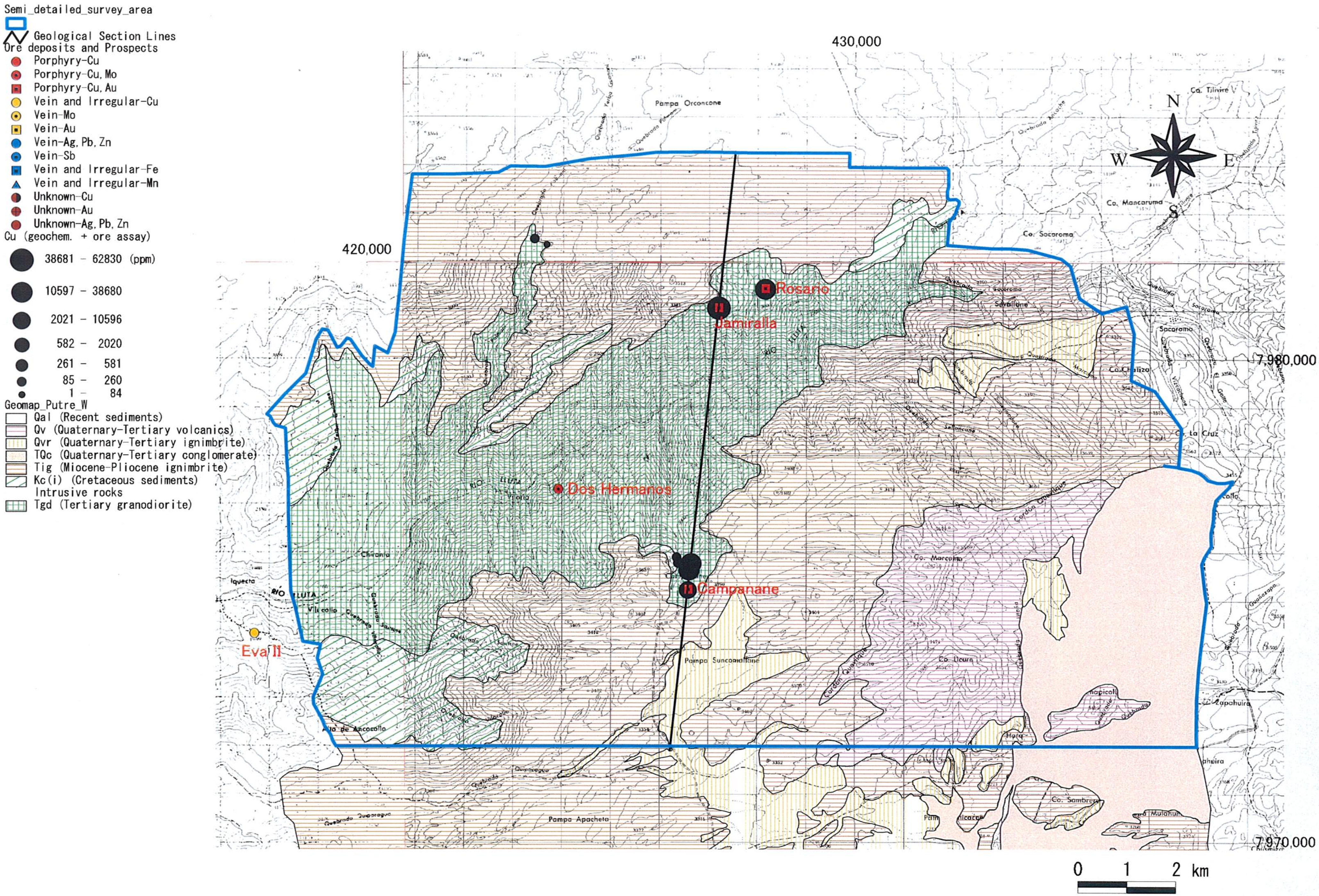

Fig. 2-1-65 (3) Geochemical Anomaly Map in the Area to the West of Putre (Cu)

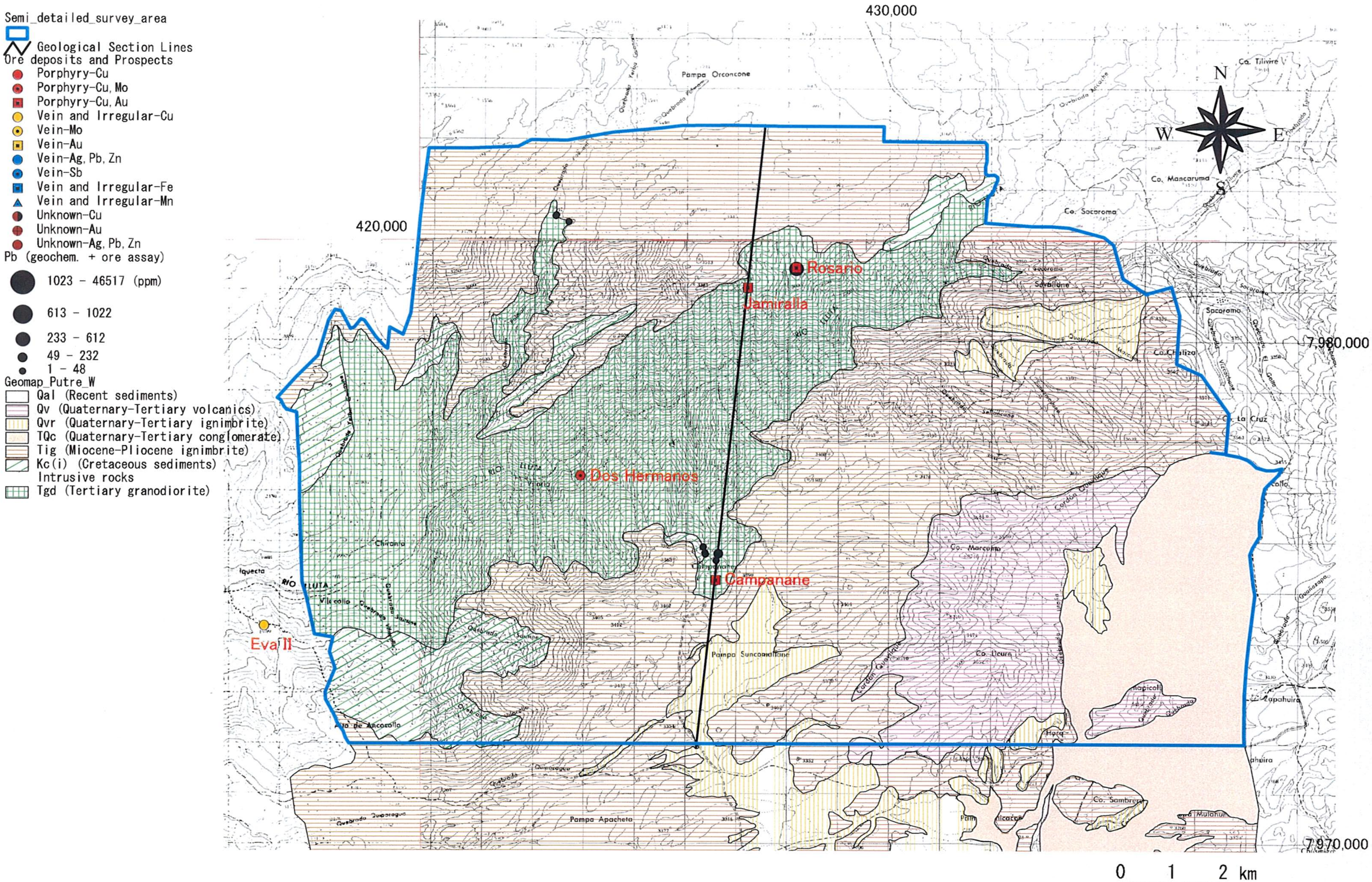

Fig. 2-1-65 (4) Geochemical Anomaly Map in the Area to the West of Putre (Pb)

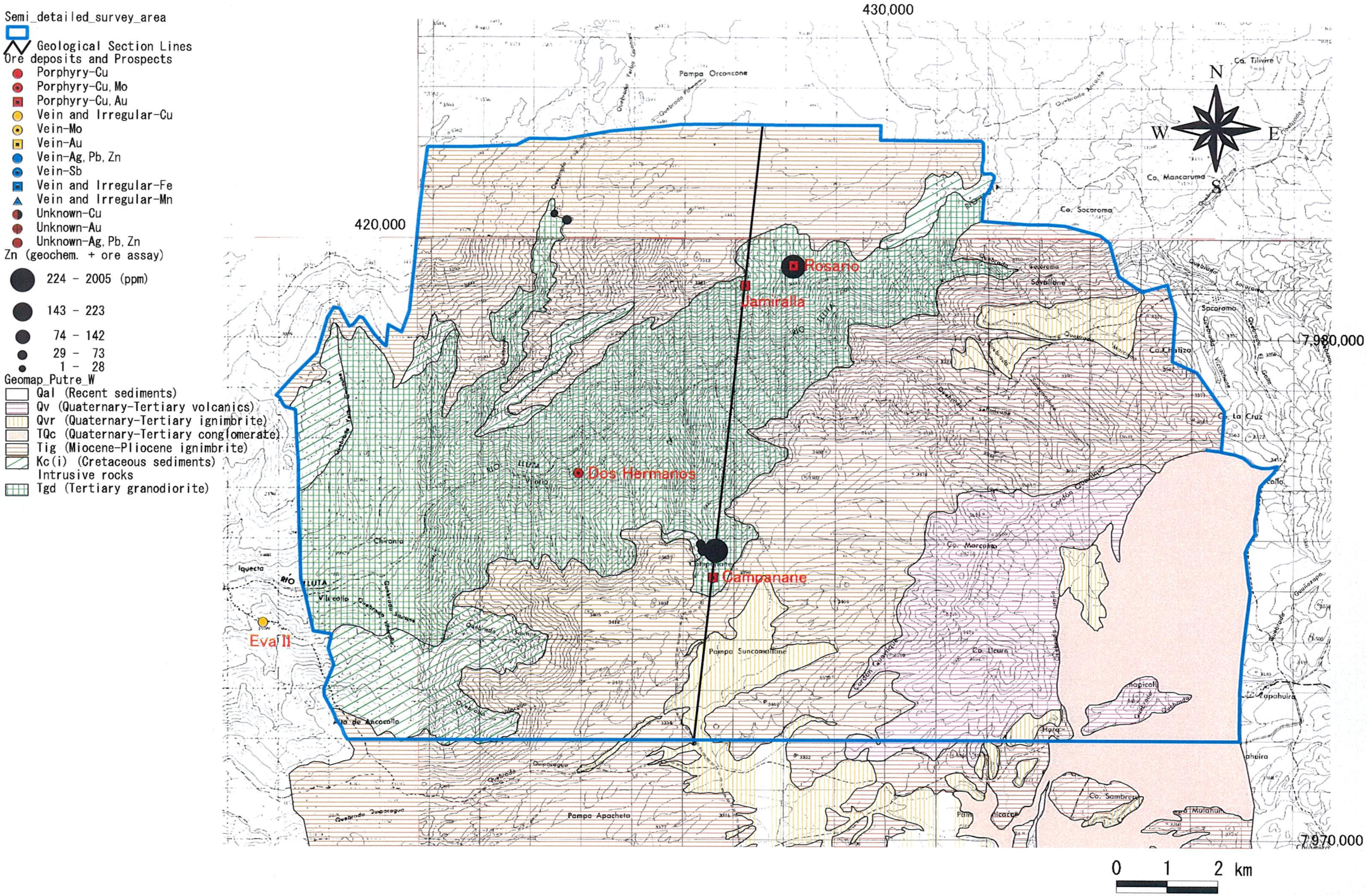

Fig. 2-1-65 (5) Geochemical Anomaly Map in the Area to the West of Putre (Zn)

55.1±1.9 Ma (whole rock), 53.8±1.4 Ma (biotite), 53.8±1.3 Ma (biotite), 52.8±1.4 (sericite), and as for the ages of intermediate to strongly altered rocks; 50.4±2 Ma (sericite), 50.0±1.2 Ma (biotite), and 44.4±2 Ma (sericite) were obtained.

The Lower Cretaceous System and the above intrusive bodies are unconformably overlain by Neogene units.

The Neogene System consists of Miocene-Pliocene ignimbrite (rhyolitic welded tuff).

The Upper Neogene-Quaternary System is composed of, from bottom upward; conglomerate, ignimbrite (pumiceous tuff), and basalt lava, these units have unconformable relation to each other.

The Quaternary System is alluvium.

In this area, vein-type copper mineralization (Campanane, Jamiralla, and Rosario Prospects) occur at three localities in granodiorite. The above prospects all consist of aggregates of copper-oxide-bearing quartz-tourmaline veins (maximum width 40cm), and they partly form network. The extension of these veins is NNW~NNE, and the Jamiralla, Rosario Prospects are located at the NNE extension of the Campanane Prospect. Chalcopyrite, pyrite, and chrysocolla occur in the Campanane veins. The vicinity of these prospects are altered by silicification and sericitization accompanied by potash feldspar and tourmaline in some places.

Au-Ag-Cu-Pb-Zn anomalies were detected by rock geochemical survey.

The above prospects are all located within a zone where intermediate airborne magnetic intensity zones and the peripheries of short wavelength low magnetic anomaly zones overlap. Medium wavelength anomaly zones do not occur in the prospective areas.

CHAPTER 2 DRILLING SURVEY

2-1 Purpose of the Survey, Drilling Sites, Geologic Boundaries

Twelve holes were drilled in order to clarify the geology and alteration associated with mineralization in zones where the intermediate airborne magnetic intensity zones and the

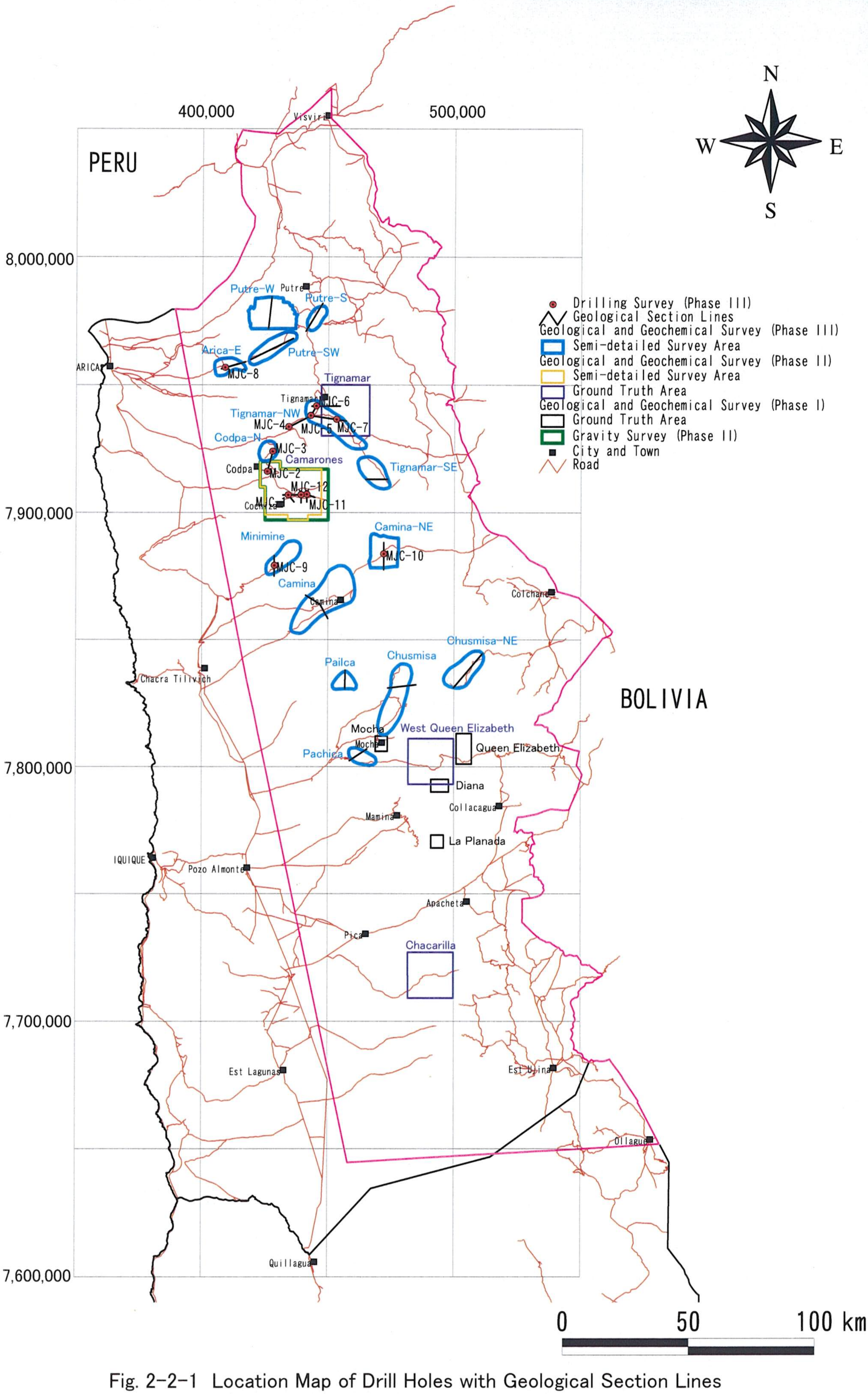

Fig. 2-2-1 Location Map of Drill Holes with Geological Section Lines

peripheries of the medium wavelength anomalies overlap.

The drill site, collar elevation, and the location of main geologic boundaries are shown in Table 2-2-1.

2-2 Drilling Method

Drilling was carried out by AUSDRLL-CHILE, a Chilean company. Its parent company is an Australian drilling company.

① Drilling method

A method of air-circulation drilling, generally called reverse circulation system (RC) was used. In this method, a hammer is attached to the end of the rod, a hammer bit is connected to the hammer base, and drilling is done by rotating the bit and impacting the rocks and thus pulverizing the rocks. The rock debris is blown to the surface by compressed air.

Double-barreled rod is used for drilling, and the compressed air is sent to the bottom through the gap between the outer and inner barrel and the rock debris is blown upward through the inner barrel. The pressure of the compressed air is usually about 1,000 psi.

The method of drilling used during the present survey is as follows.

First drilling is done by tricone bit or hammer bit connected to the end of 7" casing, and casing is set at 6~40 m depth. The depth of the casing varies with geologic conditions, but is mostly 6~20M. The main objective of the casing in this method is the protection of collar, while protection of the hole itself is not much of a problem.

After setting the casing, drilling is facilitated by 51/2" hammer bit. Without gushing water and with homogeneous hard rock it was possible to drill 200~250m per shift (12 hrs), but the average drilling rate was about 100m per shift. In cases of unconsolidated collapsible rock (i.e., sand and gravel), the sand and gravel of the upper parts often collapsed to the bottom and the compressed air was insufficient to uplift the rock debris at the bottom, thus resulting in the bit getting stuck, and drilling was stopped. Viscous clay layers were also troublesome and were apt to cause jamming and to cause stuck bit. In this case, water was poured into the hole to lower the viscosity and the rock debris was uplifted, but where the

Table 2-2-1 Location of Holes and Geologic Boundaries

MJC-1

COORDINATES		Dip angle (°)
Northing	Easting	
7906836	434234	-90
Hole depth (m)	Elevation (m)	GEOLOGIC BOUNDARY
0	1825.0	
136	1689.0	Tig / Kgd
144	1681.0	Kgd / Kv(i)
348	1477.0	Bottom of Hole

MJC-2

COORDINATES		Dip angle (°)
Northing	Easting	
7916018	425878	-90
Hole depth (m)	Elevation (m)	GEOLOGIC BOUNDARY
0	2410.0	
82	2328.0	Qcp / Tig
318	2092.0	Tig / Tc
500	1910.0	Bottom of Hole

MJC-3

COORDINATES		Dip angle (°)
Northing	Easting	
7923936	428041	-90
Hole depth (m)	Elevation (m)	GEOLOGIC BOUNDARY
0	2509.0	
342	2167.0	Tig / Tc
500	2009.0	Bottom of Hole

MJC-4

COORDINATES		Dip angle (°)
Northing	Easting	
7933518	434372	-90
Hole depth (m)	Elevation (m)	GEOLOGIC BOUNDARY
0	3126.0	Tig
500	2626.0	Bottom of Hole

MJC-5

COORDINATES		Dip angle (°)
Northing	Easting	
7937942	443117	-90
Hole depth (m)	Elevation (m)	GEOLOGIC BOUNDARY
0	3567.0	
14	3553.0	Qvc / Tig
500	3067.0	Bottom of Hole

MJC-6

COORDINATES		Dip angle (°)
Northing	Easting	
7941669	445282	-90
Hole depth (m)	Elevation (m)	GEOLOGIC BOUNDARY
0	3541.0	
368	3173.0	Qvc / Qv
402	3139.0	Bottom of Hole

MJC-7

COORDINATES		Dip angle (°)
Northing	Easting	
7936453	453301	-90
Hole depth (m)	Elevation (m)	GEOLOGIC BOUNDARY
0	3809.0	
212	3597.0	Qvc / Qv
382	3427.0	Bottom of Hole

MJC-8

COORDINATES		Dip angle (°)
Northing	Easting	
7956731	409060	-90
Hole depth (m)	Elevation (m)	GEOLOGIC BOUNDARY
0	1911.0	
54	1857.0	Qal / Tig
276	1635.0	Tig / Tc
500	1411.0	Bottom of Hole

MJC-9

COORDINATES		Dip angle (°)
Northing	Easting	
7879115	428742	-90
Hole depth (m)	Elevation (m)	GEOLOGIC BOUNDARY
0	1672.0	
66	1606.0	Qcp / Qvr
174	1498.0	Qvr / TQc
500	1172.0	Bottom of Hole

MJC-10

COORDINATES		Dip angle (°)
Northing	Easting	
7883670	472132	-90
Hole depth (m)	Elevation (m)	GEOLOGIC BOUNDARY
0	3802.0	
6	3796.0	Qal / Qv
394	3408.0	Bottom of Hole

MJC-11

COORDINATES		Dip angle (°)
Northing	Easting	
7907077	441528	-90
Hole depth (m)	Elevation (m)	GEOLOGIC BOUNDARY
0	2334.0	
138	2196.0	Tig / Tc
428	1906.0	Tc / Kgd
498	1836.0	Kgd / Tgd
500	1834.0	Bottom of Hole

MJC-12

COORDINATES		Dip angle (°)
Northing	Easting	
7906907	439245	-90
Hole depth (m)	Elevation (m)	GEOLOGIC BOUNDARY
0	2292.0	
18	2274.0	Qal / Tig (talus)
32	2260.0	Tig (talus) / Qcp
66	2226.0	Qcp / Tig
116	2176.0	Tig / Tc
300	1992.0	Bottom of Hole

abbrev. : Qal=alluvial (gravel), Qcp=colluvial (gravel, talus), Qvc=Quaternary conglomerate-sandstone
Qv=Quaternary-Tertiary andesite-basalt with tuff, Qvr=Quaternary-Tertiary rhyolitic ignimbrite, TQc=Quaternary-Tertiary conglomerate with pumice tuff
Tig=Pliocene-Miocene rhyolitic ignimbrite
Tc=Miocene-Oligocene conglomerate with tufaceous sandstone
Tgd=Tertiary intrusive rock (diorite porphyry, quartz diorite)
Kgd=Cretaceous-Tertiary intrusive rock (quartz porphyry)

viscosity is high, addition of water could not solve the problem.

The drilling rate was also slowed by gushing water, if the amount of water is in the order of several tens of liters per minute, air returning from the bottom could be diverted to the space between the outer barrel and the hole wall and uplift the dropping ground water. But this method is not applicable for water exceeding 100 liter per minute. It would cause stuck bits and jamming. This method was devised for arid areas with little groundwater and is not suitable for humid areas with high precipitation.

Drilling mud was not used, liquid "liquipol", similar in composition to "bentonite" and gypsum were used for protecting the hole wall from collapsing in the weak or fractured zones, also "foam" similar to soap was used, but in principle the work was carried out by air only.

② The major equipment consists of five units, namely "drilling machine", "compressor", "drilling tools", "fuel tank", "water tank". Each of these units is mounted on a truck, thus five trucks are necessary for the operation.

There was a regular positioning of the trucks on the drilling site, looking from the hole, water tank - drilling tool - drilling machine – compressor trucks are aligned from the right leftward. The position of the fuel tank truck was not definite. The specifications of the equipment are listed at the end of this volume.

The "drilling machine truck" is mounted with a ladder-type derrick (12 m high) which is hydraulically erected at the time of drilling (Photo A). Connecting and disconnecting the rods (6 m long) is done by raising the rods by wire through the derrick and workers need not climb the derrick except in cases of troubles. Therefore the "drilling tool truck" is always positioned at the right side of the "machine truck". The drilling machine is reverse circulation machine; Schramm T-685W made in Australia. The nominal drilling capacity is 800 m for dry vertical holes. Engine is turboengine: 650bhp (485kW) and rotation: 2,100 rpm. Compressor is also attached to the drilling machine and its capacity is 500 psi.

The "compressor truck" (Photo B) has compressor and booster, and the are both Australian made. The capacity of the former is 350psi, and that of the latter is 900psi. Engines are both turboengines.

Photo A Drilling machine truck

Photo B Compressor truck

Major drilling tools are all Australian products. Rods are steel double barrel type, and the outer diameter of the outer barrel is 11.5 cm (steel thickness 10 mm), outer diameter of the inner barrel 6.0 cm (steel thickness 10 mm), length 6 m.

The hammer at the point of the tools consists of hammer base and hammer bit. The hammer base is set between the bit and rod, and it is 1m and the outer diameter is the same as that of the rod. Hammer bit has an outer diameter of 13.75 cm (51/2"), and 16 tungsten carbide are planted in it. There are four grooves on the outer side of the bit and two round holes in the inside for air passage (Photo C).

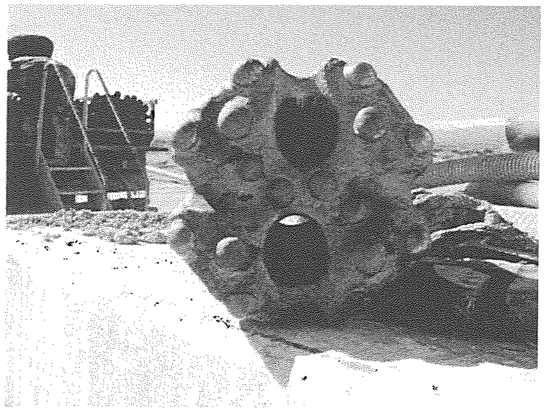

Photo C　Hammer bit

Steel pipes with 17.5 cm in outer diameter (7"), steel thickness 7 mm, and 6 m long were used for casing. The connection of the casing pipes were always welded. This was to prevent breaking at the joints or over-lapping with screw joints. Thus the welded parts had to be cut when recovering the casing and the casing insertion was quite time-consuming operation.

The fuel for the drilling machine and compressor was diesel oil and 10,000 liter fuel truck was always standing by.

For "water tank truck", box-type or oval-type tank with 20 ton capacity was used (Photo D).

Photo D　Water tank truck

Aside from the above equipment, two iron funnels were used for sampling. One was for dry samples and the other for wet samples.

③ Operations

Drilling was carried out in two12 hours shifts, each crew basically consisted of 1 driller, 3 helpers (all Chileans), and one supervisor controlled both shifts. An Australian coordinator was in control of the whole project. Also three Chilean samplers and one Japanese geologist were working with the drilling team. Aside from the above, one welder, water tank driver, fuel truck driver (both Chileans) were part of the team. Of the above, all were Ausdrill employees with the exception of the fuel truck driver, the samplers, and the Japanese geologist. The fuel truck driver was from a fuel company in Arica and the samplers came from Geometal. Two cooks were there to prepare meals. Normally the coordinator and the supervisor worked with the first shift. But, in the event of troubles during the second shift, they worked through the night. At the sites, the crew were accommodated in tents. The Ausdrill employees worked 14 day continuously and then took leave for 7 days. Other members were not relieved during the entire operation.

④ Transportation of equipment

Drilling equipment was transported from storage of Ausdrill at Antofagasta to the northernmost drilling site, and then southward to each site and then returned to Antofagasta after completing drilling of MJC-10, the last drilling site.

MJC-9→MJC-6→MJC-7→MJC-5→MJC-4→MJC-3→MJC-2→MJC-1→MJC-11→MJC-9→MJC-12→MJC-10

Transportation of equipment was done by the five trucks mentioned earlier and also another truck for accommodation and cooking. Transportation of personnel was carried out by four smaller trucks.

The trucks for equipment were all large type and the heaviest "drilling machine truck" was 34 tons and the size was 11.5m(L)×2.5m(W)×3.7m(H), thus strong road shoulder was necessary.

⑤ Drilling water

Water for drilling was obtained from nearby river and transported by 20 ton truck.

⑥ Construction of access roads, drilling platform, and tip

Construction of access road, drilling platform, and tip was contracted by Ausdrill to civil engineering contractor. Bulldozer and tire loader were used. Dynamite was used for construction of access road to MJC-10, 11, and 12, and also for platform at MJC-12. The contractors from Copiapo and Arica were used. Construction crew consisted of 1 supervisor and 6 workers.

⑦ Sampling

Sampling was carried out by 3 samplers of Geometal with assistance of 2 drilling helpers. Number of personnel was 4 in the first shift and 3 in the second shift.

Rock debris (cuttings) pushed upward by compressed air were received in a plastic bag through a funnel (Photo E), and 2m depth interval was weighed as one sample, and were divided twice by the divider in the lower photograph and 2kg were taken for assay.

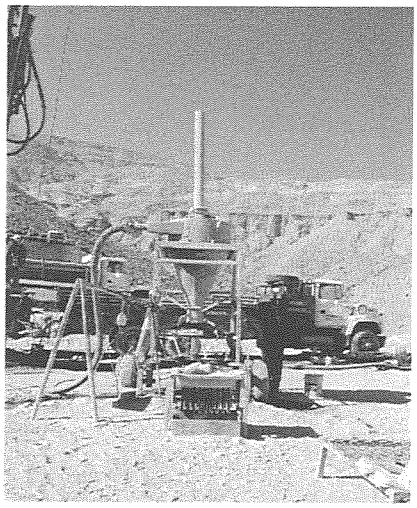

Photo E　Funnel

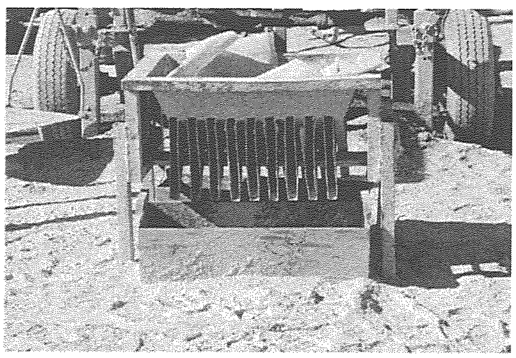

Photo F　Divider

About 200g of cuttings were sieved into coarse and fine-grained samples and were kept in the sample tray shown in Photo G.

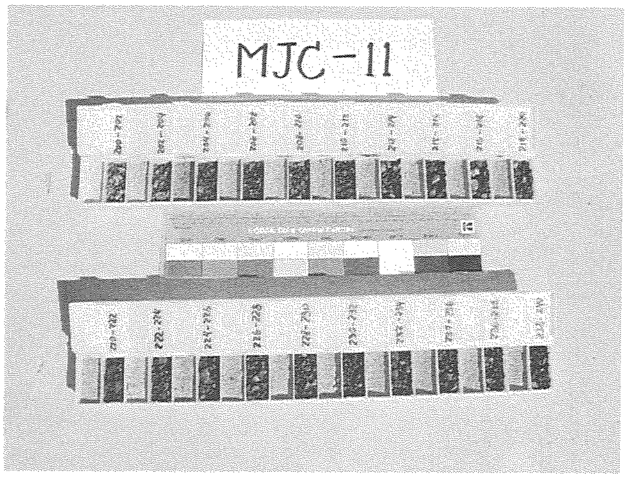

Photo G　Sample tray

Sample tray was plastic boxes of 50cm(L)×7cm(W)×4cm(H) with 20 partitions and the coarse and fine cuttings were kept in each partition. Thus cuttings for 20m depth interval were preserved in one tray. There is a lid on each partition to prevent spilling and mixing of the samples during transportation. Also samples for magnetic susceptibility measurements were collected every 20m. Mixing of artificial ferromagnetic material (such as bit fragments) was prevented by magnetic separation.

The remaining samples after separation of those for analysis were kept at CODELCO Calama warehouse in plastic bags.

2-3 Progress of Drilling

Summary of the drilling operation, record of the drilling operation and the drilling progress chart are appended at the end of this volume.

The planned drilling depth for the 12 holes was 500m. RC drilling was very efficient in hard materials such as welded tuff and igneous rocks. But at MJC-6 and -7, the drill hole collapsed due to the thick unconsolidated sand and gravel layer and water, and consequently the operation had to stop at 402m and 382m depth respectively. MJC-1, after drilling through wide alteration zone, the rod broke by the confining pressure of clay and the rod hammer could not be recovered. Thus a new hole was drilled at the site, but again the confining pressure of clay was strong and we stopped drilling at 348m depth. MJC-10 drilled through soft clay associated with pyrite dissemination and water, and the ceased operation at 394m depth after jamming.

2-4 Geology and Mineralization-Alteration of the Drill Holes

Geologic columns of the drill holes, results of X-ray diffraction, results of thin section study of representative samples, and the results of polished section examination of ore samples are appended at the end of this volume. Also the results of chemical assay are laid out in Table 2-2-2, Figure 2-2-4, and in the Appendix.

The results of the investigation of the drill holes are reported below, from north southward.

(1) East Arica area (MJC-8)

A geological map of the area is shown in Figure 2-1-55 and a geological cross section in Figure 2-1-56.

① Geology

The geology of this hole consists of, from bottom upward, Oligocene-Miocene conglomerate, Miocene-Pliocene ignimbrite, and alluvial gravel.

The conglomerate is pale green, and contains propylitic andesite, granitic rocks, porphyry, and quartzite rounded gravel, and the lower part frequently contains intercalation of thin layers of pale green tuffaceous sandstone.

The ignimbrite is gray to brown, and consists of quartz, biotite, plagioclase and minor rock fragment-bearing rhyolitic welded tuff.

The gravel bed consists of pumiceous tuff, propylitic andesite, and granitic gravel.

② Alteration-mineralization

Neither alteration nor mineralization is observed in this hole.

(2) Area to the northwest of Tignamar (MJC-4,5,6,7)

A geological map of the area is shown in Figure 2-1-37 and a geological cross section in Figure 2-1-38.

MJC-4:

① Geology

Table 2-2-2 Assay Results of Alteration Zones and Mineralization Zone

Zone	Hole No.	Depth (m)	Cu (ppm)	Mo (ppm)	Pb (ppm)	Zn (ppm)	S (%)		Pb/Cu
Oxi. Z.	MJC-1	136-142	37	6	25	42	0.84		0.66
Ser. Z.	MJC-1	142-184	45	6	8	45	4.52		0.08
Ser.-Chl. Z.	MJC-1	184-220	34	5	14	108	4.02		0.39
Chl.>Ser. Z.	MJC-1	220-266	31	5	6	94	3.02		0.22
Ser-Chl Z.	MJC-1	266-348	97	5	8	72	4.38		0.27
Oxi. Z.	MJC-11	428-456	26	6	35	35	0.37		1.45
Ser. Z.	MJC-11	456-500	20	7	14	102	1.83		0.82

Zone	Hole No.	Depth (m)	Cu (ppm)	Mo (ppm)	Pb (ppm)	Zn (ppm)	As (ppm)	Hg (ppm)	Pb/Cu
Acid A. Z.	MJC-5	178-186	8	5	30	10	237	0.028	4.02
Acid A. Z.	MJC-6	90-94	16	10	63	18	586	0.030	3.84
Acid A. Z.	MJC-6	124-146	17	4	18	34	245	0.017	1.12
Fresh z.	MJC-10	6-14	121	9	5	165	38	0.593	0.04
Oxi. Z.	MJC-10	14-24	192	7	5	121	343	1.881	0.03
Acid A. Z.	MJC-10	24-36	155	5	4	153	50	0.585	0.03
Fresh Z.	MJC-10	36-58	75	5	4	124	116	0.902	0.05
Acid A. Z.	MJC-10	58-82	167	4	8	51	406	3.115	0.08
Fresh Z.	MJC-10	82-120	68	5	7	85	24	0.233	0.10
Acid A. Z.	MJC-10	120-220	41	4	4	71	291	0.364	0.15
Fresh Z.	MJC-10	220-308	21	4	6	79	32	0.093	0.28
Acid A. Z.	MJC-10	308-342	22	2	6	74	24	0.154	0.31
Fresh Z.	MJC-10	342-350	46	3	1	81	23	0.073	0.03
Acid. A. Z.	MJC-10	350-372	52	2	6	70	24	0.274	0.12
Fresh Z.	MJC-10	372-384	62	5	10	89	105	0.331	0.16
Acid. A. Z.	MJC-10	384-394	52	2	10	82	177	0.122	0.20
Prop. Z.	MJC-12	164-300	111	5	8	88	4	0.006	0.08

abbrev.: Oxi. Z.=oxidized zone A.Z.=alteration zone Ser-Chl. Z.=sericitic-chloritic alteration zone
Prop. Z.=propylitic alteration zone
r=correlation coefficient

The geology of this hole consists of ignimbrite.

The ignimbrite of this hole is brown, and is composed of quartz-biotite-bearing rhyolitic welded tuff and the lower part contains intercalation of thin dark gray conglomerate layers consisting of andesite pebbles.

② Alteration-mineralization

Neither notable alteration nor mineralization are observed in this hole, only existence of quartz veinlets is inferred at 476~482m depth interval.

MJC-5:

① Geology

The geology of this hole consists of Miocene-Pliocene ignimbrite, with occurrence of Upper Neogene-Quaternary felsic pumiceous tuff at the surface.

The ignimbrite is gray~brown, and consists of rhyolitic welded tuff containing quartz, biotite, plagioclase, and minor amount of rock fragments.

The pumiceous tuff is white with minor amount of rock fragments.

② Alteration-mineralization

Notable alteration-mineralization is not observed in this hole, but epidote have been identified microscopically in weakly silicified part at 340m depth. Also limonite dissemination is recognized at 158~160m and 178~186m depth intervals. Alunite was identified from 158m depth sample. The results of chemical analysis of the above alteration zone indicated high As anomaly (Table 2-2-2).

MJC-6:

① Geology

The geology of this hole consists of Upper Neogene-Quaternary gravel layer, with intercalation of siltstone and pumiceous tuff. Also basalt occurs at the lower part of the hole.

The gravel layer is gray and consists of andesite~dacite pebbles. The pebble size varies considerably and changes from fine pebble layer, through coarse sand layer to silt layer.

The pumiceous tuff is white and dacitic.

Basalt is dark gray and is ferromagnetic.

② Alteration-mineralization

Notable alteration-mineralization is not observed, but yellow altered part occurs in pumiceous tuff at 90~92m and 100~102m depth intervals, and reddish alteration occurs in gravel layer at 124~128m depth interval and in pumiceous tuff at 134~146m depth interval. Sericite and jarosite were identified in 124m depth sample. High As anomaly in the above alteration zone was confirmed by chemical analysis (Table 2-2-2).

MJC-7:

① Geology

The geology of this hole consists of, from bottom upward, Upper Neogene-Quaternary basalt, mafic andesite・mafic andesitic pyroclastic rocks and gravel layer.

The basalt and mafic andesite are both black and form alternation with intercalation of pyroclastic rocks.

Gravel bed is brown to gray and consists of andesite~dacite and silicified rhyolite pebbles.

② Alteration-mineralization

Notable alteration nor mineralization occur in this hole, but there are; reddish altered parts in the gravel layer at 78~80m, 98~100m, 132~134m, and 166~170m depth intervals. Also there is a yellow alteration part in andesite at 248~250m depth interval. Sericite and kaolin were identified from sample at 168m depth. Relatively high As anomaly was detected from alteration zones at 78~80m and 98~100m depth intervals (Table 2-2-2).

(3) Codpa area (MJC-2, 3)

A geological map of the area is shown in Figure 2-1-34, and geological section in Figure 2-1-35.

MJC-2:

① Geology

The geology of this hole consists of, from bottom upward, Oligocene-Miocene conglomerate, Miocene-Pliocene ignimbrite, and Pleistocene and Holocene gravel bed.

The Oligocene-Miocene conglomerate has intercalation of pumiceous tuff and tuffaceous sandstone in the lower part.

The ignimbrite is brown and consists of quartz-biotite-bearing rhyolitic welded tuff.

The Pleistocene-Holocene gravel contains large amount of ignimbrite pebbles.

② Alteration-mineralization
Neither alteration nor mineralization is observed in this hole.

MJC-3:
① Geology
The geology of this hole consists of, from bottom upward, Oligocene-Miocene conglomerate, Miocene-Pliocene ignimbrite and Pleistocene-Holocene gravel.

The Oligocene-Miocene conglomerate has intercalation of thin dacitic pumiceous tuff in the lower part.

The ignimbrite is brown and consists of quartz-biotite-bearing rhyolitic welded tuff.

The Pleistocene Holocene gravel consists of andesite and pumiceous tuff pebble.

② Alteration-mineralization
Neither alteration nor mineralization is observed in this hole.

(4) Camarones area (MJC-1, 11, 12)
A geological map of the area is shown in Figure 2-2-2 and geological cross section in Figure 2-2-3.

MJC-1:
① Geology
The geology of this hole consists of Upper Cretaceous andesite, Upper Cretaceous-Paleogene quartz porphyritic breccia and Miocene-Pliocene ignimbrite.

The andesite is strongly sericitized and chloritized, but porphyritic texture is observed.

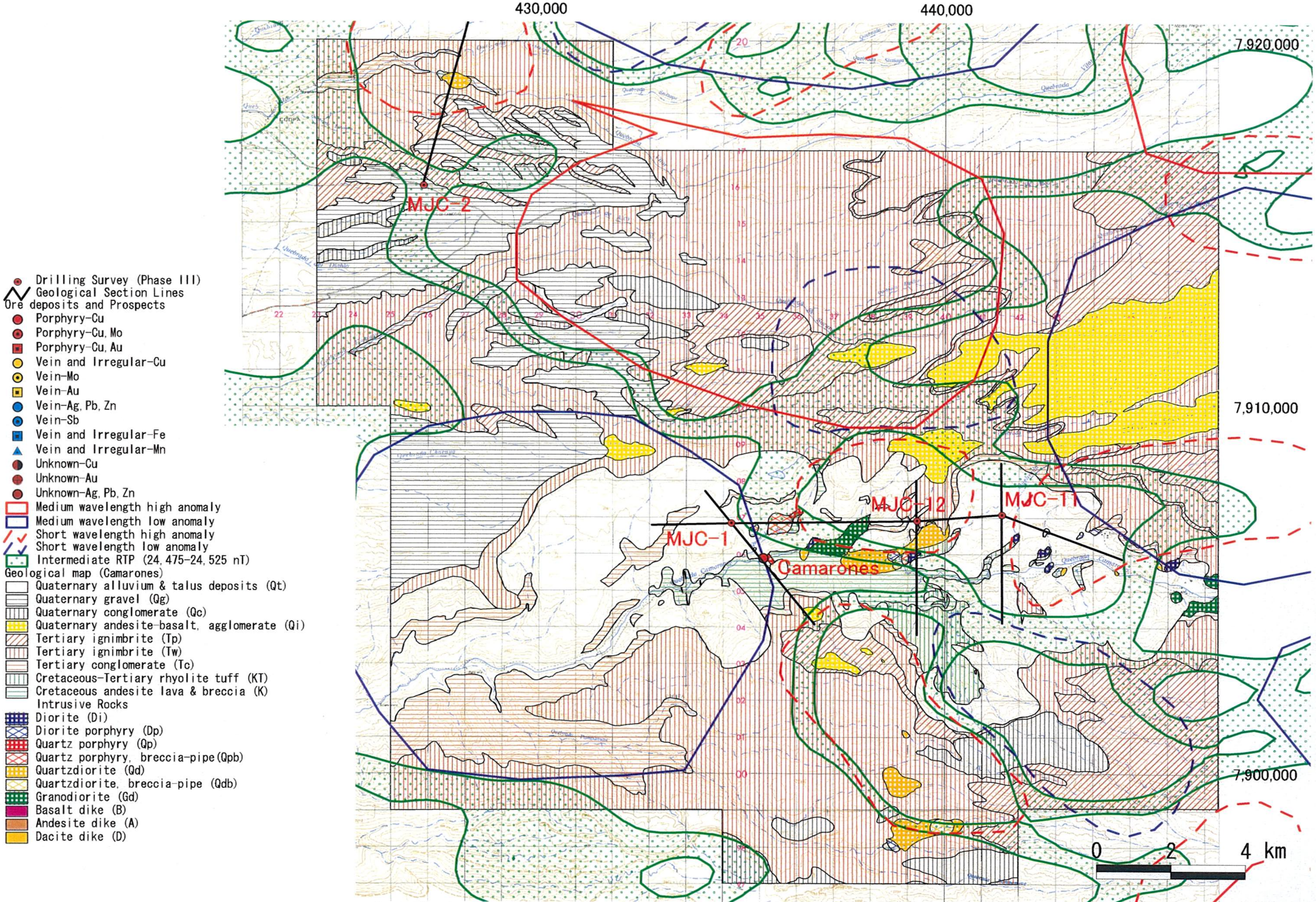

Fig. 2-2-2 Geological Map with Section Lines of the Camarones Area