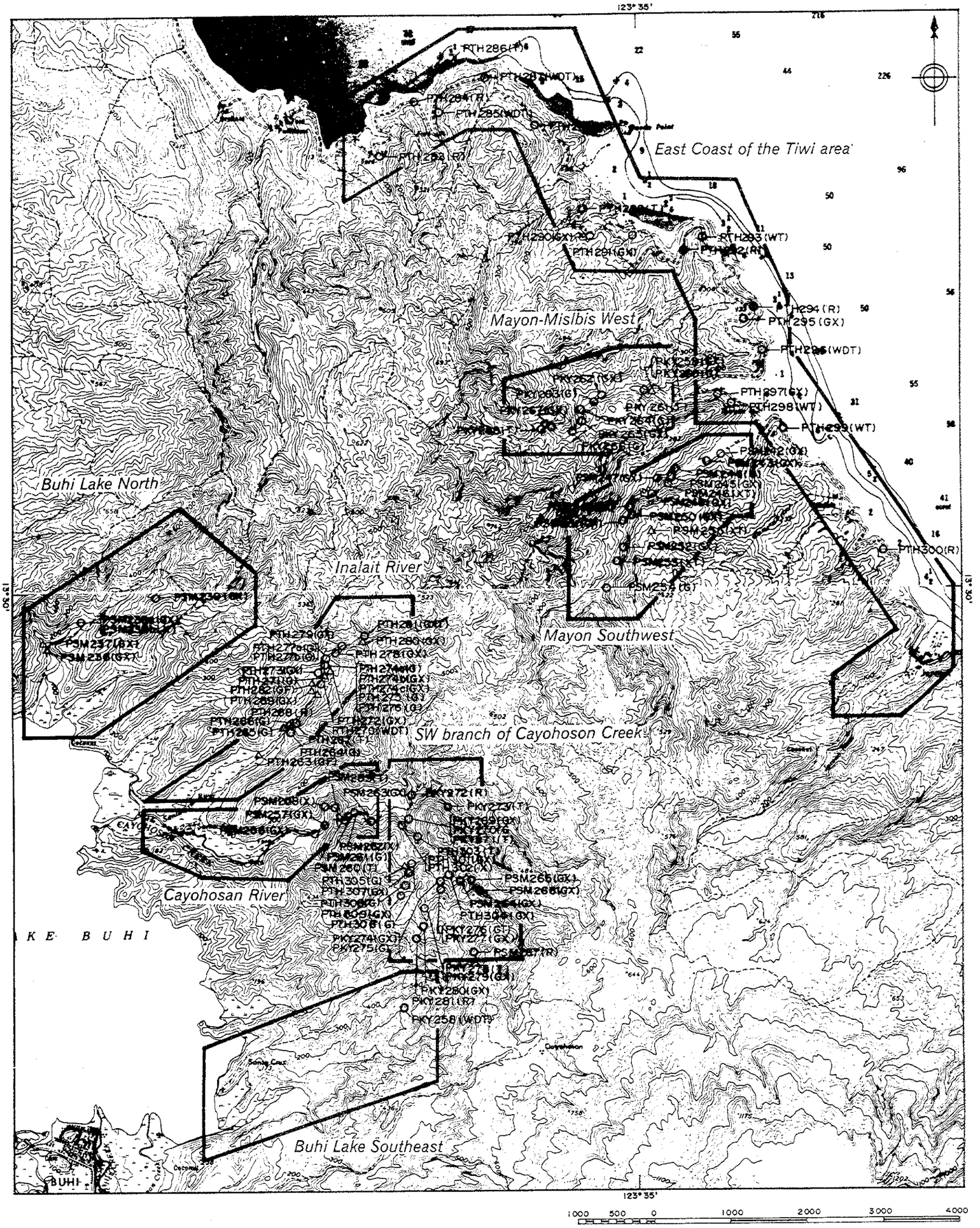
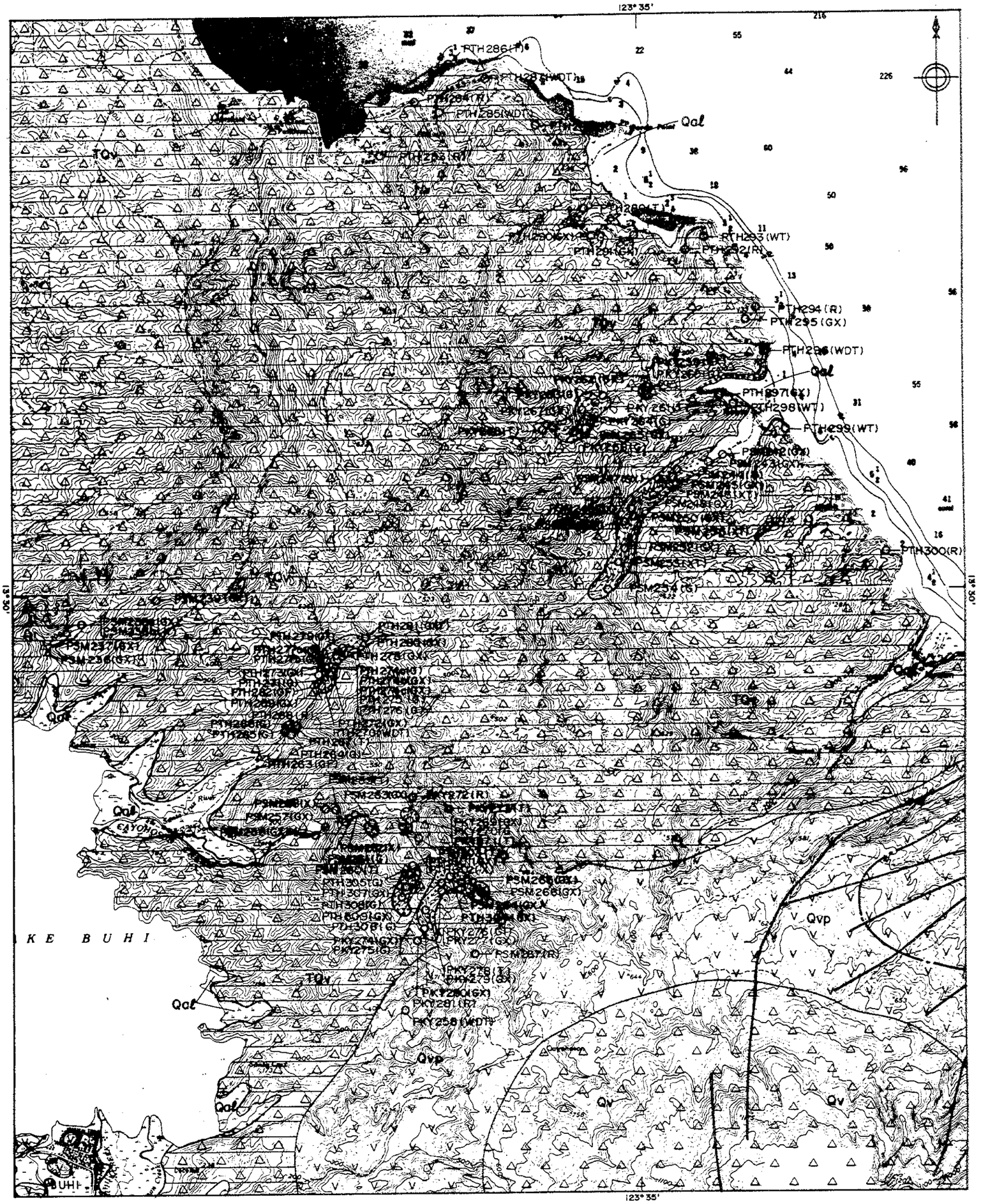


Fig. II-2-5 Root map of Northwestern Tiwi-Mt. Malinao area



LEGEND

EXPLANATION

Qal — Terrace Gravel and Alluvial Deposits

Quaternary

Qvp — Quaternary widespread pyroclastic agglomerate, volcanic breccia, tuff, pumice and volcanic debris.

Qv — Quaternary andesitic volcanic deposit.

Late Tertiary to Early Quaternary

TQv — Late Tertiary to Early Quaternary andesitic and docitic flow, dome and pyroclastic deposit.

- Fault
- Thrust
- Anticline
- Syncline
- Alteration Ground
- Quartz vein
- Hot/ Warm spring
- Geothermal Fild

- ○ Sample from outcrop
- △ Sample from floating rock
- □ Sample from drill hole

- (G) Geochemical analysis
- (O) Ore grade assay
- (X) X-ray diffraction analysis
- (W) Whole rock analysis
- (D) K-Ar dating
- (T) Thin section
- (P) Polished thin section
- (R) Reserve

Reference:

- D.T. Gambill and D.B. Beraquit (1993): Development History of the Tiwi Geothermal Field, Philippines.
- Geologic Map of Bicol Region (1:250,000) by BMG Regional Office V.

Fig. II-2-6 Geological Map of Northwestern Tiwi-Mt. Malinao area

and pyroxene-hornblende dacite is correlated with TQv3 and TQv4 (See Fig.II-1-7 in Part II Chapter 1.)

6) Alteration and mineralization

< The Inalait River >

It takes about 30 minutes to arrive at a village at the mouth of the Cayohoson Creek from Buhi by boat. The mouth of the Inalait River, which is about 1 km distant, is only accessible on foot.

Floats of quartz veins were discovered at the mouth of this river in the Phase I field survey. In the present survey, a lot of floats of quartz veins were discovered from the middle reaches of the river to the upper reaches. Quartz veins discovered as floats are white and chalcedonic. They are accompanied by a very small amount of pyrite. In the upper reaches, an outcrop of quartz veins was found in a mixed layer clay alteration zone. However, the analysis revealed that these floats of quartz veins and the quartz veins discovered at an outcrop had no gold mineralization.

Pyroxene andesite is mainly distributed along this river. Pyroxene andesite of PHT270 contains 57.04% of SiO_2, which belongs to the Medium K series. It is obvious that the composition of this rock is different from that of (pyroxene) hornblende andesite – dacite distributed along the coast on the northeast side described later (Appendix 18). The K-Ar age of this rock is 0.20+/-0.03 Ma, indicating Late Pleistocene age. Hornblende andesite is also distributed in the area stretching from the middle reaches to the upper reaches (PTH273).

All the floats of quartz veins (PTH263, 265, 266, 271, and 282) are white and chalcedonic. They contain Au<5 ppb and have no remarkable geochemical anomaly. Fluid inclusion geothermometry was conducted on PHT263 and 282, among these samples. They have a homogenization temperature of 181 – 237 ℃ and 152 – 188℃, respectively. They have salinity of 0.0-0.53 wt% NaCl equiv. and 0-0.88 wt% NaCl equiv., respectively.

PTH269 is a float of strongly silicified rock having a pyrite dissemination. The X-ray diffraction showed that it consists of quartz, anatase, and rutile and contains Au<5 ppb, Ba: 250 ppm. PTH272 is a float of mixed layer clay altered rock, containing quartz and calcite veins. The X-ray diffraction revealed that it consists of plagioclase, quartz, potassium feldspar, sericite/ smectite mixed layer, chlorite/smectite mixed layer, and calcite. Contained quartz and calcite veins have no gold mineralization.

PHT273-282 is located in the middle reaches of the Inalait River, and quartz veinlets were discovered in an outcrop. Quartz veinlets appear in a mixed layer clay mineral zone. This fact made it clear that an epithermal system alteration zone of a low sulfidation system exists in this area. Also, it is presumed from a combination of quartz – sericite/smectite mixed layer clay that a temperature area of approximately 150℃ of a low sulfidation system

crops out. The value of analysis of the confirmed quartz veins revealed that there is no anomaly level gold. However, the values of Au: 10 ppb and Mo: 43 ppm were obtained from a quartz vein of PTH274a. A quartz vein of PTH277a contains Au: 5ppb and Mo: 88 ppm. It was recognized that a quartz vein tends to have concentrations of metal elements even though the amount is very small (Appendix 14: PH10). PTH273, which is hornblende andesite, is light greenish gray and indicates a low-temperature propylitic alteration (Plagioclase, quartz, potassium feldspar, smectite, chlorite, and calcite). PTH274a is a quartz vein having greenish gray andesite (PTH274c) as a host rock. It is 3 to 6 mm wide and its strike and dip are N6° E and 80° E, respectively. There is an almost parallel vein 30 cm away from this (N18° W, 70° E). Those vein have a yellowish brown colored reaction halo (PTH274b) of 5 cm width (10 cm on both sides), which accompanied with pyrite dissemination. The X-ray diffraction revealed that PTH274b contains quartz, plagioclase, sericite/smectite mixed layer clay, and pyrite and PTH274c contains plagioclase, quartz, calcite, sericite/smectite mixed layer, and chlorite/smectite mixed layer. PTH275 is a quartz vein of an outcrop which continues to PTH274. It contains Au: 5 ppb and Cu: 48 ppm, which are not anomaly level values. It is 8-10 mm wide and has a strike of N20° W and a east dip of 75° .

PTH276 is also a quartz vein observed at an outcrop which continues from PTH274. It is 3-6 mm wide and its strike and dip are N24° E and 75° E, respectively. PTH277a is a quartz veinlet observed on this side of the waterfall, and it is 3-10 mm wide. Its strike is N40° E and its dip is vertical. Its host rock is smectite altered to low-temperature propylitic altered andesite. There are about 10 quartz/calcite veins which have a direction different from that of this quartz vein (PTH277b). It is 5-10 mm wide and its strike is N80° W and its dip is vertical. PTH278 is andesite which underwent a very weak low-temperature propylitic alteration (quartz, plagioclase, chlorite/smectite mixed layer, potassium feldspar, hornblende, and calcite). Calcite quartz veinlets are also observed. PTH279 is also rock which underwent a weak low-temperature propylitic alteration (smectite, chlorite/smectite mixed layer, quartz, plagioclase, calcite, potassium feldspar, and pyrite).

PTH280 is a large float with a diameter of 6 m (Appendix 14: PH11). It is highly silicified rock containing quartz, anatase, and goethite. PTH281 is an outcrop of the waterfall. It is weakly silicified and belongs to a mixed layer clay alteration zone (hematite, marcasite, quartz, plagioclase, potassium feldspar, sericite/smectite mixed layer, and chlorite/smectite mixed layer). This sample has a pyrite dissemination. A temperature area where mixed layer clay is formed crops out. The assemblage may show low-temperature propylitic alteration.

It is presumed by the airborne geophysical exploration that an intrusive body or volcanic center is situated in the north of the survey end point of this route (See Fig. II-1-9).

< Buhi Lake North >

It takes 35 minutes to reach a river on the north shore of the Buhi Lake by boat, which

is 5 km distant from Buhi. An outcrop appears at elevations above 160 m or so. Andesite is largely distributed in the surveyed area, and some thin tuffaceous layers were observed. The andesite is gray pyroxene andesite rich in plagioclase phenocryst, and occur in both massive lave and breccia. Tuff is slightly coarse-grained. Some tuff contains accidental rock fragments of a size equivalent to lapilli. This tuffaceous facies appears at an elevation of 230 m in a western river and at an elevation of 200 m in an eastern river. This tuff with a thickness of at least several meters or more is intercalated with andesite lava.

A 1.5-m wide light green vein-like smectite alteration is observed at an elevation of 200 m in a western river. The difference between a vein-like alteration (PSM238a) and a weakly altered host rock (PSM238b) is the proportion of the amount of pyrite, smectite, and tridymite from the X-ray diffraction, and the vein-like alteration zone has a large amount of each alteration minerals. These two are separated by a considerably straight border in the direction of N80 ° E. A weak pyrite dissemination was partially observed in andesite. A pyrite dissemination was observed in andesite (PSM239: halloysite, calcite) around a pit situated on the ridge between eastern and western rivers and in floats of andesite (PSM236: halloysite, cristobalite) near the mouth of the river. This pit is approximately 6 m across and 8 m deep. It seems to have been excavated at the beginning of 1990's. The purpose of the excavation is unknown. Since the degree of mineralization or hydrothermal alteration is very low. In addition to this pit, two similar smaller pits 2 m across were excavated toward the ridge, and the exposed lithology and alteration are similar to the first one. Highly silicified rock floats accompanied by a limonite dissemination (PSM237: quartz, anatase, and goethite) at an elevation of 140 m in a western river. Floats of andesite rich in kaolinite was also observed at an elevation of 220 m. Such highly silicified or argillized floats are relatively unusual in this survey route. Neither altered rock has geochemical anomaly of gold, but geochemical anomaly of arsenic is observed in some samples (PSM237: As: 190 ppm; PSM238a: As: 26 ppm).

< Buhi Lake Southeast >

This route is situated on the southeastern shore of the Buhi Lake. It is accessible not by vehicle but by boat from Buhi.

It consists of unaltered pyroxene hornblende andesitic lava (PKY258) and pyroclastic rock. Lava has developed platy joints with a gentle dip. The K-Ar age determination revealed that PKY258 is 0.42+/-0.05 Ma.

No hydrothermal alteration has been observed in the survey area.

< East coast of the area >

There is a road along the eastern coastline of this area, and this area is accessible by vehicle. Hornblende andesite to dacite is distributed in the northern half of this route (from PTH283 through PTH296). It is dark gray or light gray in color. It has heterogeneous groundmass and contains a lot of cognate inclusions. A flow banding can be observed in

some places (particularly, PTH296. Appendix 14: PH13). The whole rock analysis was conducted on PTH285, 287, 293, and 296. The SiO_2 content of each sample is as shown below. PTH285: 63.85%, PTH287: 64.65%, PTH293: 61.72%, and PTH296: 62.21%. Judging from the SiO_2 content, PTH285 and 287 are dacite, and PTH293 and 296 are andesite close to a dacitic composition. Both of them belong to the High K series (Appendix 18). The age determination was conducted on two samples of PTH285 and 287. The K-Ar age value of these samples is 0.29+/-0.03 Ma and 0.28+/-0.03 Ma, respectively, indicating Late Pleistocene. Light gray colored dacite (PTH286) rich in hornblende phenocryst contains a lot of oxidized hornblende phenocryst having an opacite rim. A lot of tridymite is observed in matrix. A flow banding is formed by an alternation of beds of a dark gray band and a light gray band (Appendix 14: PH13). This corresponds to a shade of a glassy matrix color. This may be a product of magmatic mixing.

Some alteration zones are also distributed beside the road along the coastline. One of them is PTH290. It underwent silicification along a fault, and limonite is found. The X-ray diffraction showed that it contains alunite, quartz, and tridymite. Probably, this quartz may be primary quartz in the host rock. A remarkable fissure is observed on an outcrop (N40 ° W, 62 ° W). Even now, water springs out along this fissure. This is considered to be a steam heated type acid alteration. PTH291 is an altered outcrop, which is difficult to be distinguished from a weathered outcrop. It underwent a halloysite alteration. The X-ray diffraction revealed that it contains halloysite, cristobalite, tridymite, hematite, and rutile. PTH295 also underwent a similar alteration. The chemical analysis showed that it contains Cu: 315 ppm, which is an anomaly level value.

Almost circular magnetic and radioactive element response were detected in this area through the airborne geophysical exploration (Fig. II-1-7 and Fig. II-1-9: 1496000 mN, 546000 mE). The analysis results suggest that this is an intrusive rock or the volcanic center (See Part II Chapter 1.). Topographically, the EW-trending ridge is distributed at the center of a circular depression. There are drainage dissected into the northern and southern parts of that ridge. A ridge distributed around both drainage and in their center is discovered as a high- magnetic anomaly area while both drainage correspond to a low-magnetic anomaly area. An alteration zone of PTH290 exists at the mouth of the drainage on the north side. A dissected drainage on the south side corresponds to the Mayon area route described later, and it was made clear that an alteration zone mainly having a silicified alteration is distributed in this drainage. From this fact, it is presumed that a circular structure discovered in this area was caused by the alteration zones distributed in the drainage. The deepest slice of the magnetic pseudo depth slices(Appendix 3: TMI RTP Pseudo Depth Slice 3) showed that a high-magnetic anomaly was observed in the depths of the ridge at the center of the circular structure, suggesting a possibility that the volcanic center or an intrusive body may exist. The analysis results of the airborne geophysical exploration revealed that a semicircular structure of a high-magnetic anomaly (Fig. II-1-7 and Fig. II-1-9: 1498000 mN, 560000 mE)

discovered at the northern end of this area corresponds to a dacite dome. It is thought that the semicircular structure is the volcanic center or an intrusive body.

Pyrite dissemination is observed in PTH297, and a limonite stain caused by oxidation of pyrite is recognized. The X-ray diffraction revealed that it contains plagioclase, halloysite, calcite, and pyrite.

An outcrop of (hornblende) pyroxene andesite of PTH298 has well-developed joints in the form of hexagonal prism (Appendix 14: PH14). It has a lot of small vesicles. It is aphanitic, but a small amount of hornblende and pyroxene is observed. The microscopic observation showed that anhedral hornblende has been completely replaced by opacites. As for pyroxenes, both clinopyroxene and orthopyroxene exist, and they are microphenocryst in size. The whole rock analysis showed that PTH298 contains 58.5% of SiO_2 and belongs to andesite of the High K series (Appendix 18).

PTH299 is an outcrop of pyroxene andesite lava. It has a lot of small vesicles. The whole rock analysis showed that it contains 57.63% of SiO_2 and belongs to andesite of the Medium K series (Appendix 18). In the further southern part of this area, outcrops of pyroxene andesitic lava or pyroclastic rock continue. PTH300 is an outcrop of pyroxene andesitic and pyroclastic rock. It is dark gray or black. Fine-grained or medium-grained pyroxene phenocryst is observed. Pyroxene andesite is distributed from here to Jaroan, but hornblende dacite is not observed.

< Mayon Southwest >

It takes two hours from the Mayon village to Baao by vehicle.

Unaltered pyroxene andesite crops out around the mouth of the river. Many floats of unaltered hornblende andesite are distributed on the NS-trending ridge from a 422-meter peak. Hydrothermal alteration is observed along the drainage. The source rock is andesite. Rock is exposed well along the drainage and almost fully crops out.

A silicified alteration zone accompanied by alunite is distributed over 800 m on the survey route. The survey results of the western river in the adjacent Mayon village showed that the silicified alteration zone stretches in the direction of NW-SE. An acid alteration zone composed of alunite and quartz on a hillside of the drainage and a cristobalite, tridymite, +/- kaolinite, +/- halloysite alteration zone in the upper and down streams of the drainage surrounding the above acid alteration zone are observed. The former is mainly composed of silicified rock and the latter is largely composed of white argillized rock. Silicified rock often forms a vertical cliff exceeding a height of 10 m. In addition, a neighboring drainage is generally filled up with boulders of silicified rock with a diameter of 5 m or more. While a relatively weak silicified rock with kaolinite is often recognized at the bed of drainage. Most of altered rocks are massive and some altered rocks have a remarkable brecciation (PSM243: cristobalite, tridymite, anatase; PSM245: quartz, natroalunite, pyrite). Altered rock is often

accompanied by a large amount of pyrite. Particularly, pyrite shows a tendency to increase in a relatively weakly silicified portion adjacent to strongly silicified rock. Pyrite is generally produced in dissemination. In some part, it occurs as a massive fine-grained pyrite aggregate (PSM248: quartz, pyrite, natroalunite) and as a 1 cm-wide network veinlet. No quartz veins were recognized in the survey area.

Altered rock contains very little gold, silver, and base metal. The analytical grade revealed that gold, silver, lead, and zinc are very close to the detection limit value. However, some samples showed copper concentrations on a geochemical anomaly level (PSM242: Cu: 102 ppm; PSM248: Cu: 105 ppm; PSM251: Cu: 170 ppm). Look at the correlation between analysis values of copper and other elements and you will find a good positive correlation between copper and iron. Three samples whose copper analytical grade exceeds 100 ppm (PSM242, PSM248, and PSM251) are equivalent to rock relatively rich in iron exceeding 6% of iron contents. This suggests a trace of copper minerals have the same behavior as that of pyrite. On the other hand, taking into consideration a correlation between intensity of silicification in an outcrop through observation with the naked eye and trace elements, a good positive correlation with strontium, potassium, sodium, and phosphorus concentrations can be recognized to some extent in the package analysis range. There is a strong possibility that such elements are controlled by the proportion of the amount of alunite accompanied by a silicification zone.

< Mayon-Mislbis West >

Pyroxene andesite (PKY268), hornblende pyroxene andesitic lava (PKY261), and hornblende pyroxene pyroclastic rock are distributed. A wide range of silicified alteration (PKY262, etc.) was observed, and a small-scale distribution of argillized alteration (PKY267) was recognized. Silicified rock ubiquitously contains tridymite. Natroalunite and alunite are sometimes detected. Argillization is characterized by smectite. A pyrite dissemination is generally recognized in a silicified alteration zone, and may partially form a network (Appendix 14: PY20). Quartz (+/-pyrite) veinlets (PKY264, 266) are rarely recognized in silicified rock, too. The strike is N20° - 35 ° E and the dip is 65° - 75° SE. This structure of silicified alteration zone is concordant with a neighboring fault and clastic dike.

Although no Au mineralization is observed in a collected sample of altered rock, a weak Cu anomaly (approximately 100 – 150 ppm) can be recognized ubiquitously.

< The Cayohosan River >

This route has approximately 5 km from the mouth of the Cayohosan River. Since a survey in the upper reaches is difficult on a day trip, the survey team camped out approximately 4 km east of the mouth of the river where the river branches out north and south and conducted the survey.

Pyroxene andesite is distributed. There are only two outcrops from the mouth of the river to an elevation of 100 m. A section from here to the campsite corresponds to a wide-range argillized alteration zone, and propylite is partially distributed.

The argillized and altered rock is white or grayish white and is accompanied by a pyrite dissemination. The X-ray diffraction revealed that PSM257, PSM258, PSM262, and PSM263 consist of smectite or smectite/sericite mixed layer, quartz, pyrite, and +/-chlorite. Gypsum is also detected from PSM263, a sample collected near the campsite. A quartz vein is collected each from two places as floats. Floats (PSM256: quartz, calcite, and rutile) collected at an elevation of 100 m is massive white vesicular rock with a diameter of 50 cm composed almost of silica. A portion of silicified rock accompanied by vugs and a portion of a quartz vein surrounding this can be recognized from the observation of the texture. Since the quartz vein has a very fine grain, it is presumed that the quartz vein is generated at low temperatures. This sample has very little sulfide mineral. Similarly, the sample (PSM261) collected at an elevation of 160 m is a float composed of silicified rock + a quartz vein, and a banded structure composed of fine-grained pyrite is observed in the quartz vein. No gold mineralization is recognized in the quartz vein or silicified rock.

<Tributary 1 of SW branch of Cayohoson River >

PTH301 is from an altered outcrop. A quartz vein, pyrite, and silica veinlets (W = 1 cm) were observed. They develop on the joint face of andesite. The joint face is N32 ° E, 75 ° W; N6° W, 42° W. Silica is chalcedonic. The analysis revealed that it contains Au<5 ppb. The X-ray diffraction showed that the altered part is composed of alunite, cristobalite, tridymite, halloysite, and pyrite. Amorphous silica is also observed on the chart. This sample indicates an acid alteration.

Among them, the halloysite seems to be generated by the oxidative destruction of pyrite (supergene). It is thought that others are generated by the steam heated type acid alteration (hypogene). PTH302 is andesite that is host rock of PTH301. It is light greenish gray in color. The X-ray diffraction shows that it is composed of plagioclase, smectite, calcite, and pyrite, and the greenish gray indicates a color of smectite. It underwent a low-temperature propylitic alteration. PTH303 also looks greenish gray and it is thought that this sample underwent a low-temperature propylitic alteration. Since there are boulders of highly silicified rock in the neighborhood, the source region must be near there.

PTH304 is situated almost in the center of the drainage where a "magnetic flat region" is distributed. The sample is collected from an outcrop of highly silicified rock. It looks like a massive silicified rock, but it has turned into a strongly silicified breccia with a diameter of 1 to 8 cm. It is cemented with silica and iron oxide again (Appendix 14: PH12). The analysis showed that it contains Au<5 ppb and Cu: 134 ppm.

PTH305 to PTH309 were collected from a route of drainage stretching southward or south-southwestward from the main drainage. On this route, floats and outcrops of weakly argillized altered rock are observed.

The X-ray diffraction showed that PTH307 is composed of plagioclase, cristobalite, smectite, tridymite, potassium feldspar, gypsum, and pyrite. PTH309 is composed of kaolinite, tridymite, and alunite. It is thought that these samples underwent a steam heated type alteration.

The value of analysis of every altered rock found in the Cayohosan River is Au<5ppb.

<Tributary 2 of SW branch of Cayohoson River >

A river of the NW-SE system in the southeast of the campsite and the tributary of the N-S direction leading to a 671-m peak were surveyed. Altered andesite is distributed in the drainage of the NW-SE-trending.

PTH304 (quartz, pyrite, rutile, and goethite) is a brecciated silicified rock with 5 cm in diameter. This type of silicified rock continues about 100 m, and transitions into altered rock low in silicification accompanied by a large amount of pyrite (PSM264: pyrite, tridymite, alunite, kaolinite; Cu: 140 ppm). A brecciated texture similar to that of silicified rock remains in this altered rock.

A sulfuric smell hangs in the air around the outcrop due to a large amount of pyrite. Such a brecciated argillized rock continues about 100 m toward the upper stream, but the brecciation disappears around PSM265, turning into a massive lithofacies. The sample PSM265 (natroalunite, tridymite, pyrite, kaolinite; Cu: 104 ppm) contains less pyrite than PSM264 does, and the X-ray diffraction showed that PSM265 has the same constituent minerals as those of PSM264 except the composition of alunite. Highly silicified altered rock appear again from an elevation of 280 m in the upper reaches (PSM266: alunite, tridymite; Cu: 13 ppm). A weakly brecciated texture is observed on silicified rock and is accompanied by pyrite of different contents. No quartz veins are recognized in the above alteration zone. Incidentally, a lot of waterfalls appear from elevations of 280 m or 290 m. The survey team climbed up onto a higher branch drainage of the N-S system, avoiding these waterfalls.

Since rock is not exposed well in the drainage of the N-S direction, a survey was conducted on floats up to an elevation of 440 m. Unaltered pyroxene andesite is distributed. Outcrops of andesite were observed only between elevations of 440 m and 460 m, but no outcrops can be recognized after that level to the vicinity of ridge. A trace of hornblende was observed in a lower outcrop among these outcrops (PSM267). From the fact that floats of white altered rock are distributed along a narrow path in the western part of the ridge on the west side of the drainage of the N-S-trending, it can be concluded that this neighborhood is the eastern limit of the alteration zone.

The analysis of the ore grade showed that copper is contained on the geochemical anomaly level and that the ore grade of other elements is at a detection limit. No gold mineralization is recognized.

<Tributary in the northern part of Cayohosan River and Tributary 3 SW branch of Cayohoson River >

Pyroxene andesite (PKY271, 273, and 278) is widely distributed and some of the pyroxene andesite is produced in a form of dike (PKY276). Gray plagioclase pyroxene andesite (PKY281) different in color quality and texture from the lower pyroxene andesite is distributed in the apparent upper stratum.

The lower andesite is generally unaltered or underwent a weak propylitic alteration (PKY276 and 278). Smectite alteration (PKY274, 277, and 279) and pyrite stain are remarkable. The geology locally underwent a strongly silicified alteration. The silicified altered rock (PKY280) indicates an assemblage of altered minerals of kaolinite, tridymite, and alunite. No alteration is observed in the upper plagioclase pyroxene andesite (PKY281).

The chemical analysis revealed that there is no gold mineralization.

6) Potential

A low-sulfidation epithermal alteration zone is distributed in the western part and central part of this area, and a quartz vein is found in a mixed layer clay zone. It was made clear that a relatively wide-range silicification zone rich in pyrite is distributed in the eastern part. Figs. II-2-18 and II-2-19 show a conceptual position of the alteration zone distributed in this area in the magma-hydrothermal system. An assemblage of quartz and mixed layer clay minerals indicates a temperature environment near 150℃ of a low-sulfidation system. This suggests that the alteration zone distributed in this area is higher-temperature and deeper than that of the western Bacon-Manito area and Gate Mountains area. On the other hand, in the case of an alteration zone mainly caused by silicification distributed in the eastern part of this area, silicified rock seems to be distributed at the top of the argillized alteration zone. Consequently, it can be judged that this alteration zone is a steam heated type alteration zone widely distributed in both areas mentioned above. In other words, a shallow part to a medium part of a low-sulfidation system is exposed in this area.

It is thought that a mixed layer clay zone indicates an upper part where gold is deposited in many epithermal systems. If a gold mineralization occurs, a gold (ore) grade can be expected to some extent in the quartz vein discovered in this survey. However, since the analysis showed that gold is below the detection limit, it is judged there is only a limited possibility that a gold deposit exists in this area.

7) Mine claim

A geothermal reservation is established by PGI on the southeast side of this area, but

others are areas free from exploration rights.

2-2-4 Eastern area of the Caramoan Peninsula

1) Reasons for selection

This was also considered to be one of high potential areas in the Phase I survey. No survey was conducted in Phase I because this area is difficult of access and security problem.

An ophiolite sequence is widely distributed in the Caramoan Peninsula, and mineralization of volcanic massive sulfide type deposit are distributed in green schist and mica schist accompanied by the sequence. Recently, a new mineralization of volcanic massive sulfide type was discovered in this area through the BMG Region V survey (Laud, 1997). This area was selected as a candidate of the Phase II geological survey because of improvement of security and accessibility.

2) Location and transportation

The Caramoan Peninsula, situated in the central part of the Bicol Peninsula, is a peninsula stretching WNW-ESE in direction. This area is located in the eastern part of the Caramoan Peninsula. As a road from the Presentacion village to the Caramoan town has been recently opened to traffic, Caramoan is accessible by vehicle from Lagonoy through an unpaved road. The survey team was separated into two parties: one party surveyed mineralization around Caramoan town by vehicle and the other surveyed an area along the coast facing the Lagonoy Gulf by boat.

3) Survey routes and points (Fig. II-2-7)

Survey Route	Survey Point
Bulalacao	The purpose is to survey the copper mineralization and area around diorite described in the existing geological map. The diorite intrudes limestone, and there is a possibility that skarn or porphyry-type mineralization may occur.
Baliguian	The purpose is to survey the copper mineralization and area around diorite described in the existing geological map. The diorite intrudes limestone, and there is a possibility that skarn or porphyry-type mineralization may occur.
Alto point – Maangas	The purpose is to obtain petrologic information on intrusive diorite described in the existing geological map as well as to observe a reported copper mineralization zone near this diorite and verify a deposit type and other matters.
Malaiba	Existing copper mineralization zones distributed in the western part of the Caramoan town are produced concordant with a

	schistosity of schist.
Pili - Pagsanghan	A mineralization of volcanic massive sulfide type deposit was discovered in green schist and mica schist through the BMG survey (Laud, 1997). There is a possibility that a deposit of the same type may also exist around that.

Among the above areas, the Pili-Pagsanghan area was given up because of security problem. Incidentally, some of the samples collected in this area by Mr. Marcel Laud of BGM Region V were offered for analysis.

4) Outline of survey results

The geology and distribution of alteration zones, sampling points in this area are shown in Fig. II-2-8.

5) Geology

The geology in this area is reported by Fernandez (1983), David et al. (1994 and 1996). According to David et al (1994 and 1996), this area can be divided into two units (Table II-2-3): Western Caramoan structure unit and eastern Caramoan structure unit. Bulalacao, Baligian, Alto Point, and Pili-Pagsanghan in the survey area belong to the Western Caramoan structure unit. Malaiba belongs to the eastern Caramoan unit. The Lagonoy ophiolite of the pre-upper-Cretaceous(?) system and the Pagsanghan Formation of Cretaceous age are distributed in the Western Caramoan structure unit. On the other hand, the Garchitorena Formation that is correlated to the Pagsanghan Formation is distributed in the eastern Caramoan structure unit, and the Caramoan Formation of the Eocene covering this unconformably is distributed. Guijal limestone is distributed as a huge olistolith. Both ophiolite and Cretaceous Formations underwent a metamorphism from green schist facies to chlorite-epidote-amphibolite facies.

6) Alteration and mineralization

<Bulalacao>

Only one sample of andesite which underwent copper oxide stain was found in floats in a stream (PTH310: Cu: 6.19%, Au<5ppb, As: 344 ppm). PTH311 is a float of andesite, which is a host rock of copper oxide dissemination of PTH310. PTH311 is light purplish gray or light greenish gray in color. It contains coarse-grained plagioclase and pyroxene phenocryst and has a stockwork of epidote + quartz veins.

Near the border with limestone, metapyroclastic rock (PTH312) is cropped out. It has fine grains and is light greenish gray or dark gray in color. It has well-developed hairline cracks, which are very compact. It is judged that a high confining pressure caused a deformation. Metavolcanic rock – metapyroclastic rock are exposed near the ridge.

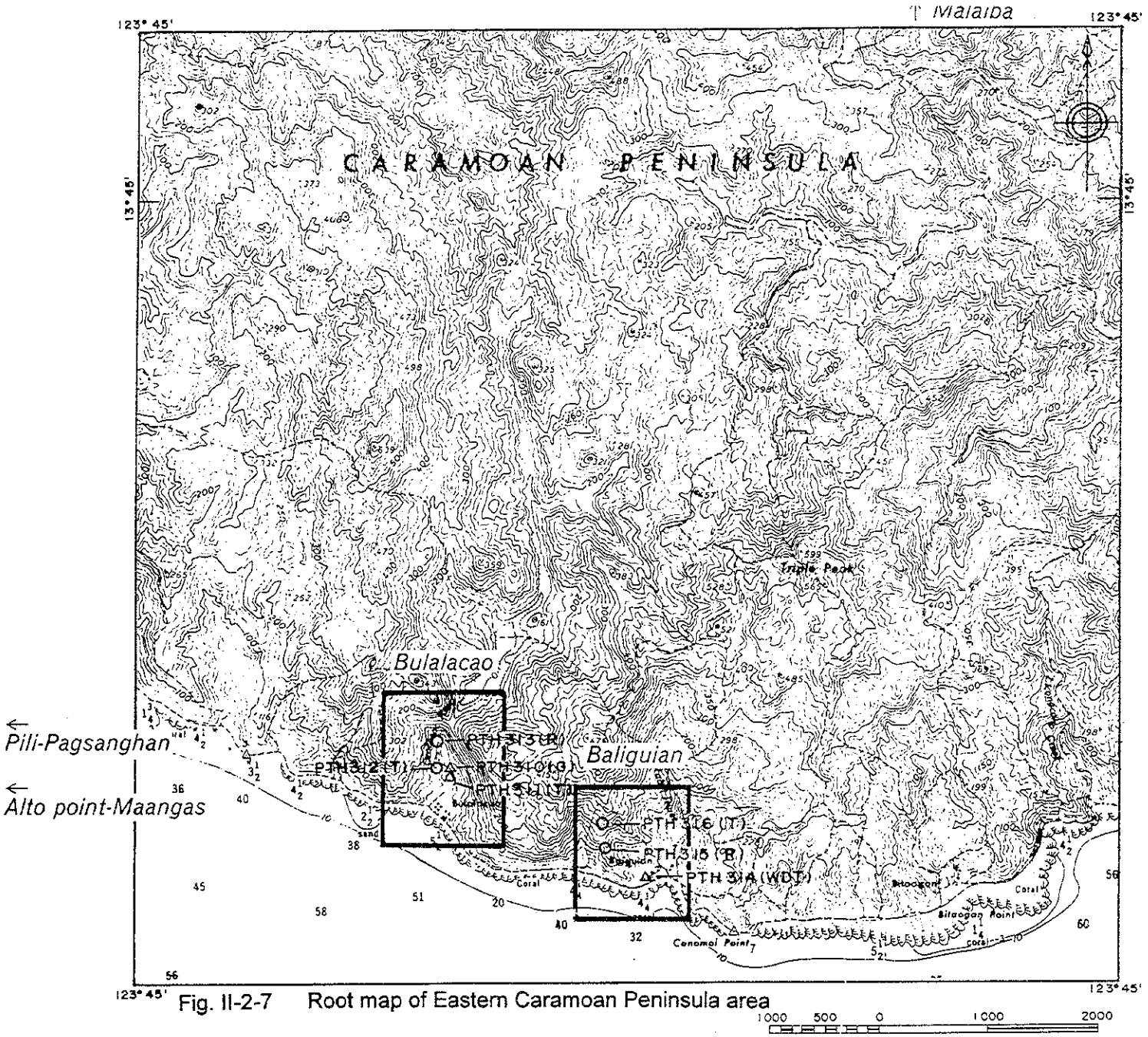
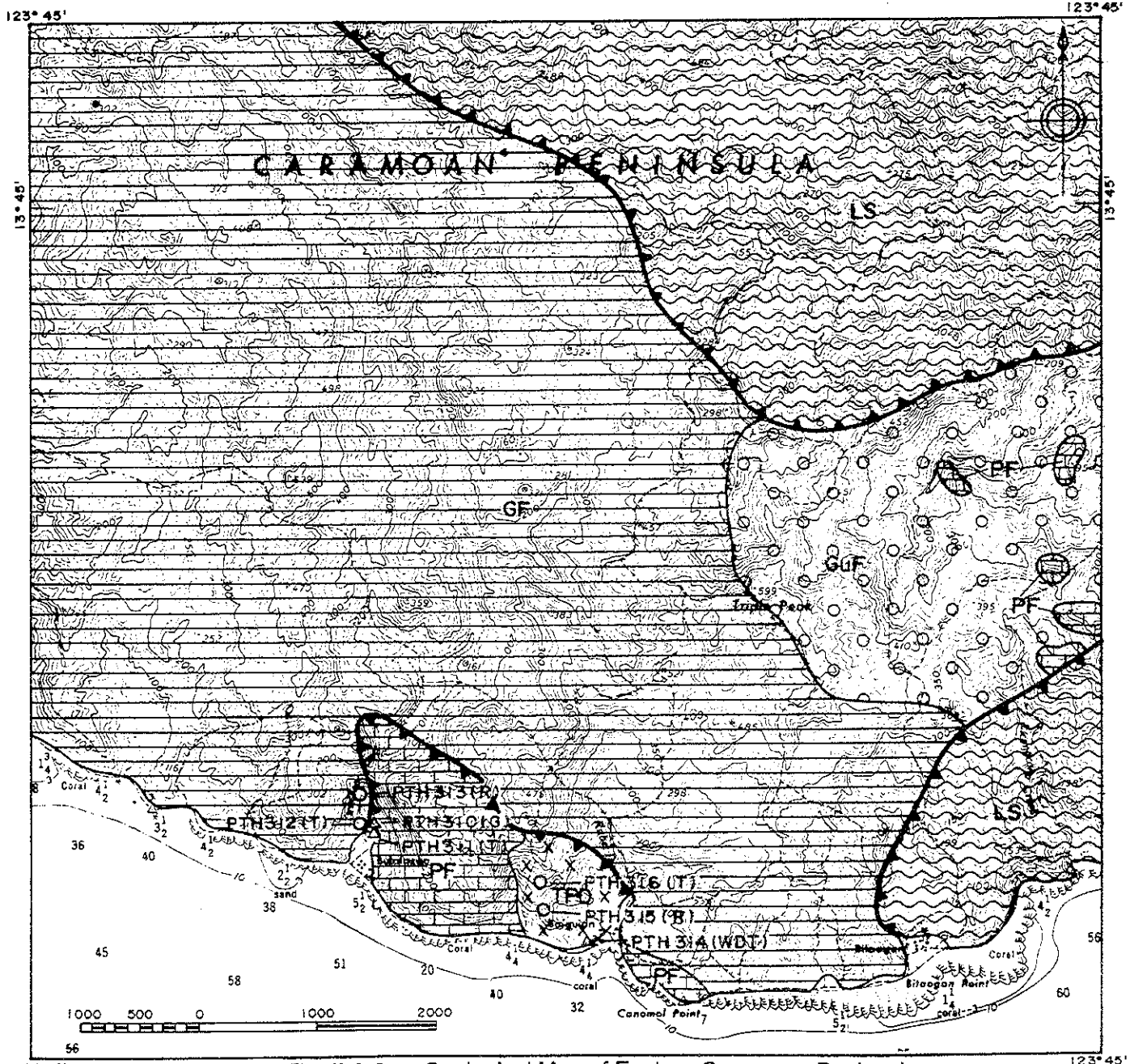


Fig. II-2-7 Root map of Eastern Caramoan Peninsula area



LEGEND

EXPLANATION

Eocene

GuF — Guijalo Formation
Consist of conglomerate with interbeds of orkosic sandstone, shale and limestone

Paleocene

GF — Garchitorena Formation
Thick sequence of slightly metamorphosed volcanic wackes; highly indurated shale with associated coal seams; and thick layers of chert and basaltic flows

Cretaceous

PF — Pagsangahan Formation
Predominatly indurated graywacke, shale and chert; altered basaltic and andesitic flows; and bedded oolitic and cherty limestone

Pre-Cretaceous

LS — Lagonoy Schist
Regionally metamorphosed schist of the greenshist and chlorite-epidote-amphibolite facies with interbedded marble and weakly schistose tuff and conglomerate

Intrusive Rocks

Oligocene

TPDx — Tambang Point Diorite
Occurs as small stocks, dikes and sills classified as quartz diorite and hornblende diorite

- Fault
- Thrust
- Anticline
- Syncline
- Alteration Ground
- Quartz vein
- Hot / Warm spring

- ○ Sample from outcrop
- △ Sample from floating rock
- □ Sample from drill hole

- (G) Geochemical analysis
- (O) Ore grade assay
- (X) X-ray diffraction analysis
- (W) Whole rock analysis
- (D) K-Ar dating
- (T) Thin section
- (P) Polished thin section
- (R) Reserve

Reference:

Bureau of Mines and Geosciences (1983)
Geological Map of "CARAMOAN" Quadrangle
(Sheet 3761 II)

Fig. II-2-8 Geological Map of Eastern Caramoan Peninsula area

Table II-2-3 Geology of Eastern part of Caramoan Peninsula
From David et al. (1994)

Minas Fault (WNW trending left-lateral fault); faulting: the end of Cretaceous～Early-Late Oligocene

the Western Caramoan Structural Unit (WCSU)		the Eastern Caramoan Structural Unit (ECSU)	
Lagonoy Ophiolites	Pre-Late Cretaceous		
ultramafic rocks, gabbros	112.7±3.9 Ma (gabbro)		
pillow basalt	151-156 Ma (metamorphosed leucodiabase and gabbro)		
volcaniclastics	emplace: pre-Middle Eocene		
Pagsangahan Formation	Late Cretaceous	*Garchitorena Formation*	Late Cretaceous
volcanics, volcaniclastics	60.32±1.37 Ma (basaltic dike)	volcanics, volcaniclastic	67.56±1.50 Ma (basalt)
	62.79±1.38 Ma (gabbro)		121.09±2.61 Ma (basalt)
	64.74±1.67 Ma (gabbro)		91.1±0.5 Ma (basalt)
hemipelagic limestones		hemipelagic limestones	
Guijalo Limestone	Middle Eocene	*Guijalo Limestone*	Middle Eocene
limestones		limestones	
Isarog Volcanics	Pliocene to Quaternary	*Caramoan Formation*	the latest Middle Eocene ～earliest Late Eocene
		flysch and oliststrome deposits	

PTH313 is greenish gray and underwent chlorite – epidote alteration. This can be regarded as a regional low-temperature metamorphism. It is compact and hard. A lot of quartz + epidote veinlets can be observed. These veinlets are 0.5 to 2 cm wide. The rough trend is N60° W, 42° SW dipping. It has a shear fault, which is 40 cm to 1 m wide. Its direction is N30° W, vertical dipping. A 1.5-cm wide quartz vein can be also observed. It has a strike of N48° W and dips southwestward. It is diagonal to schistosity. There is no alteration halo at the edge of the vein.

<Baliguian>

Diorite (PTH314) is greenish gray, has chlorite – actinolite, and underwent a low-temperature metamorphism. The whole rock analysis revealed that it contains 52.84% of SiO_2, which is basic rock. The Spider diagram showed that it has a feature of subduction-related magma (Appendix 20). It is judged that the sample's a high value, K_20 = 2.59%, is influenced by metamorphism and alteration. Outcrops of metasedimentary rock appear where a ridge inclination changes. A lot of quartz veinlets can be observed (PTH315). The trend of quartz veins is N50° W, 30° S, which is almost horizontal. This is cut by a vertical fault (normal fault: N50° E, 76° N) accompanied by epidote.

PTH316 is an outcrop of metasedimentary rock. The grain has the size of silt to sand. Grains compose rock originating from igneous rocks. It underwent chloride alteration. From the fact that diorite is distributed at the top of the ridge again, it is expected that metasedimentary rock exists in the form of roof pendant.

<Malaiba>

Because the mineral showing of Malaiba is relatively easily accessible and local residents lead the way for the survey team, a survey was conducted. It takes about 30 minutes by with four-wheel drive car from Salvacion in the southern part of the Caramoan town to the survey area through an unpaved road. The ridge is a 1.5-km walk southwest from the end of the road. It is 200 meters above sea level. This area has a slightly steep topography.

The host rock of the Malaiba mineralization zone is greenschist and mica schist (PSM268), and the mineralization zone corresponds to a 1.5-meter wide shear zone, which develops in schist. The shear zone has well-developed crenulation and kink bands, and the direction of extension of the shear zone is concordant with neighboring schistosity. The shear zone is characterized by abundance in pyrite, compared to the vicinity. The shear zone also has a large amount of limonite generated by the oxidative destruction of pyrite. Pyrite is produced in euhedral shape with a diameter of about 1 mm and occurs in dissemination. Pyrite seems to be accompanied by a small amount of chalcopyrite. Samples have been collected from an outcrop of this shear zone to conduct various laboratory tests. Such

minerals as quartz, sericite, chlorite, and pyrite were detected through the X-ray diffraction. The chemical analysis revealed a copper grade of 0.28% (PSM268: cf. Au: 10 ppb, Zn: 740 ppm).

A mineralization of the same type distributed in the eastern part of the Caramoan Peninsula is described as a massive sulfide deposit mainly containing pyrite, which is sandwiched between schist. Malaiba has a mineralization zone similar to that of the eastern part of the Caramoan in that both are rich in pyrite. Because the mineralization is limited to the shear zone and pyrite is occurred in dissemination, it is considered to be an epigenetic hydrothermal deposit. Since a plastic deformation is recognized, it is thought that the shear zone was generated at the last stage of the regional metamorphism period when schistosity was formed. The distribution of igneous intrusive rock is not known around this area.

The size of the Malaiba mineralization zone, which is1.5-meter wide, is small. Its copper grade and economic value are low. The size of the mineralization zones of the same type distributed in the eastern part of the Caramoan Peninsula seems to be also small.

<Alto point-Maangas >

The geological map shows the distribution of diorite in Alto point, but it is reasonable to consider it is metagabbro that is distributed in this area.

According to local residents, the Cu mineralization in the northeastern part of Alto point has been excavated. Because those who engaged in the excavation are already dead, the details including its location are unknown.

Metagabbro ("diorite") is one of the units composing ultrabasic rocks and belongs to an older period, compared to a type accompanied by a porphyry type mineralization.

<Pili-Pagsanghan>

The idea of conducting a field survey in this area was given up because of security problem. The analysis of samples obtained from BMG Region V revealed the Au content is 10 ppb to 2190 ppb and the Cu content is 240 ppm to 10,000 ppm, which indicates the Au and Cu mineralization. In addition, Mo, Pb, and Zn have values at a geochemical anomaly level. Laud (1997) reports that the mineralization is accompanied by quartz veins in schist or silicified zones. As the result of the X-ray diffraction, it is presumed that some sericite and chlorite belongs to metamorphic rock of schist and other is caused by hydrothermal alteration accompanied by quartz veins and silicification. From such a occurrence, it is thought that the mineralization in this area is not that of a sedex-type massive sulfide deposit but an epigenetic hydrothermal mineralization.

7) Potential

The Pili-Pagsanghan section, which is the main survey section of this area, could not be surveyed. Other mineralization could not be thoroughly surveyed because they were hard of access. Consequently, at present it is difficult to evaluate potential of this area.

8) Mine claim

Two or more companies have applied for FTAA.

2-2-5. Kilbay area

1) Reasons for selection

This was also considered to be one of high potential areas in the Phase I survey. This area was not surveyed in Phase I for some reasons of schedule.

This area is situated on the west side of Mt. Labo. From the degree of dissection, it was presumed that volcanic rocks in this area may be older that of Mt. Labo area. Distributed volcanic rocks are hornblende-biotite dacite. Judging from the presence of a hydrous magma, it is possible that a hydrothermal system develops. In addition, kaolinite clay deposit distributed in this area is considered to be a shallow environment of the hydrothermal system. It is thought there is a high possibility that a hydrothermal deposit exists in the depths.

A geothermal survey was conducted by PNOC around Mt. Labo. The geothermal drilling data indicates alteration and mineralization of a high sulfidation system are found in the depths of this geothermal system. On the analogy of this geothermal system, it is possible that a similar mineralization or a porphyry-type mineralization exist in the depths of this area.

2) Location and transportation

This area, situated in the west of the Bicol Peninsula, is located the border between Camarines Sur Province and Quezon Province. The Quilino Highway runs along the coast in the south of this area. Tagkawayan, where a base camp is set up, is easy of access. It takes about an hour by car with four-wheel drive from Tagkawayan to the survey area through an unpaved road. If the road is muddy because of rain, it is very difficult to reach the mouth of the drainage in the survey area even by four-wheel-drive car.

3) Survey routes and points (Fig. II-2-9)

Survey Route	Survey Point
Layaton Creek	Because the literature describes the existence of quartz veins in these creeks, it was expected that a mineralization would exist.
Alawihaw – Kilbay Creek	
Bacaco	
Tabion Munti	The literature pointed out that a clay deposit distributed in this area is that of an epithermal type. Since no volcanic topography is recognized nearby, it is presumed that an old

	hydrothermal activity, prior to the geothermal activity around the present Mt. Labo, contributed to the formation of the clay deposit. A mineralization accompanied by this was also expected.
Susungdalaga Mountains South	The purpose of this survey is to confirm the extension range to the western part of the alteration zone from Alawihaw-Kilbay Creek to Layaton Creek.
Molocboloc Creek	
Tonton River	The purpose of this survey is to confirm the extension range not only to the western part of the alteration zone from Alawihaw-Kilbay Creek to Layaton Creek but to the north of Susungdalaga Mountains.

4) Outline of survey results

Figure II-2-10 shows the geology, distribution of alteration zone, and sampling points in this area.

It was made clear that the alteration zone has a wide distribution in this area. A quartz-mixed layer clay zone is widely distributed in the alteration zone, and quartz veins also develop. Gold mineralization of a low-sulfidation system is recognized.

5) Geology

Very little data describing the geology of this area is available. According to a geological map on a scale of 1 to 50,000, Labo volcanic rocks are distributed in this area. According to Zeide-Delfin et al. (1995) and Banos et al. (1996), the Susundalaga layer composed of volcanic rocks of the Miocene Epoch is distributed on the bed rock (Table II-2-4). The K-Ar age determination of volcanic rock distributed in this area was carried out in this survey. The K-Ar age is 4.32+/-0.48 Ma (PKY297), 3.75+/-0.42 Ma (PTH333), and 3.45+/-0.39 Ma (PTH353), indicating early Pliocene in age. This rock indicates the oldest age of all the volcanic rocks distributed in the Central Belt that have been so far found.

6) Alteration and mineralization

<Layaton Creek>

The hydrothermal alteration zone developed in this area. Quartz vein were observed in the hydrothermal alteration zone. And gold mineralization was recognized in quartz veins. In addition to gold, Cu anomaly was recognized in common. Mo anomaly and P anomaly were also detected.

A lot of silicified rocks (PTH317) and floats of argillized rock (PTH318: quartz, pyrophyllite, pyrite, and kaolinite) were observed at the mouth of the creek. They have values at an anomaly level, containing Au: 20 ppb and Cu: 106 ppm and Au: 40ppb and Cu: 142 ppm, respectively. PTH319 is an outcrop of lapilli tuff. Lapilli are hornblende – biotite

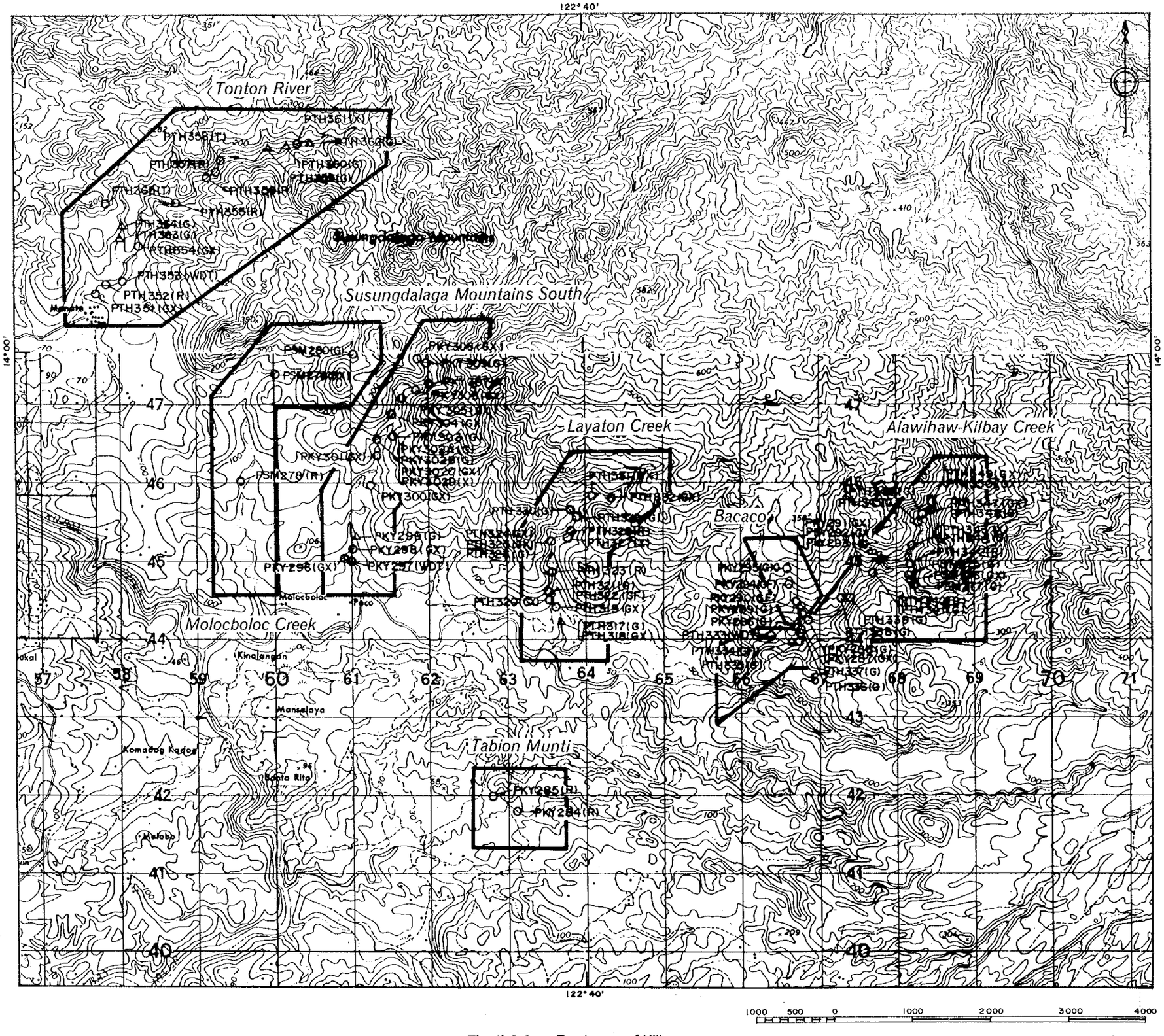
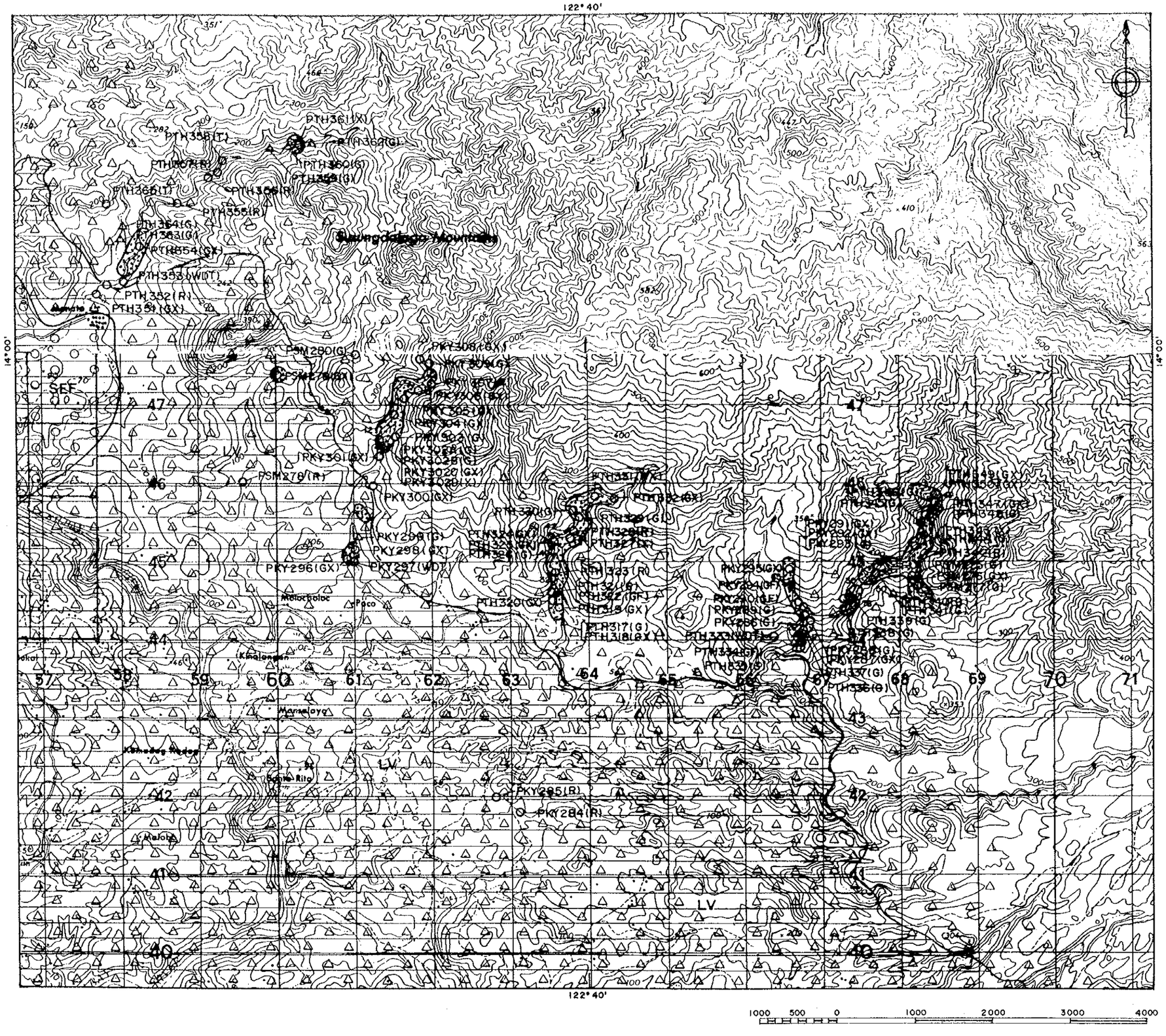


Fig. II-2-9 Root map of Kilbay area



LEGEND

EXPLANATION

Pleistocene

LV — Labo Volcanics
- andesitic and dacitic volcanic deposits occurring mainly as lava flows
- widespread pyroclastic agglomerate, volcanic breccia, tuff around volcanic cones and volcanic plains

Late Miocene

SEF — Sta. Elena Formation
Thick interbedded sequence of conglomerate, sandstone, shale and minor limestone

- Fault
- Thrust
- Anticline
- Syncline
- Alteration Ground
- Quartz vein
- Hot / Warm spring

- ○ Sample from outcrop
- △ Sample from floating rock
- □ Sample from drill hole

- (G) Geochemical analysis
- (O) Ore grade assay
- (X) X-ray diffraction analysis
- (W) Whole rock analysis
- (D) K-Ar dating
- (T) Thin section
- (P) Polished thin section
- (R) Reserve

Reference:

- Bureau of Mines and Geosciences (1984) Geological Map of "BAYABAS" Quadrangle (Sheet 3562 III)
- Geologic Map of Bicol Region (1:250,000) by BMG Regional Office V

Fig. II-2-10 Geological Map of Kilbay area