noted centering on the Calpi Creek, which are not continuous with those low-resistivity zones, might be indicative of the hot fluid passages of a little older age than the present.

3.2.2 Tiwi-Mt. Malinao Area (Fig. II-3-7)

Location: 2-5 km west of Tiwi in Albay Province in the vicinity of 13°27' to 13°29' N, 123°38' to 123°40' E.

Accessibility: Tiwi can be reached by vehicle in 50 minutes by the national highway going north from Legazpi.

Geology: It consists of andesite lava and pyroclastic rock from Mt. Malinao in the vicinity of that mountain to the north and east of it, and according to David T. et al. (1993: AL-16), it is dated as 0.5-0.06 Ma. Furthermore, there is wide development of alluvial fan sediment from Mt. Malinao in the northeastern part. Eight kilometers to the northeast of Mt. Malinao there is 3.2 Ma biotite-hornblende dacite, underlain by Miocene-Pliocene Polangi volcanics (Hoagland and Bodell, 1991) andesitic lava to pyroclastic rock, those volcanic rocks forming a geothermal reservoir. Those volcanic rocks consist mainly of hornblende-pyroxene andesite and pyroxene andesite. The geothermal reservoir is thickest from east to west, and the basement rock gets deeper going closer to the volcanic body.

According to the borehole geology, the basement rock changes to quartz-muscovite schist after about 600 m of mudstone, limestone and andesitic wacke. In the Nag area it is distributed to approximately 1500 m above the sea level, but it is not noted in the western part of the geothermal exploitation area to 2000 m above the sea level.

In the Matalibong-25 (Mat-25) borehole drilled in the geothermal reservoir of the Matalibong (Mat) area the highest temperature is nearly 270°C, at depths less than 1601 m it consists of andesitic and basaltic lava and pyroclastic rock, becoming lava and pyroclastic rock caused by subaqueous volcanic activity in the depth range 1601-2012 m and sandstone in the depth range 2012-2439 m.

The main elements of the geological structure of the Tiwi area are the NE-SW system of faults comprised by the Kagumihan fault, Tiwi fault and Naglagbong fault, which form the main geothermal reservoir, and the NW-SE system comprised by the Putsan-Bolo fault. The Kagumihan fault is divided into the Matalibong (Mat) area, where the steam pressure is higher, and

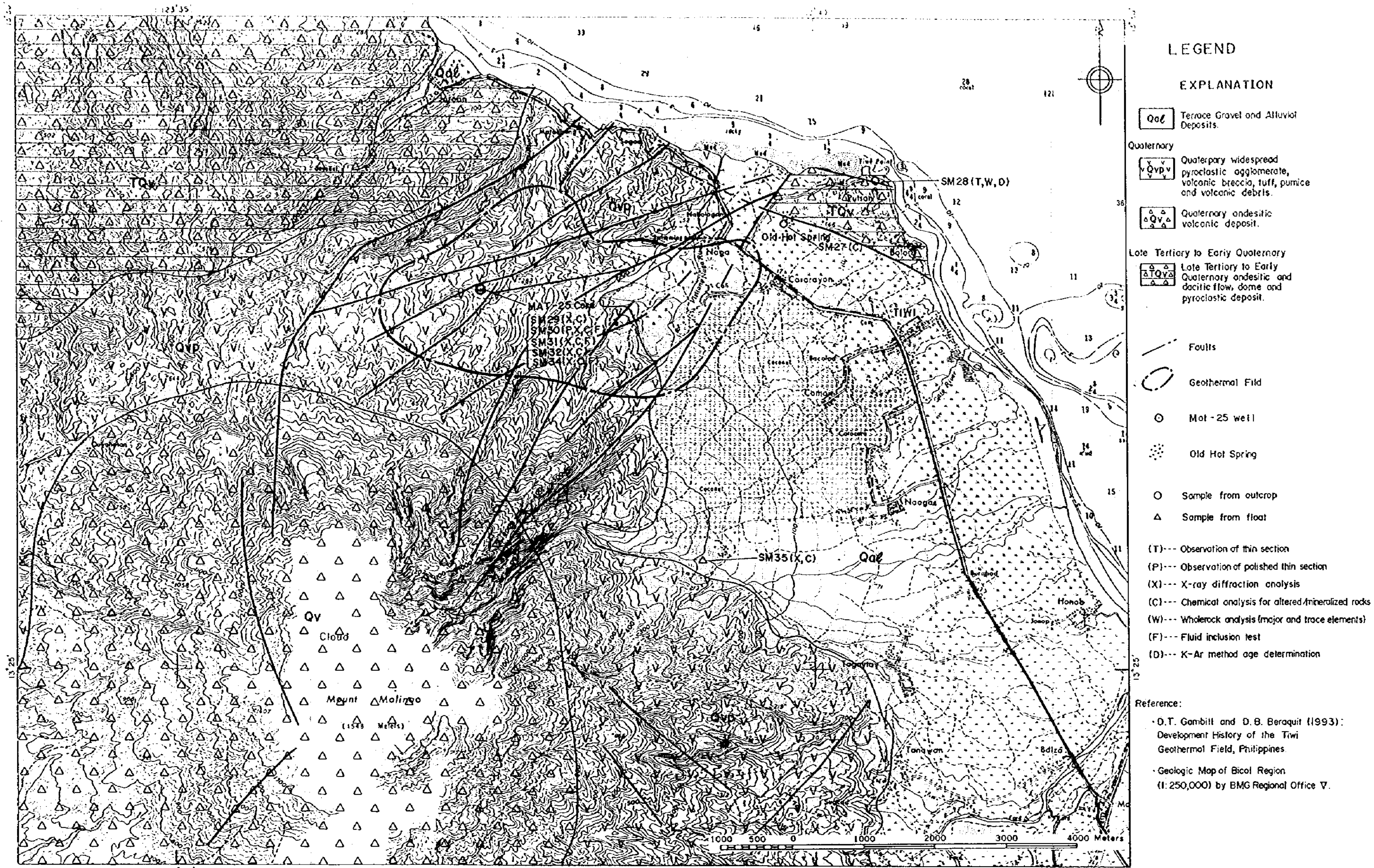


Fig.II-3-7 Geological map of the Tiwi－Mt. Malinao Area and sample locations the Nag area, where it is lower. Furthermore, in the eastern part of the geothermal energy development field the argillization plane is the shallowest along the Naglagbong fault as an indication that the geothermal fluid rises along that fault. At the eastern part of the Tiwi fault there is wide distribution of silica sinter, with formation of sinter cones (Fig. II-3-8). There used to be geysers, but they got weaker and disappeared after commencement of geothermal exploitation. The existence of such silica sinter indicates that the geothermal fluid has a high concentration of silica dissolved in it.

Alteration: Within the geothermal reservoir most of the rock has undergone propylitization alteration and is characterized by chlorite, quartz and epidote. At some places in the southwest part and the south part the shallow reservoir has undergone advanced argillic alteration and is characterized by sericite, pyrite, pyrophyllite, alunite, anhydrite and diaspore. Furthermore, the top part and lateral part of the reservoir have undergone argillic alteration and are characterized by smectite and calcite. A part is a shallow steam-heated zone. The core from a depth of 6905 ft. in the Matalibong-25 (Mat-25) borehole contains calcite and epidote, with partial intense silicification, and adularia, chalcopyrite, sphalerite and galena were observed.

The X-ray diffraction analysis of an altered rock float sample (SM35) from Mt. Malinao revealed quartz, cristobalite, tridymite and alunite, indicative of shallow acidic alteration. In the core from a depth of 2986 ft. in the Mat-25 borehole quartz, sericite-smectite mixed-layer mineral, wairakite zeolite and calcite were detected. The 5093 ft. core showed quartz, chlorite, sericite-smectite mixed-layer mineral and calcite, that from 5840 ft. quartz, sericite and anhydrite and that from 6905 ft. quartz, adularia, sericite, sphalerite and galena, which are indicative of medium- to high-temperature hydrothermal alteration due to neutral hydrothermal fluid (low sulfidation alteration) in the deep part of the Mat-25 borehole. Furthermore, it appears that the clay minerals change from sericite-smectite mixed-layer mineral to sericite at a depth of about 1700 m.

The results of homogenization temperature measurements of fluid inclusion showed 232-283°C (average of 270.3°C) for the core from 2986 ft., 241-288°C (average of 262.0°C) for the core from 5840 ft. and 223-251°C (average of 237.4°C) for the core from 6905 ft, i.e. almost all the same temperatures, which results are in harmony with the compositions of the alteration minerals. Probably there is coexistence of alteration minerals from the period of highest temperature and minerals from after the temperature fell. The values of salinity were all low: 0.18-0.53 Wt% in the core from 2986 ft., 0.35-1.23 Wt% in the core from 5840 ft. and 1.91-2.41 Wt% in the core from 6.095 ft. That can be considered to be due to strong influence on the part of meteoric water. The values rise going deeper, which can be considered to be due to the influence of the deep

Fig.II-3-8(a) View of the Tiwi geothermal electricity plant, looking from sinter terrace

Fig.II-3-8(b) Occurrence of sinter cone and sinter terrace in the Tiwi geothermal field

hydrothermal fluid.

Mineral showings: In the 6905 ft. core from the Matalibong-25 (Mat-25) there are galena and sphalerite crystals that can be recognized by the naked eye, and analysis of that core showed high-concentration anomalies for Au, Pb and Zn: 85 ppb Au, 674 ppm Pb and 722 ppm Zn.

Evaluation: The results of analysis of the core from 6905 ft. in the Mat-25 borehole, i.e. from the middle part of the geothermal reservoir, which showed high-concentration anomalies for Au, Pb and Zn, and the fact that adularia was noted as an altered mineral suggest existence of low-sulfidation mineralization. However, it is considered that discover of a large-scale deposit is unlikely considering the great depth of such mineralization of about 2300 m below the surface, the fact that mineralization was identified in the Mat-25 borehole only at that part and the fact that the deposit is presently in the stage of formation as made clear by the present activity of high-temperature geothermal fluid. But the presence of silica sinter at the surface of the ground shows that high-temperature geothermal fluid with a high concentration of silica rises to a shallow depth.

Mining claim: Philippine Geothermal, Inc.

3.2.3 Nagas-Pio Duran Area (Fig. II-3-9, Fig. II-3-10)

Reason for selection: This area corresponds to almost the entire Panganiran Peninsula. The fact that the Eocene Pantao limestone has undergone thermal metamorphism (recrystallization) due to the influence of intrusion by the Oligocene Panganiran diorite can be surmised from the existing geology (de Guzman, 1963). There is therefore the possibility of deposits of the skarn type or Carlin type at the contact between the diorite and the Pantao limestone. There is also potential for skarn or porphyry type deposits at the contact between the diorite and the Ragay volcanic rock. Furthermore, the existing literature shows distribution of copper mineral showings in this region (see the section on deposits and mineral showings of the Bicol Region). The Pantao-Nagas-Cabarian route on the west coast side of the Panganiran Peninsula and the Pio Duran-Kapulak route at the south side of the peninsula were surveyed.

(1) Pantao-Nagas-Cabarian Route (Fig. II-3-9)

Location: It is situated in the vicinity of 13°00' to 13°10' N, 123°17' to 123°21' E along the west coast of the Bicol Peninsula 30 km southwest of Oas in Albay Province.

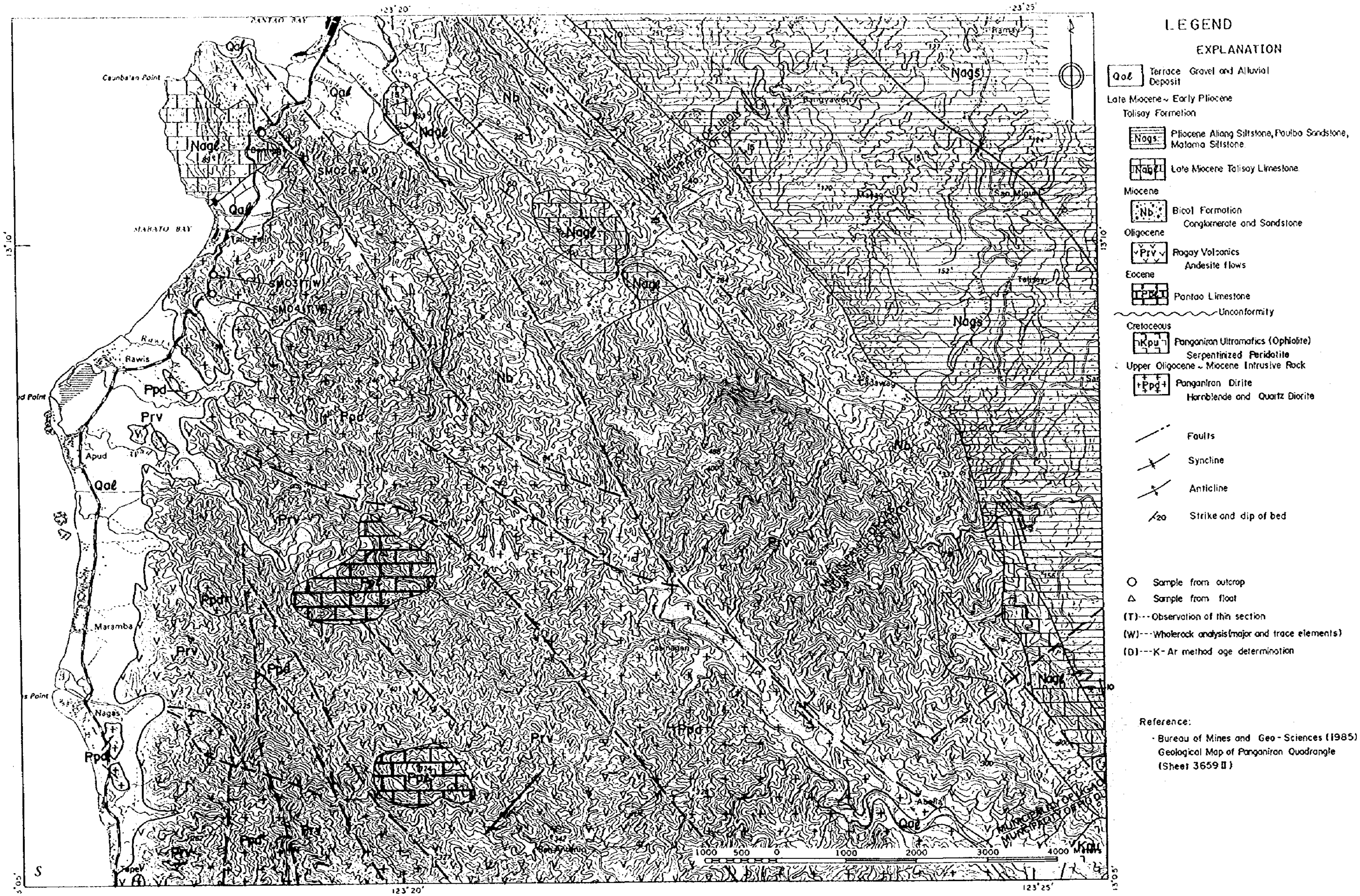
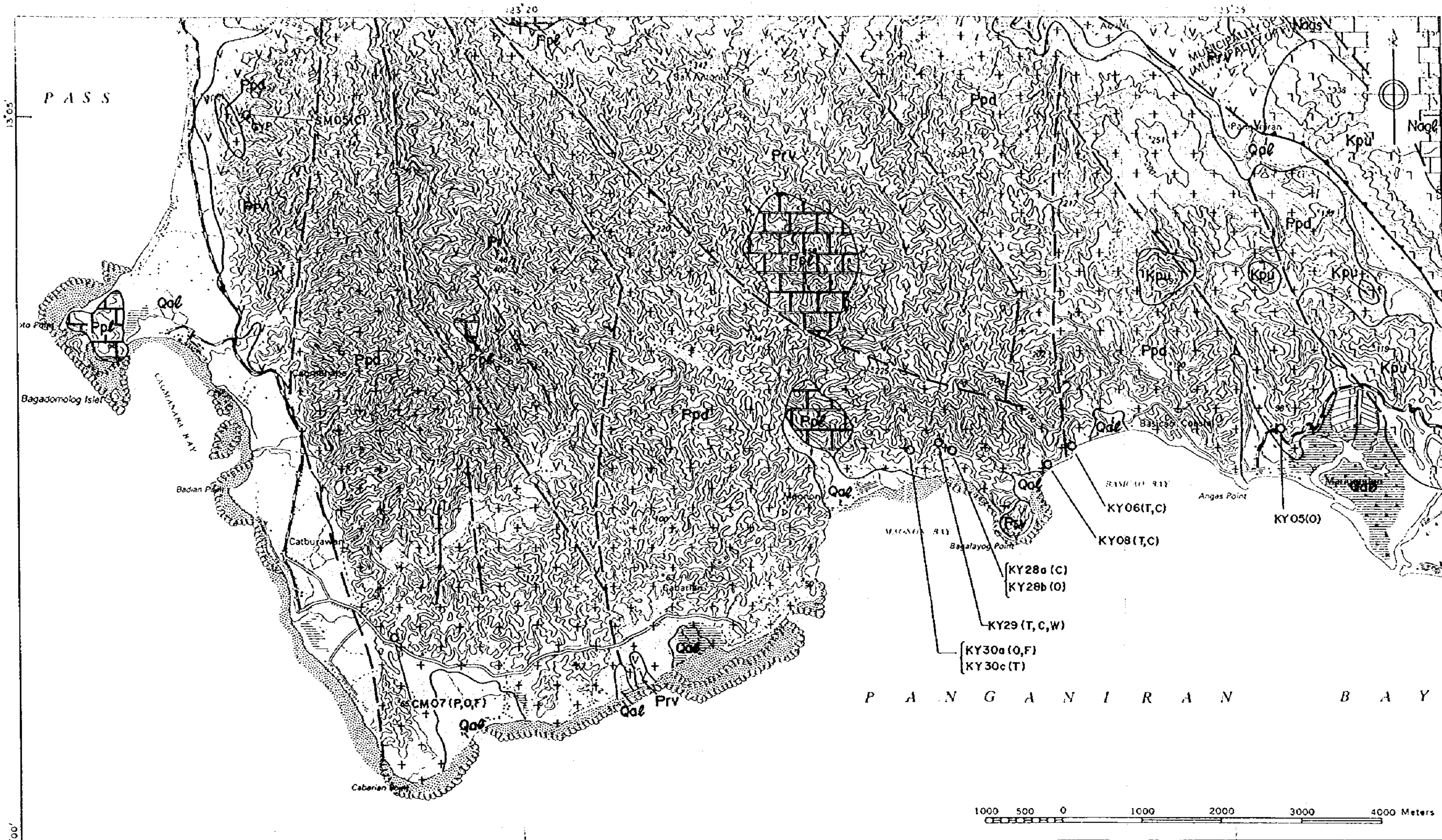


Fig.II-3-9 Geological map of the Nagas－Pio Duran Area (1) and sample locations



LEGEND

EXPLANATION

Qal	Terrace Gravel and Alluvial Deposit

Late Miocene ~ Early Pliocene
Talisay Formation

Nags	Pliocene Aliang Siltstone, Paulba Sandstone, Malama Siltstone.
Nagl	Late Miocene Talisay Limestone

Miocene

Nb	Bicol Formation Conglomerate and Sandstone

Oligocene

Prv	Ragay Volcanics Andesite flows

Eocene

Ppl	Pantao Limestone

Unconformity

Cretaceous

Kpu	Panganiran Ultramafics (Ophiolite) Serpentinized Peridotite

Upper Oligocene ~ Miocene Intrusive Rock

Ppd	Panganiran Diorite Hornblende and Quartz Diorite

Faults
Thrust fault
GYP Gypsum Deposit

O Sample from outcrop
△ Sample from float
(T)---Observation of thin section
(P)---Observation of polished thin section
(O)---Ore grade assay analysis
(C)---Chemical analysis for altered/mineralized rocks
(W)---Wholerock analysis (major and trace elements)
(F)---Fluid inclusion test

Reference:
- Bureau of Mines and Geo-Sciences (1985): Geological Map of Panganiran Quadrangle (Sheet 3659 II)

Fig.II-3-10 Geological map of the Nagas – Pio Duran Area (2) and sample locations

Accessibility: Oas can be reached from Legazpi by vehicle by way of the national highway in 1 hour and 10 minutes, and it takes another 50 minutes from Oas to Pantao by vehicle to the starting point of the survey route. The terminal point of the survey route, Cabarian, is a 1-hour drive from that starting point.

Geology: The geology of the area is made up of the Pantao limestone consisting of Eocene crystalline limestone, the Ragay volcanics consisting of early Oligocene phenocryst-rich andesite and the Miocene Bicol formation consisting of conglomerate, sandstone and calcareous sandstone as well as the Panganiran diorite consisting of hornblende diorite, which penetrates it. Covering those with unconformity, there is distribution of the Talisay formation consisting of Miocene to Pliocene limestone, siltstone and sandstone and the Ligao formation consisting of Pliocene to Pleistocene limestone.

ENE-WSW and NW-SE lineaments are predominant in the vicinity of Tapel, and N-S and E-W lineaments are predominant in the vicinity of Catburawan.

Alteration: In the vicinity of Tapel the Ragay volcanics consisting of coarse grained andesite have undergone dioritic and argillic alteration, and gypsum deposits with meta-basalt as the wall rock have been formed at places 400-500 m from the coast. There are three main gypsum deposits, with a N-S trend. Those gypsum deposits are thought to have been formed, at the time of covering by limestone, by mixing of meteoric water rich in calcium carbonate with the sulfides that filled underground cracks. They have a width of about 1-2 m and consist mainly of selenite. They include dense zonal pyrite at places and have some accompaniment of silicification as well. The wall rock near the deposits has undergone intensive argillic alteration and is fragile.

Furthermore, reddish brown quartz veins measuring several centimeters were noted in the diorite from Catburawan to Cabarian (Fig.II-3-11).

A sample from those quartz veins (SM07) showed high fluid inclusion homogenization temperatures of 147 to 191°C (average of 168.8°C), but since the salinity values were a low 0.35 to 0.71 Wt%, that is thought to be indicative of strong influence by meteoric water.

Mineral showings: Copper oxide minerals are recognizable by the naked eye in the quartz veins found in outcrops southeast of Catburawan. Chemical analysis showed high-concentration anomalies for copper (14,500 ppm, or 1.45%) and zinc (1,810 ppm, or 0.18%) as well as a value of 10 ppb for gold, and the Tapel gypsum ore also had a comparatively have value for gold: 55 ppb.

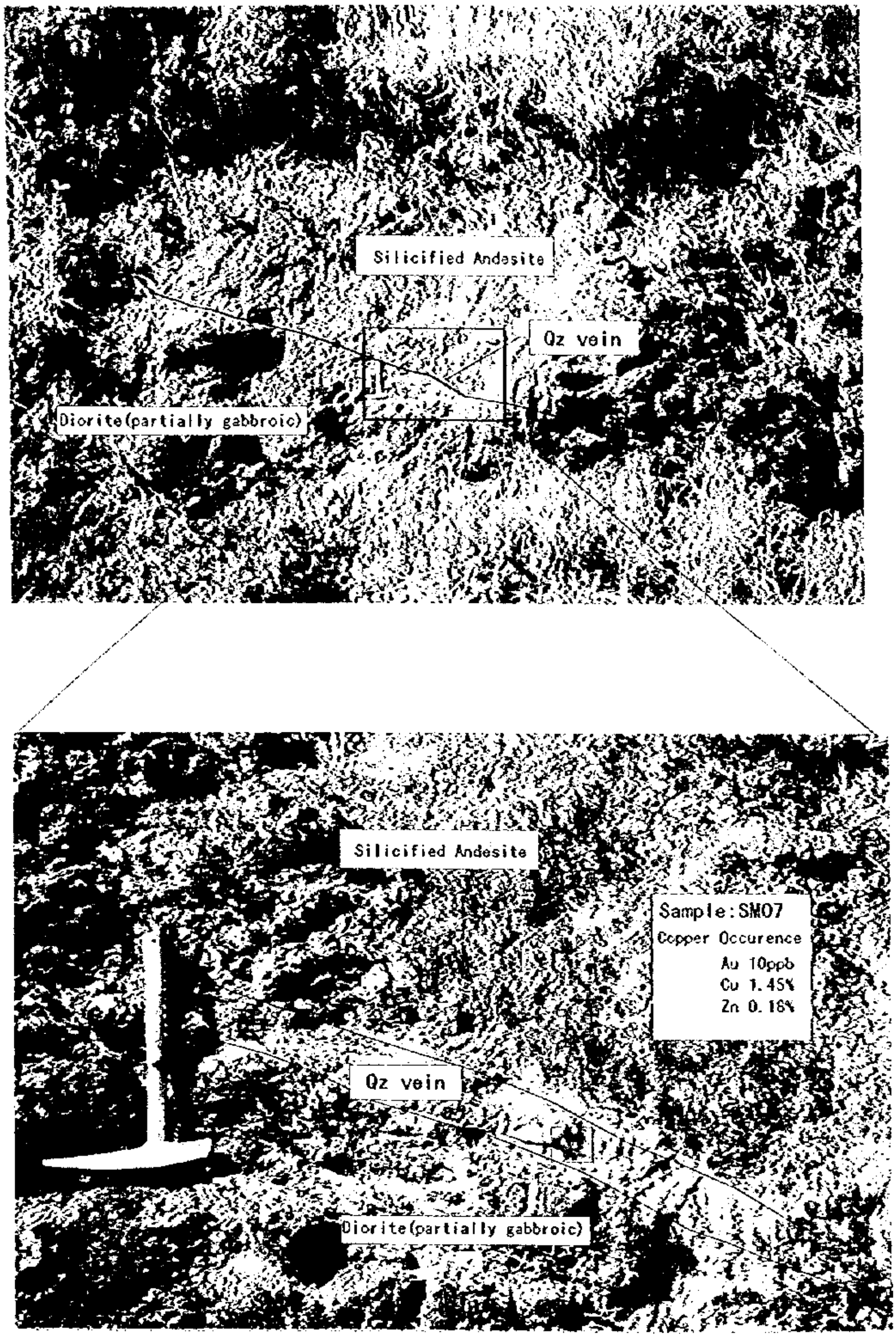


Fig. II-3-11 The copper occurence in Nagas-Pio Duran Area
(The outcrop at the south-eastern Catburawan)

Mining claim: MPSA and FTAA.

Evaluation: Gold and base metal mineralization accompanying intrusion of diorite into the pyroclastic rock is noted in this area. When ore solution rich in sulfides passes through cracks in the pyroclastic rock representing the wall rock of the deposits, there is formation of crack filling material rich in pyrite, and when limestone is present above the pyroclastic rock, gypsum deposits are formed by reaction with meteoric water rich in calcium carbonates. Gold mineral showings are noted in such crack filling materials, and base metal mineralization accompanying quartz veins is noted in the diorite below.

One can expect Carlin type gold deposits in the Paotao limestone as well as skarn deposits replacing the Pantao limestone. However, potential of the deposit is considered to be low because of the small area of distribution of the Pantao limestone. There is also possibility of porphyry type to pluton-related base metal vein type mineralization from the diorite to the Ragay volcanics, but the scale of the noted alternation and mineral showings is small.

(2) Pio Duran-Kapulaki Route (Fig. II-3-10)

Location and Accessibility: It takes about 2 hours by vehicle to Pio-Duran from Legazpi. Access by vehicle to the survey area is possible up to Kapulaki, but after that the going is by foot.

Geology: The geology of this survey area consists of diorite and gabbro with frequent development of foliation. The gabbro is sometimes accompanied by serpentine and schist, forming continuous ultrabasic rock bodies. The existing opinion is that diorite intrudes or penetrates into the ultrabasic rocks. Furthermore, from floats it is surmised that there is distribution of limestone, sandstone and conglomerate in the survey area, although the extent thereof is unknown. Tupas, M.H. (1951, AL11) points out the possibility that the age of the limestone is the Paleogene period. In this survey, too, crystalline limestone floats were noted. Assuming that it represents accompaniment of the igneous activity that formed the diorite with a measured K-Ar age of 40 Ma (according to interview of BMG geotechnicians), the age of the limestone is in harmony with what was pointed out by Tupas, M.H. (1951, AL11). Moreover, in the east to northwest part of the survey area there is wide distribution of neritic sedimentary rock covering those rocks with unconformity, which in turn is covered by limestone.

Alteration: The ultrabasic rock has undergone white alteration in the vicinity of distribution of diorite intrusive rock.

Mineral showings: Although oxidized copper ore has been noted very rarely in the white altered ultrabasic rock, it easily disappears at outcrops as a result of swelling and contraction. Some of the oxidized copper ore follows the planar structure of the gabbro, and some of it follows faults. Furthermore, although the details are not known, at several places there has been small-scale exploitation of copper. Piles of mine dump and collapsed tunnels, trenches, etc. were noted at places not mentioned in Tupas, M.H. (1951, AL11). The values from analysis of mine dump samples were 13,900 ppm and 1,460 ppm for copper and 640 ppb for gold, and those from analysis of quartz vein in the diorite (KY30) were 10 ppb for gold and 230 ppm for copper. For the KY30 sample the homogenization temperature of fluid inclusions varied 193-242°C, with an average of 220°C, and the salinity was 1.74-3.23%. There is dispersion in the size of the bubbles, on which basis the phenomenon of boiling can be surmised.

Evaluation: Although there is evidence of small-scale exploitation of copper having taken place, the scale of production and other details are unknown. Considering the fact the copper mineralization has noted in only extremely limited ranges in this survey, the potential as regards scale can be said to be low.

The mineralization appears to be related to gabbro intrusion and structural weak lines, and there is room for evaluation of the mineralization potential of the gabbro. Furthermore, considering the possibility of presence of Paleogene limestone, the possibility of skarn deposits cannot be entirely ruled out.

According to local residents, there is a place called Kinagatan in the deep interior of the valley where gold was exploited. Since the results of analysis show that copper mineralization is accompanied by gold mineralization, the relationship between copper mineralization and gold mineralization is a matter of interest.

Mining claim: Application has been made for FTAA status.

3.2.4 Pilar-Donsol Area (Fig. II-3-12)

Reason for selection: Considering development of lineaments with a NW trend as determined by SAR image analysis and the fact that there is distribution of limestone, this area was selected because of the possibility of formation of deposits of the skarn, porphyry or Carlin type if

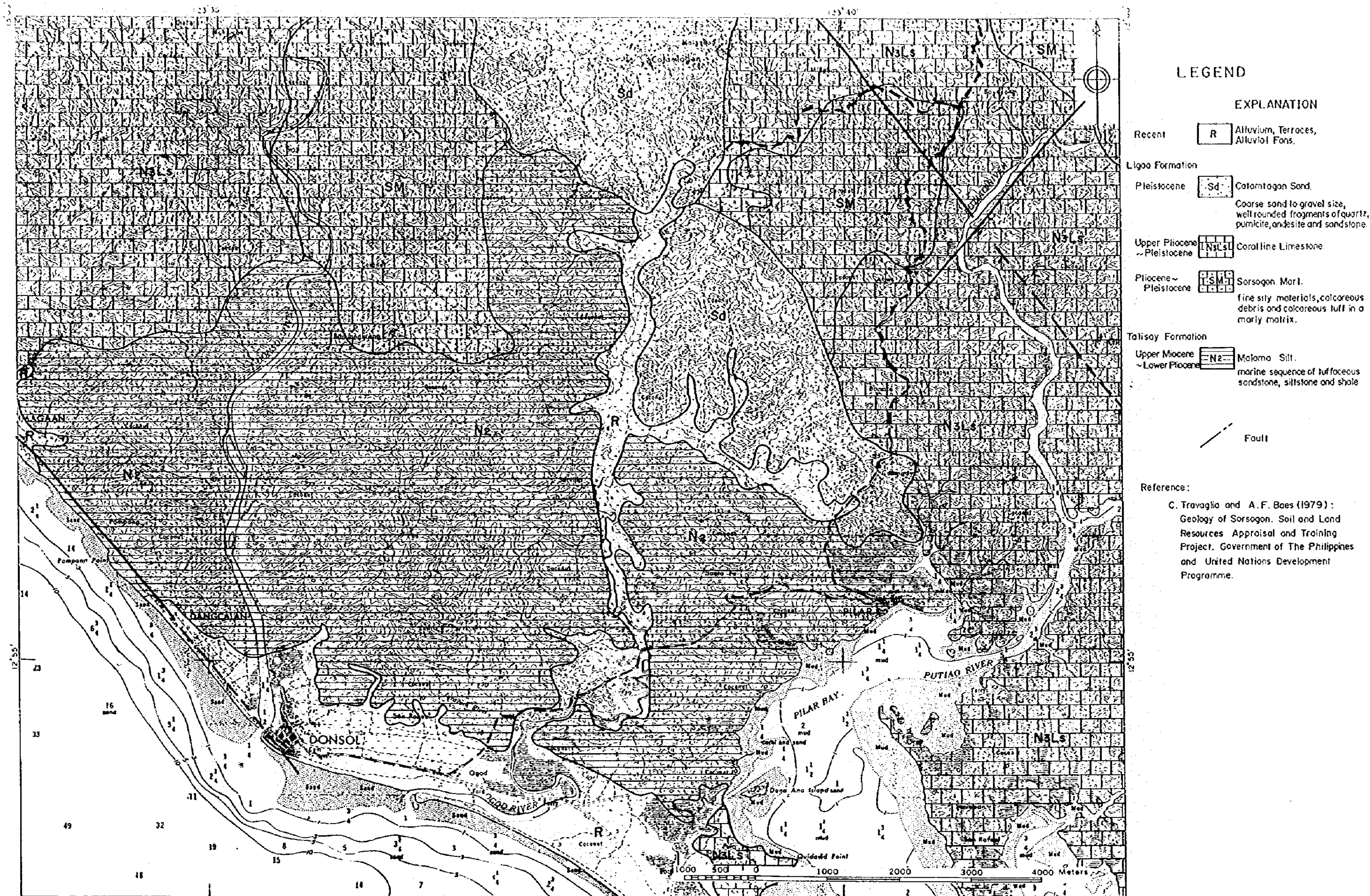


Fig.II-3-12 Geological map of the Pilar-Donsol Area there is existence of diorite or other intrusive rock. In the existing literature there is no mention of mineral showings or alteration zones in this areas, but there is an iron sand deposit (magnetite) at one place on the coast.

In the ground truth survey it was decided to make a check for parts of the terrain with greater resistance to erosion than the surroundings, e.g. protruding parts in creek, to determine whether or not there is any distribution of intrusive rock. Furthermore, iron sand used to be extracted on the coast near Donsol, and since the source of supply of that heavy mineral might have been intrusive rock distributed in the area, it was decided to check for existence thereof.

Location: About 50 km south of Legaspi.

Accessibility: It takes about 1 hour by car. Access is easy because there is a paved road to it.

Geology: The terrain of the area is gently sloping hills, and it has wide distribution of Pleistocene calcareous siltstone as well as distribution of coral limestone. The coral sandstone is distributed mainly round Pilar on the eastern side of the area. It was not possible to observe direct contact with the calcareous siltstone, but considering the mode of occurrence of the two, the coral limestone is considered to mount the calcareous siltstone.

Around TH03 in Fig. II-3-12 there is terrain protruding from the NE-direction linear creeks. At first that was thought to be due to intrusive rock, but since there is no intrusive rock, it is considered to be terrain due to coral limestone. The reason is that there coral limestone mounts the calcareous siltstone, and the fact that the coral limestone is more resistant to erosion that the calcareous siltstone would appear to be responsible for formation of such terrain.

Heavy minerals were extracted on the coast at Donsol, mainly magnetite, pyroxene and hornblende and a little olivine. A check was made for distribution of intrusive rock at the upper reaches of the Donsol River, but none was found within the scope of the survey. What was found is mainly distribution of alternation of strata of sandstone and siltstone.

Alteration: None.

Mineral showings: None.

Evaluation: Both the limestone and the calcareous siltstone are thought to be new, from near the Quaternary period. Also considering the fact that there is no distribution of intrusive rock, contrary to expectations this area is judged to have no potential concerning deposits of the Carlin and other types.

Mining claim: Application has been made for FTAA status by Batu Ao Mining Corporation.

3.2.5 Irosin-Gabao-Bulan Area (Fig. II-3-13)

Reason for selection: This region is situated along the southern fringe of the caldera terrain extending on the south side of Mt. Bulusan, an active volcano. In view of distribution of Pliocene to Pleistocene volcanic rock around the caldera and reports of alteration zones, there are expectations concerning endowment with epithermal gold deposits accompanying young geothermal activity.

Geological survey and geophysical prospecting have been carried out in this region by the PNOC in conjunction with geothermal surveys (Defin et al., 1988: SR-04; Villasenor, 1988: SR-05; PNOC-EDC internal documents). The Monte Calvario area and the Gabao area were selected as places indicated on the maps included in those documents as alteration zones around the caldera. Also selected, although not indicated as alteration zones in those documents, were the Sisigon area and the Irosin South area.

Since they are mentioned elsewhere as having silicified rock an altered rock in the form of floats. Detailed geological surveying and geochemical exploration have been carried out in the Monte Calvario area by BMG (Carranza, 1992: SR-01; Rint, 1991: SR-02, 1993: SR-03). It is known that in that area there is distribution of silicified rock and, around it, kaoline and smectite alteration zones, but we were not able obtain geochemical exploration data. In such reports there is mention of silica sinter in the silicification zones, which is indicative of alteration of the surface shallow part of epithermal gold deposits.

(1) Monte Calvario Area

Location: It is situated about 10 km west of Irosin.

Accessibility: It takes about 1 hour by car to the site from Irosin via Bulan.

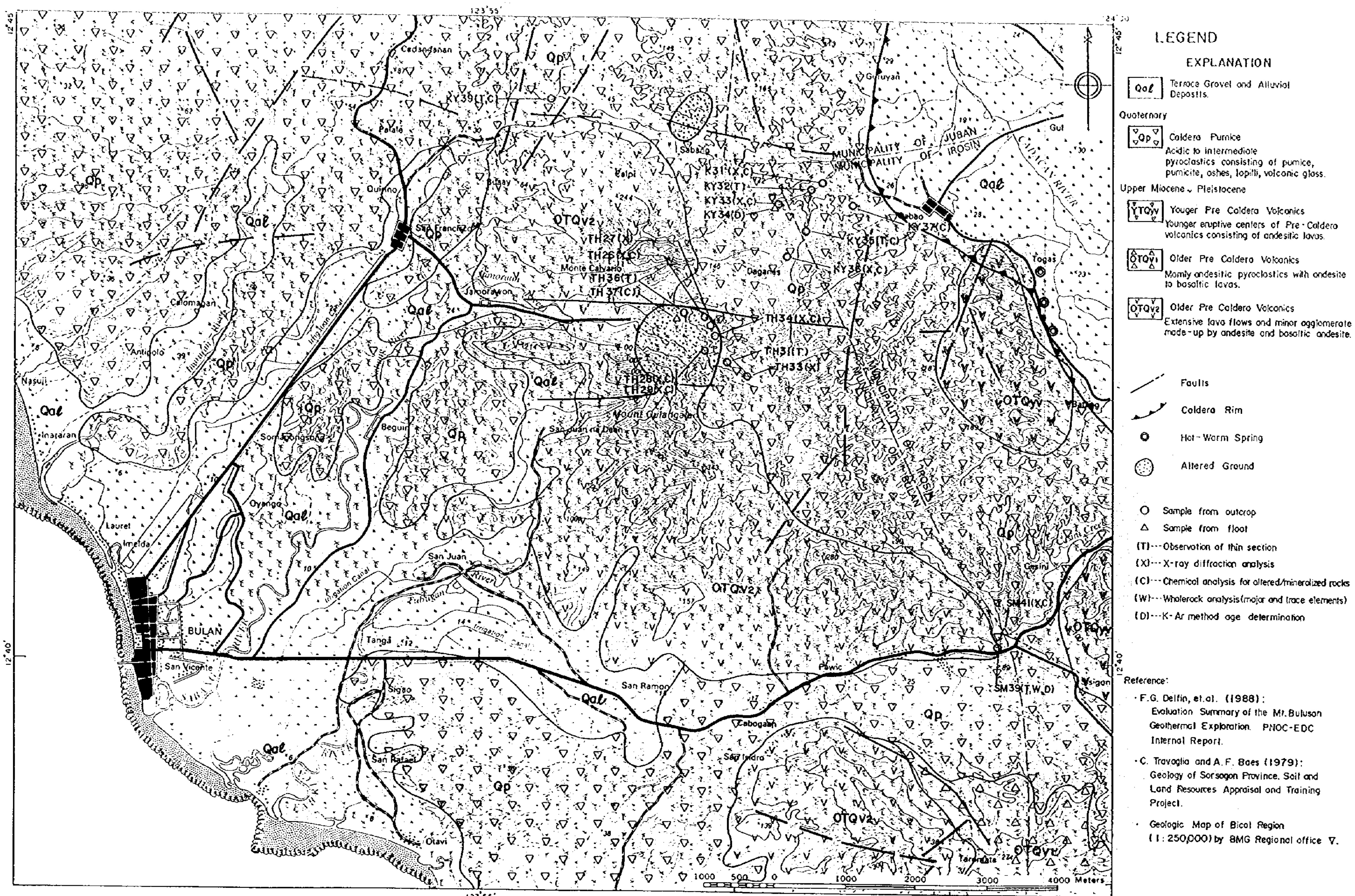


Fig.II-3-13 Geological map of the Irosin- Gabao-Bulan Area and sample locations

Geology: According to the PNOC (Delfin et al., 1988: SR-04), this area is underlain by pyroxene andesite belonging to pre-caldera volcanics. Although the source rock of the places of silicification alteration is not known, in the ground truth survey it was found that there is distribution of pyroxene andesite lava and homogeneous pyroclastic rock in the surrounding slight alteration zone. They are covered by pyroclastic flow deposit rich in pumice thought to have been erupted from the caldera.

Alteration: The alteration zone is distributed over the range indicated in Fig. II-3-13, centering on the 149 m peak. The silicified rock of the 149 m peak is yellowish brown to reddish brown in color and has undergone slight to intense silicification. Some of the silicified rock is brecciated, and the matrix is filled with goethite. There is dissemination of pyrite, and natural sulfur is also to be observed. According to X-ray diffraction analysis the intensely silicified rock consists mainly of quartz and contains small quantities of hematite and rutile. The slightly silicified rock consists of quartz, kaolinite, alunite, anatase and goethite. There is development of smectite alteration zone crops out in the topographically lower places around the 149 m peak. There is also kaolinitization, some of which is thought to be due to acidic alteration of supergene produced by oxidation decomposition of pyrite. The silica minerals coexisting with all of them are cristobalite and tridymite. The range of distribution of the silicified rock and altered rock floats is limited to the above-mentioned topographical depression. On the southeast side the alteration is slighter, plagioclase remaining, and there is change to a propyritic alteration zone consisting of diorite/smectite mixed-layer clay, calcite and pyrite.

Mineral showings: All of the silicified rock and altered rock samples showed gold values of less than 5 ppb, no gold mineralization being noted. Only one sample (TH34) had a copper anomaly: 123 ppm Cu. Its value for phosphorus was also high (P: 1730 ppm).

Evaluation: It is considered to be a matter of an alteration zones formed by hydrothermal activity accompanying volcanic activity before formation of the caldera. Considering the assemblage of low-temperature alteration minerals, the alteration zones are thought to be steam-heated alteration zones formed in the vicinity of the paleo-water table. Therefore, although there is no concentration of metal elements in such alteration zones, there is possibility of epithermal gold deposit (low-sulfidation type) endowment deep in the ground in their vicinity.

Mining claim: MPSA.

(2) Sisigon Area

Location: The area is situated in the vicinity of 12°14' to 12°42', 123°59' to 124°01' 3-5 km southwest of Irosin in Sorsogon Province.

Accessibility: It can be reached in about 15 minutes by vehicle from Irosin.

Geology: The geology of the area is comprised by the Sisigon volcanics consisting mainly of plenocryst-rich two pyroxene andesite lava, which belong to the younger volcanics among the pre-caldera volcanics, and the caldera pumice covering them and consisting of dacitic to andesitic pumiceous pyroclastic flow sediment.

Alteration: Along the creek running east-southeast from Casini Creek near the village of Salvacion small quantities of floats of altered rock with strong dissemination of pyrite and with medium to intense silicification and white argillization were noted. In the X-ray diffraction analysis quartz, alunite (minamiite) and pyrite were detected as an indication of medium- to slightly high-temperature acidic alteration in the float sample of the silicified altered rock from along the creek going east-southeast near the village of Salvacion (SM38), in the float sample of the silicified altered rock from along the creek going northwest from the turn off to Matnog of the road from Irosin to Bulan (SM41) and in the float sample of the silicified altered rock from along the creek going south-southeast from the village of Bacolod south of Irosin.

Mineral showings: The results of chemical analysis of the altered rock did not show any high-concentration anomalies of either useful metal elements or useful metal indicator elements.

Evaluation: Steam-heated alteration was noted on the northern slope of Mt. Sisigon (peak: 419 m), which is indicative of hydrothermal activity deep in the ground in this area, but the scale thereof is considered to be small.

Mining claim: MPSA status and an exploration permit has been applied for.

(3) Gabao Area

Location and Accessibility: This survey area is situated west of Irosin as a hilly area encompassing lower lying land including the developed part of Irosin. There is mention of alteration zones in PNOC documents. It is easy to reach Gabao at the foot of the hills by vehicle.

Geology: It consists of two pyroxene andesite or basaltic lava and accompanying volcanic breccia. Furthermore, there is distribution of pumiceous tuff thought to be interbeded in them although the direct relationship is not clear. There is also distribution, apparently above them, of hornblende-containing biotite pumiceous tuff to unwelded pyroclastic flow deposit, sometimes also including light green altered andesitic fragment. In some places its consolidation has not progressed, and it is in the form of "shirasu", forming steep precipices along the hill ridges. From those circumstances it is surmised that there is a gap in age between the pyroclastic flow sediment and the two pyroxene andesite or basaltic volcanic rock, the pyroclastic flow sediment being a comparatively new sediment.

Alteration: The apparently upper level andesite to basalt volcanic rock and the pumiceous tuff thought to be intercalated in it have partly undergone bluish gray argillic alteration. The altered mineral in the argillic alteration is mainly smectite, accompanied by fine pyrite dissemination and with some occurrence of kaoline as a result of supergene alteration. In X-ray diffraction analysis mixed-layer clay minerals were detected in all of the samples, and in many of the samples plagioclase remained. Whereas the entire pumiceous tuff breccia has undergone argillic alteration evenly, in the thin lava flows intensive argillic alteration has occurred only locally in parts with development of faults and other fissures. Furthermore, in the argillic altemation zones floats of silicified rock are often to be seen, and even at the ridge part of the hills silicified rock is sometimes found, although only rarely.

Mineral showings: Pyrite dissemination was noted, but no other metal minerals. Apart from the value for zinc of 124 ppm in a sample of rock that has undergone argillic alteration (KY33) no other analysis results worthy of mention were obtained.

Evaluation: The assemblage of alteration minerals suggests that the hydrothermal fluid that caused alteration in this area was low- to medium-temperature and neutral. From the existence of silicified rock it is surmised that there was also locally an environment for development of steam-heated acidic alteration zones. Furthermore, although no information directly suggesting the age of the alteration was obtained, it is surmised from the relationship between the area's geology and alteration that the alteration occurred before formation of the apparently upper level acidic pyroclastic flow sediment. Silicified rock floats are sometimes to be found above the acidic pyroclastic flow sediment of the ridge part of the hills, but they are considered to come from silicified rock bodies with resistance to erosion that are thought to have maintained a comparatively protruding topography (e.g. Monte Calvario).

In this survey area the distribution of alteration zones is limited to within the unit and rocks with high permeability and the vicinity of development of fissure systems, and considering the mode of occurrence, no clear characteristics have been noted that are indicative that the area might be one of predominant gushing of hydrothermal fluid. Furthermore, the fact that plagioclase remains in the altered rock of the argillization zones suggests that there was generally little reaction between the hydrothermal fluid and the rock. From those considerations, it is thought that the alteration in this area was caused by hydrothermal fluid restricted by high permeability contrastbased on joint systems that frequently develop in massive lava.

Mining claim: MPSA status has been established, but no conspicuous prospecting activity is to be noted.

(4) Irosin South Area

Location and Accessibility: This area is a hilly area near and southeast of the lowland zone that includes Irosin. It is thought to constitute a part of the caldera wall.

Geology: Although one can only judge from floats in view of the poor situation regarding outcrops, it would seem that the hilly part with steep precipices consists of melanocratic basaltic andesite and homogeneous lapilli tuft to tuft breccia. There are also parts, however, with mode of occurrence suggesting dikes.

Alteration: On the east side of the survey route bluish gray argillic alteration was noted, both the degree of alteration and the extent of distribution thereof increasing going eastward, but no alteration was noted on the west side.

Fine grains of pyrite are to be noted throughout the argillic alteration, the alteration mineral being smectite. Besides that, kaolin due to dissolution of pyrite is sometimes to be noted. The X-ray diffraction results also showed general occurrence of potassium feldspar.

The alteration is more conspicuous in the tuff breccia than in the lava. In the lava the alteration is trace to slight, with only partial argillization of the plagioclase and mafic minerals.

Mineral showings: The only thing noted in the way of metallic minerals was pyrite dissemination.

Analysis of the argillized rock showed values for gold of less than 5 ppb, but the arsenic content was a rather high 30-50 ppm (maximum of 52 ppm). Furthermore, for all of the samples analyzed the potassium values were higher than 1000 ppm (maximum of 2120 ppm).

Evaluation: The assemblage of alteration minerals suggests low-temperature neutral hydrothermal fluid, but potassium feldspar is detected in spite of the fact that the rock wall is basic andesite. Although plagioclase remains at places, from the fact that the sodium values are low (Na <0.01%) it is highly probable that the potassium feldspar precipitated as a result of hydrothermal activity. Furthermore, it is surmised that the alteration had a high water-to-rock ratio. The possibility remains that this area is near upwelling zone of hot hydrothermal fluid. It would appear that the interaction between the hydrothermal fluid and the wall rock is greater on the east side, and it is considered appropriate to surmise that the zone of gushing of the hydrothermal fluid is on that side. According to local residents, many silicified rock floats are to be seen in the eastern part of the survey zone, but the limited time make it impossible to investigate that. It should be investigated in the future, however, when possible.

Mining claim: Although exploration drilling permit have been established, no notable prospecting activity is taking place.

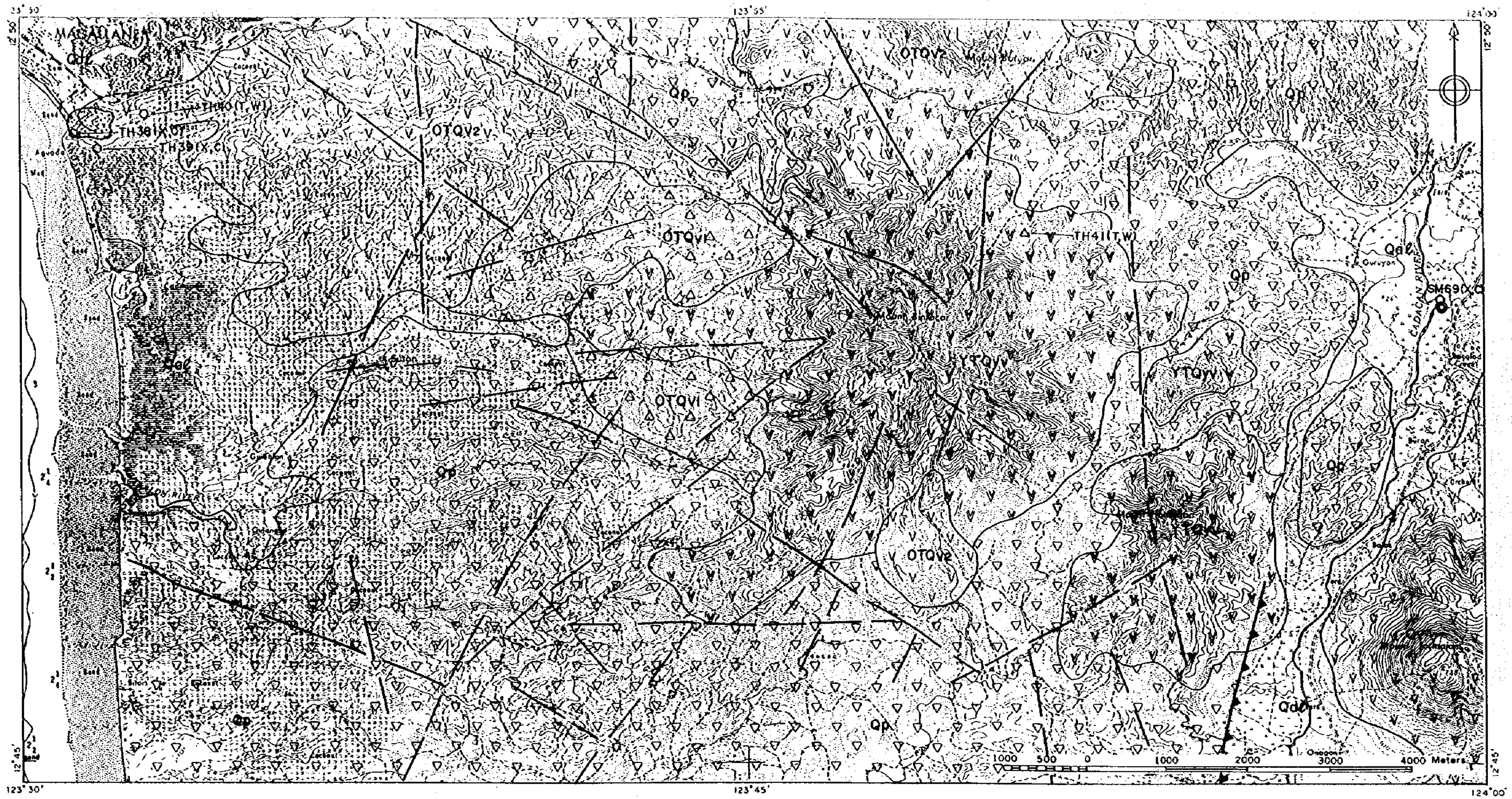
3.2.6 Magallanes-Mt. Bintacan Region (Fig. II-3-14)

Reason for selection: A PNOC report (Delfin, F. G. et al., 1988) mentions an alteration zone at Magallanes. That alteration zone has a rather low position topographicallyand is surmised to be a zone of steam-heated alteration controlled by lateral flow. If that is so, the position of the upflow is expected to be in the vicinity of Mt. Bintacan. Since the PNOC report also mentions distribution of biotite-hornblende dacite with pyrite dissemination and hematite stringers on the northern slope of Mt. Bintacan, a check was made concerning the possibility of an alteration zone there.

Location: Magallanes is situated about 25 km northwest of Irosin.

Accessibility: It takes an hour and 20 minutes by car from Irosin to Magallanes.

Geology: The floats of the volcanic breccia are polylithologic. Bright gray and reddish brown andesite floats are plentiful, and black basalt is also to be noted. The floats are subangular



LEGEND

EXPLANATION

Qal	Terrace Gravel and Alluvial Deposits.

Quaternary

Qv	Post Caldera Volcanics Andesitic lavas and pyroclatics
Qp	Caldera Pumice Acidic to Intermediate pyroclastics consisting of pumice, pumicite, ashes, lapilli, volcanic glass.

Upper Miocene ~ Pleistocene

YTQyv	Younger Pre Caldera Volcanics Younger eruptive centers of Pre Caldera volcanics consisting of andesitic lavas.
OTQV1	Older Pre Caldera Volcanics Mainly andesitic pyroclastics with andesite to basaltic lavas.
OTQV2	Older Pre Caldera Volcanics Extensive lava flows and minor agglomerate made-up by andesite and basaltic andesite.

Faults

Caldera Rim

Hot-Warm Spring

Altered Ground

O Sample from outcrop

Δ Sample from float

(T)---Observation of thin section

(X)--- X-ray diffraction analysis

(C)---Chemical analysis for altered/mineralized rocks

(W)---Wholerock analysis (major and trace elements)

Reference:

- F.G. Delfin, et al. (1988): Evaluation Summary of the Mt. Bulusan Geothermal Exploration. PNOC-EDC Internal Report.
- C. Travaglio and A.F. Baes (1979): Geology of Sorsogon Province. Soil and Land Resources Appraisal and Training Project.
- Geologic Map of Bicol Region (1:250,000) by BMG Regional office V.

Fig.II-3-14 Geological map of the Magallanes-Mt. Bintacan Area, the Bacolod Area and sample locations to subround and have a diameter of 0.2 mm to 60 cm. Sorting is poor. Apparently the volcanic breccia is mounted by black pyroxene andesite lava.

Alteration: Along the road near the coast the alteration zone is to be observed at outcrops. The wall rock is andesitic volcanic breccia. The color is yellowish brown to white. The matrix part has undergone argillic alteration, i.e. smectite and kaolinite (halloysite?) alteration. That kind of alteration is to be observed over only a narrow range with a diameter of 200-300 m. Furthermore, the alteration is extremly slight and could even be alteration by weathering. In X-ray diffraction analysis alunite was detected in some samples, though only in trace quantities, in the assemblage of cristobalite, tridymite, halloysite and goethite. That leads one to believe that the alteration in this area is due not just to weathering, i.e. that steam-heated alteration also occurred.

Mineral showings: There were no mineral showings worth mentioning, analysis of the slightly argillized rock showing gold values of less than 5 ppb in all samples.

Evaluation: Considering how slight the alteration is and how narrow its range of distribution, there is little possibility of epithermal gold deposit endowment in this area.

Mining claim: Not established. An exploration permit has, however, been applied for for the surrounding area including Mt. Bintacan.

3.2.7 Bacolod Area (Fig. II-3-14)

Reason for selection: According to the PNOC survey, this area is a center of resistivity anomalies, and the low resistivity anomalies are continuous from the surface layer to deep down. Furthermore, analysis of hot spring water in the area shows comparatively high values for concentration of chlorine, which is indicative of the possibility of rise of deep hydrothermal fluid. That is grounds for expectations of formation of veins accompanied by mineralization.

Location: Banyo and Bacolod springs in Sorsogon Province 7 km northwest of Mt. Bulusan in the vicinity of 12°48' to 12°49' N, 124°00' to 124°01' E.

Accessibility: The site can be reached by walking 10 minutes after a 30-minute drive on the national highway heading from Irosin in the direction of Sorsogon.

Geology: The geology of the area is comprised of caldera pumice consisting of dacitic to andesitic pumiceous tuff breccia and post-caldera volcanics consisting of hornblende, two pyroxene andesite and olivine- and two-pyroxene-bearing andesite, etc.

Alteration: The water temperature of Banyo Spring is 30-50°C, and that of Bacolod Spring is 39°C. limonite scale is to be noted in the vicinity of the gushing outlets.

In the X-ray diffraction analysis sericite/smectite mixed-layer minerals and calcite were detected in the surrounding altered rock containing such scale (SM67).

Mineral showings: In the chemical analysis of the altered rock high-concentration anomalies for useful metal elements were noted. In the way of elements indicative of useful metals, for arsenic there was a high-concentration anomaly of 1930 ppm, and for potassium there was a high value of 1290 ppm.

Evaluation: Since the vicinity of Banyo and Bacolod is the center of a low resistivity anomaly area, the existence of an underground alteration zone can be surmised. Furthermore, in view of the high chlorine concentration of the Banyo and Bacolod hot springs and the arsenic high-concentration anomalies noted in the scale, there is reason to believe that the deep hydrothermal fluid rises.

Mining claim: An exploration permit has been applied for.

3.2.8 San Roque-Mt. Malobago Area (Fig. II-3-15)

Reason for selection: In the PNOC's survey the vicinity of San Roque was found to be located in a low resistivity anomaly are running north-northwest, and there is also a small-scale low resistivity area on the northwest side of Mt. Malobago. Furthermore, there is also distribution of alteration zones in the area.

Location: The area is situated in the vicinity of 12° 43' N, 124° 05' to 124° 07' E about 7 km north-northeast of Irosin in Sorsogon Province.

Accessibility: San Roque can be reached in 15 minutes by road from Irosin. From it takes 15 minutes by car on an unpaved road to reach a small village on the upper reaches of the Patubayan River, and Mt. Malobago can be reach from there walking along that river in the downstream direction for about 1 hour and 30 minutes.

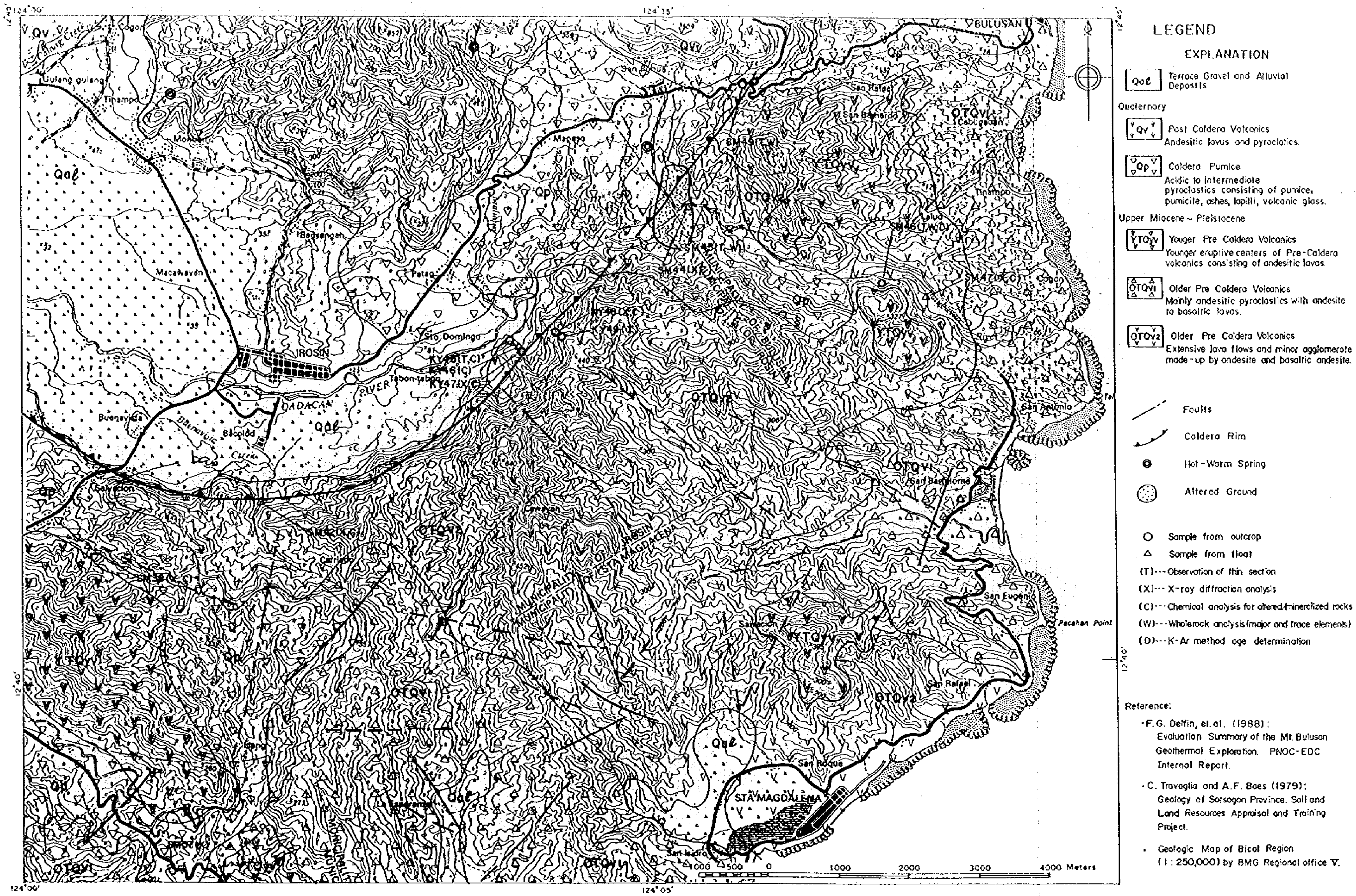


Fig.II-3-15 Geological map of the San Roque-Mt. Malobago Area and sample locations

Geology: The geology of the area is comprised of two pyroxene andesite which presents the Older Volcanics of the Pre-Caldera Volcanics, hornblende-biotite dacite, which forms the dome of Volcanics Mt. Malogago and represents the Younger Volcanics of the Pre-Caldera Volcanics, and the Caldera Pumice, consisting of dacitic to andesitic pumiceous tuff fragment.

Alteration: The Nag-aso alteration zone noted near San Roque (according to the PNOC report) has a scope of about 30 m x 40 m. The andesite wall rock has undergone white alteration and medium to intense silicification alteration, and is in parts bluish gray in color as a result of pyrite dissemination.

Furthermore, along the Patubayan River on the northwest side of Mt. Malobago are to be found large floats measuring about 3 m x 3 m from intensely silicified rock reddish brown in color that has pyrite dissemination and has partly changed to limonite, from which it is surmised that there is an alteration zone in the vicinity.

In X-ray diffraction analysis cristobalite, tridymite and alunite were detected from an altered rock float (SM44) in the above-mentioned Nag-aso alteration zone, which is indicative of low-temperature acidic alteration. Furthermore, quartz, cristobalite, alunite and hematite were detected in a float (SM47) from the intensely silicified rock along the Patubayan River, which also is indicative of medium- to low-temperature acidic alteration.

Mineral showings: The results of chemical analysis of the altered rock did not show any high-concentration anomalies of useful metal elements or associated elements.

Evaluation: Since the vicinity of San Roque and the northwest side of Mt. Malobago are low resistivity areas where steam-heated alteration has been noted, one can surmise the existence of hydrothermal activity deep underground. However, in view of the limited distribution of the alteration zones, the scale thereof is considered to be small.

3.2.9 Gate Mountains Region (Fig. II-3-16, Fig. II-3-17)

Reason for selection: This region, situated in the southern part of the Sorsogon Peninsula, includes a fairly broad area. Since there is distribution there of Pre-Caldera Volcanics (Delfin, F. G. et al., 1988), there is expectation of Pliocene hydrothermal activity. In Delfin, F. G. et al. (1988) there is mention of an alteration zone on the southwest slope of Mt. Sujac, and a low

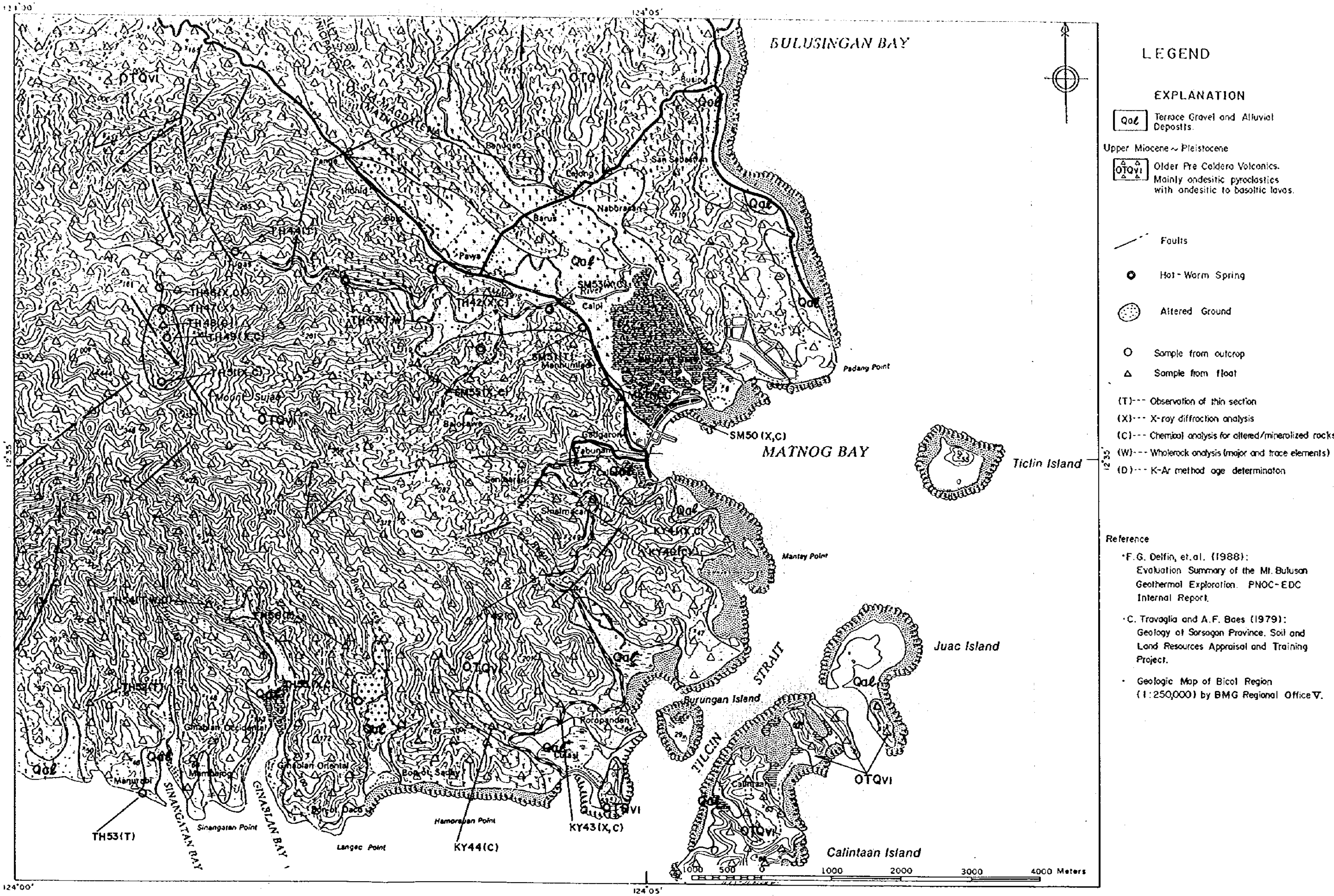
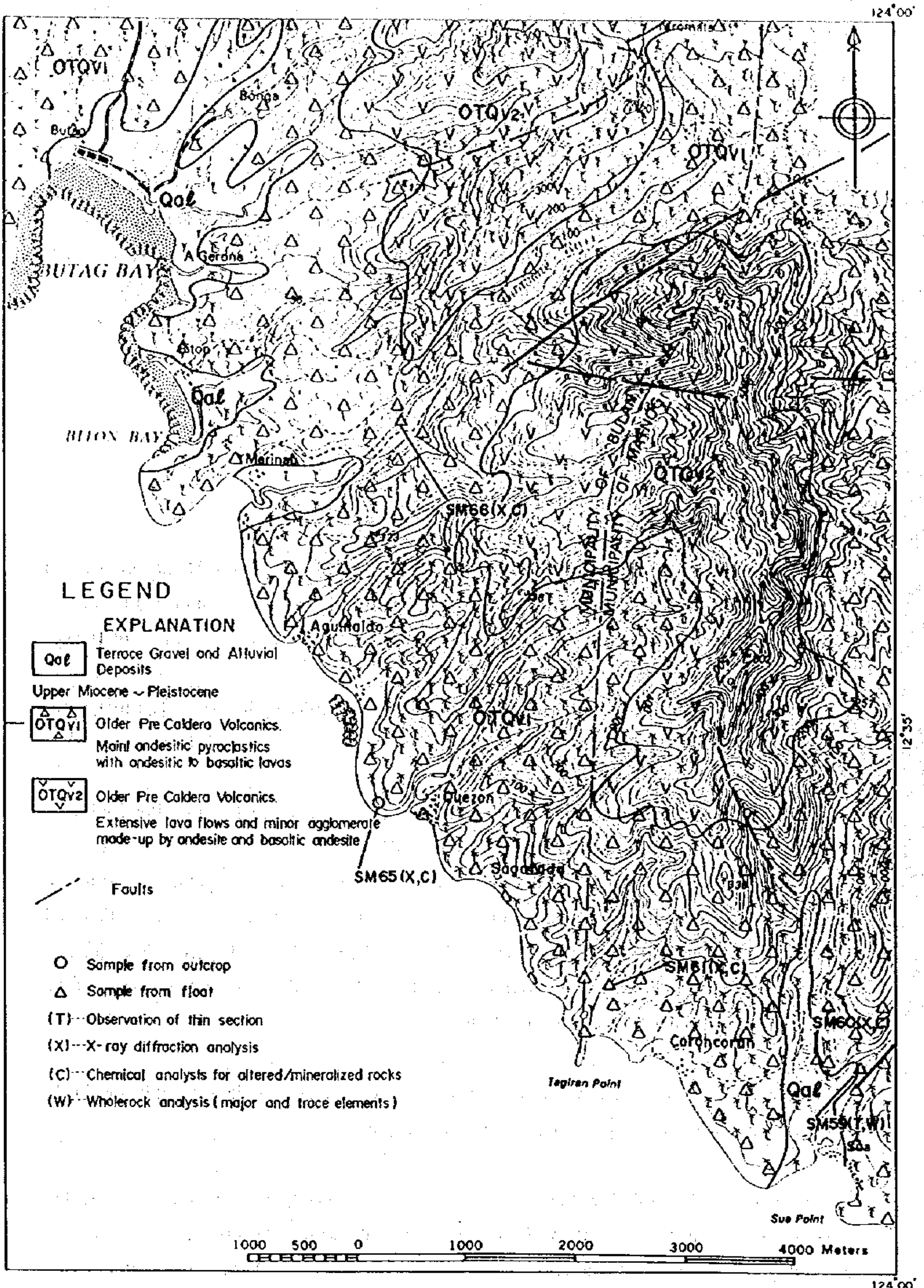


Fig.II-3-16 Geological map of the Gate Mountains Area(1) and sample locations



Refence

- F. G. Delfin et.al. (1988): Evaluation Summary of the Mt. Bulusan Geothermal Exploration. PNOC-EDC Internal Report.
- C. Travaglia and A.F. Baes (1979): Geology of Sorsogon Province. Soil and Land Resources Appraisal and Training Project.
- Geologic Map of Bicol Region (1:250,000) by BMG Regional Office V.

Fig.II-3-17 Geological map of the Gate Mountains Area(2) and sample locations