2.4 Physiography

The 20 kilometers volcanic chain extending from Pola to Nauhan along the southeast-northwest axis is bounded by a wide alluvial plain which covers the northeastern sector of Mindoro Island.

The volcanic chain is characterized by moderate to rugged topography with maximum elevation reaching as high as 500 meters a.s.l. and slopes in the range of 30-40%. In a few places, the remains of dissected plateau are still recognized, probably these are remnants of fissure lava flows. Parasitic volcanic cones and dike-like bodies stand out conspicuously around the base of the Nauhan volcano either as isolated peak or in clusters.

The area is drained by radial-type tributaries which discharge their water eastward into the sea and westward into Lake Nauhan. The main discharge channel of Lake Nauhan is the Butas river that meanders on the alluvial plain. The topography is typically old as exhibited by Mount Pola and gets to youthful topography towards Mount Nauhan where the erosion largely predominates over deposition. Mangrove swamp dominates the northern sector of Lake Nauhan which is confined along the flood plain of Butas river.

The area is covered by second growth forest dominating the upper slopes of Mount Pola and Mount Nauhan. Agricultural crops, short bushes and coconut trees are grown on the lower slope and over the flood plain.

Rainy season is prevalent from June to October reaching its peak in August.

2.5 Power Market

The northern half of Mindoro Island is being serviced by the Oriental Mindoro Electric Co. (ORMECO). Present installed capacity of ORMECO's power plant in Calapan is 5.5 MW. Another 3.5 MW generating unit will be commissioned soon by the end of 1979 giving a total installed capacity of 9 MW. Average demand is approximately 1 MW with daily peak demand of 1.5 MW. This represents the needs of five towns presently being serviced by ORMECO, namely: Calapan, Nauhan, Victoria, Baco and San Teodoro. ORMECO is also operating an 80-KW generator to service the poblacion of Puerto Galera pending the completion of the distribution system to this town.

By late 1979, ORMECO will expand its operations to the southern towns of Pinamalayan, Bongabon, Pola, Roxas and Bulalacao. A sub-station will be set up in Pinamalayan to service these additional towns via a transmission line from the Calapan station.

ORMECO is confident that they can readily supply the power needs of the whole island. A subsidiary company, OMECO, services the town of San Jose, Occidental Mindoro and its surrounding communities.

Major consumers of ORMECO are rice mills. There are no other big consumers in the island aside from a small barite mine operating in Roxas. Other prospective industries for the power market will be fishing and mining operations. Due to the high cost of electricity charged by ORMECO, other residents are reluctant to use electricity for their daily needs. ORMECO charges ₱0.96/KW/hr. for small consumers, i.e., < 200 KW hrs. Opinion is that consumption may increase if electricity can be operated by cheap fuel such as geothermal energy.

If Montelago geothermal area has enough potential, the excess power can be delivered to the Luzon grid through a submarine cable. This would take about 25 kilometers long cable connecting Puerto Galera to Batangas peninsula through Verde Island. This submarine connection is being considered in view of a plan to set a coal-fired power plant at the southeastern tip of Mindoro that would utilize the coal from Semirara Islands.

3 DESCRIPTION OF FINDINGS

3.1 Geology

3.1.1 Regional Geology

The Nauhan-Pola andesite volcanic chain lies along the eastern periphery of the downthrown block of a northwesterly trending regional structure of Mindoro Island. This Plio-Quaternary volcanic chain is the southeasterly extension of the westerly convex volcanic front of Luzon (Datuin & Uy). This volcanic front can be traced along the northwestern Luzon which served down south towards Zambales-Bataan and finally passes along the eastern Mindoro Island. Tectonic activity is still quite active along the convex side of the volcanic front particularly on its southeastern extension as indicated by the recorded seismicity of the region pinpointed by the Philippine Weather Bureau seismic station. A dense populated seismic epicenters commonly occured along the northeastern tip of Mindoro and gradually spread down south towards the eastern half of the island.

The northwesterly trending broad highlands on the western half of Mindoro constitute the uplifted block which is dominantly underlain by strongly folded Paleozoic-Mesozoic volcanic and sedimentary rocks. The rocks were likewise subjected to severe fracturing by several events of plutonic-tectonic activities in the Pre-Tertiary which was highlighted by the intrusions of Early Tertiary ultra-mafic complex and Miocene diorites.

The lowlands occupying the eastern half of Mindoro are underlain by Late Tertiary marine volcanoclastics dipping gently to the east which may constitute the basement of the northeasterly trending chain of andesite volcanoes in the island. The flatland area occupying the broad valley from Calapan down to Nauhan is covered by thick alluvial deposit mostly of marine-volcanoclastic derivatives.

3.1.2 Local Structural Setting

The NW trending volcanic centers east of Lake Nauhan where the Montelago geothermal area is located reflect the regional fissure activity of volcanism in the past which occurred during the Plio-Quaternary. Plate 1002 has shown two prominent volcanic edifices with known affinity of calc-alkali rock suite. The oldest is Mount Pola - a hornblende-pyroxene andesite volcano followed by Mount Nauhan which is a biotite-hornblende andesite. The extrusion of voluminous pyroclastics and lahars around the vicinity of Mount Nauhan suggests its explosive nature in the past. The presence of two prominent parasitic cones formed along the south-eastern and northwestern basal sections of Mount Nauhan reflects a NW trending major fracture. This NW structure passes through the central vent of the volcano which probably serves as the main feeder for the extrusion of lavas and pyroclasts in the area. The volcanic materials extruded by Mount Nauhan could have come immediately below the northern portion of Lake Nauhan. The withdrawal of materials caused continuous subsidence of the western quadrant of the volcano producing the present geomorphological feature of the vast swampland which dominates the northern tip of Lake Nauhan. Moreover, it is very unlikely to expect a complete absence of lahar on the western base of the volcano. It is possible that once there had been lahar deposit on the western side of the volcano but was later submerged under the lake due to the collapse of the western base.

There are two sets of fracture system recognized in the area; the easterly and NNE trending systems of fracture.

The two sets of fracture are pronounced in the southern section of Mount Nauhan, while the east trending fractures dominate the area of Mount Pola.

It is a conjecture that the east trending fissures are tension fractures generated by the lateral movement of the northwest trending volcanic rift zone in the area which controls the two major volcanic centers of Mount Pola and Mount Nauhan. The NNE fractures dominating the western and eastern quadrants of Mount Nauhan are younger sets of fracture believed to be of shallow types with vertical displacements and more or less related to the cooling cracks of the lava.

3.1.3 Local Geologic Setting

There are four major volcanic rock suites mapped in the area of Mount Pola and Mount Nauhan which are temporarily classified according to composition and locality. These are as follows:

YOUNGEST ↑	Plio-Quaternary	Lahar	- loosely compacted bouldery fragments of andesite
		Nauhan Andesite	- Biotite-hornblende andesite porphyry
		Montelago Andesite	- Hornblende-biotite andesite porphyry
OLDEST		Pola Andesite	- Hornblende-pyroxene andesite porphyry

Pola Andesite - The hornblende-pyroxene andesite underlies the whole Mount Pola volcanic edifice and is the oldest volcanic rock in the area. The volcanic rocks are dominantly lava flows intercalated by effusive volcanic equivalent of breccia and tuff. The lava is generally microporphyritic with grain sizes ranging $\leq$ 0.5-1.7 mm. The rock contains 30% plagioclase phenocrysts of andesine-labradorite, 7-15% pyroxene and 5-15% hornblende. The pyroclastics contain large crystals of plagioclases and pyroxene-hornblende embedded in a glassy matrix.

The contact of the Pola andesite extends from Buloc-Buloc Bay and swerves towards the northwestern sector of Lake Nauhan where the thermal manifestation is located.

The thermal activity in Montelago and Buloc-Buloc Bay apparently is controlled by a fault contact of the Pola volcanics and the Montelago volcanics which appear to be plunging moderately to the north underneath the Nauhan volcano. The Pola volcanics are slightly propylitic in some sections of the volcano where the fault contact passes through.

Montelago Andesite - is generally hornblende-biotite andesite porphyry which contains 1-2% pyroxene. It underlies the narrow isthmus which links Mount Pola to Mount Nauhan. The presence of an old eruption vent in the area of Montelago pointed to past volcanic activity that had taken place in the area causing the deposition of the hornblende-biotite andesite. It is perhaps genetically related to the later phase of magmatic differentiation of Pola volcanics which gave rise to the extrusion of andesite volcanics richer in hornblende and biotite but poorer in pyroxene content. The Montelago andesite is generally microporphyritic with grain sizes ranging $<$ 0.5-2.5 mm. in crystal length. The rock contains 30-40% andesine-labradorite, 5-15% reddish-brown biotite and 3 - 12% brownish green hornblende. The hornblende approaches the composition of lamprobolite which probably had been oxidised by hot gases at the end of the magmatic stage of Montelago volcanics.

The thickness of Montelago andesite lava and pyroclasts may range from a few hundred of meters and overlapped the Pola volcanics.

Nauhan Andesite - Continued extrusion of biotite-hornblende andesite had taken place along the northwest trending volcanic rift. Several hundred meters thick of voluminous andesite lava and pyroclasts covered an area of 12 square kilometers which pinched out to the southeast and overlapped the Montelago andesite across the northern section of the isthmus.

The Nauhan andesite contains 25-30% andesine, 5-10% biotite and 10-15% hornblende. There is a significant reversal in the ratio of hornblende to biotite in the two areas, i.e., Montelago andesite contains more biotite over hornblende while Nauhan andesite has more hornblende over biotite plus the reappearance of pyroxene. The difference in their mafic ratio suggests a rejuvenation of the andesitic magma as the volcanism proceeded northward in the direction of the Dome hill.

This renewed magmatic episode in the area which led to the extrusion of voluminous lava and pyroclasts could have contibuted to the development of secondary fractures in the underlying basement rocks.

Several eruptive cones formed around the base of the volcano have their craters that are still well defined.

Lahar - Lahars are restricted within the seaside portion of the area and occurred as patches along the eastern coastal area of Mount Nauhan and Montelago. They are almost flat lying beds composed mainly of volcanic blocks of andesite and pyroclastic debris. They are loosely consolidated to moderately compacted. The lahar is occasionally overlain by a few meters thick lithic and crystal tuff.

The absence of lahar deposit on the western section of the area facing Lake Nauhan can be due to subsidence that took place at the western base of Mount Nauhan because of excessive withdrawal of volcanic materials during the height of its volcanic activity in the past.

3.2 Hydrogeology

The intricate and extensive fracture system dissecting the Montelago geothermal area represents a good secondary permeability which provides ideal channelways for the upflow of hot fluids at depth as indicated by the pronounced wide alteration and thermal spring manifestation along the lakeshore of Montelago and Buloc-Buloc Bay. The NE and NW sets of fracture dominate the structural pattern in the area. Such system of fractures (NE and NW) is not quite distinct on the NE quadrant of Nauhan volcano which probably is masked by the younger volcanic cover and alluvial deposits in the area.

The northeasterly and northwesterly fractures dissecting Mount Nauhan have influenced the influx and outflow of meteoric water to and from the heated zone inducing a complete circulation of hydrothermal fluid in the reservoir. The delineated northwesterly volcanic rift zone being outlined by the linear occurrence of the eruption vents in the area could have generated an extensive northwest fractures which served as channelways for the percolating groundwater.

The recharge of groundwater in the reservoir is mainly contributed by the continuous effluent flow of lakewater along the Butas River encircling the western and northern section of Mount Nauhan. Moreover, the easterly dipping beds of marine clastics underlying the geothermal area has likewise contributed to the influx of groundwater into the reservoir.

The lateral outflow of the hot water from the reservoir could have been influenced by the easterly dipping beds and as such, has been detected on the shallow artesian wells dug in the municipality of Nauhan. The chemical composition of the warm water in these wells are comparatively the same with the hot springs of Montelago thermal area. The outflow of the hot water being manifested by the artesian wells in Nauhan and the hot springs of Montelago point out that the possible area of geothermal activity is located closer to Mount Nauhan.

The 100-200 meters thick impermeable cap rock of Nauhan andesites as inferred from the geo-resistivity profile undertaken in the area helps in minimizing the considerable heat loss in the geothermal system.

3.3 Hydrothermal Alteration

The distribution and occurrence of thermal manifestations at Montelago and Buloc-Buloc area (Plate 1002) reflect a pronounced northeast structural control which could have a close association with the lithologic contact of Mount Pola and the central volcano of Mount Montelago. The geologic contact appears to be plunging moderately to the northwest.

The alteration zone of Mount Montelago covers an area of 3 kilometers (NE-SW) by 2.5 kilometers (NW-SE). Extensive iron-oxide stainings are caused mainly by the oxidation of pyrite-magnetite and the mafic mineral constitutents of the andesite pyroclasts and lavas. The iron-oxide staining commonly masks the primary alteration minerals assemblage, i.e., quartz-epidote-calcite-and pervasive clay. Thin quartz stringers occasionally cut the andesite rocks and are confined along narrow structures. The quartz stringers are commonly peppered by magnetite and pyrite disseminated grains. Such occurrence of quartz stringers were noted in the Montelago area outcropping along the lakeshore of Nauhan.

The extreme brecciation of the andesite volcanic rocks which reflects a NE fault has influenced an extensive hydrothermal alteration in the area. This is primarily caused by the southeast outflow of the active hydrothermal fluid coming from the northwest quadrant of Mount Nauhan which is controlled by the Northwest dipping structure. The slightly porphyritic alteration exhibited by Mount Pola - a broad volcanic edifice located southeast of Mount Montelago, could be related to the past geothermal activity of the Northwest trending upheaval of Mount Nauhan and Mount Montelago during the Late Pleistocene period.

3.4 Geochemistry

3.4.1 Work Performed

A geochemical survey was conducted over the Nauhan geothermal area, covering the volcanic chain of Pola volcano in the southeast up to Nauhan alluvial plain in the northwest. Fifty-five water samples were collected; 11 from the thermal springs; 4 from cold springs; 31 from surface water (streams, lake and sea) and 9 from shallow artesian wells. The samples were analyzed by the BED geochemists at the PNOC-EDC geochemical laboratory for Na, K, Ca, Mg, Li, As, B, Cl, SO_4, HCO_3, CO_3, and SiO_2. Moreover, ammonia determination was carried out in some selected places such as the Montelago thermal area and the water wells at Nauhan.

Results of the chemical analyses are shown in Table I and their locations are plotted in Plate 1005.

3.4.2 Characteristics of the Water

The square chemical diagram of Figure-1 clearly displays the existence of different families of water in Nauhan geothermal area.

The thermal springs emerging along the northeast shoreline of Lake Nauhan are sodium-chloride type waters characterized by neutral pH, admixture of minor carbonates and sulfates, moderate to high contents of boron (up to 92 ppm), lithium (up to 6 ppm) and arsenic (up to 4 ppm) and contain total dissolved solids in the range of 6,500-7,500 ppm. The warm springs in Buloc-Buloc emerging along the seashore exhibit moderate to high surface water dilution as shown by samples 4 and 5.

The lakewater is aligned along a straight dilution line. Lake water sample -36 and -37 taken close to the warm springs in Montelago have intermediate composition between the thermal springs and the lakewater. Samples 10 to 14 represent the lake composition during the dry season, while sample -40 was taken in the peak of rainy season which is relatively richer in magnesium and carbonates.

The river and cold spring waters contain Ca-Mg carbonate, although Na and Cl admixtures are common. It is noticeable on sample -2, -3, -6, -30 and -31 collected from the creeks that flow into the Lake Nauhan have equal or higher sulfate to carbonate ratio. This is probably due to the leaching of metallic sulfides contained in the moderately to weakly mineralized volcanics that abound in the alteration zone of the thermal area. Sample -19 and -25, taken at the outlets of two small creeks are obviously contaminated by sea water encroachment.

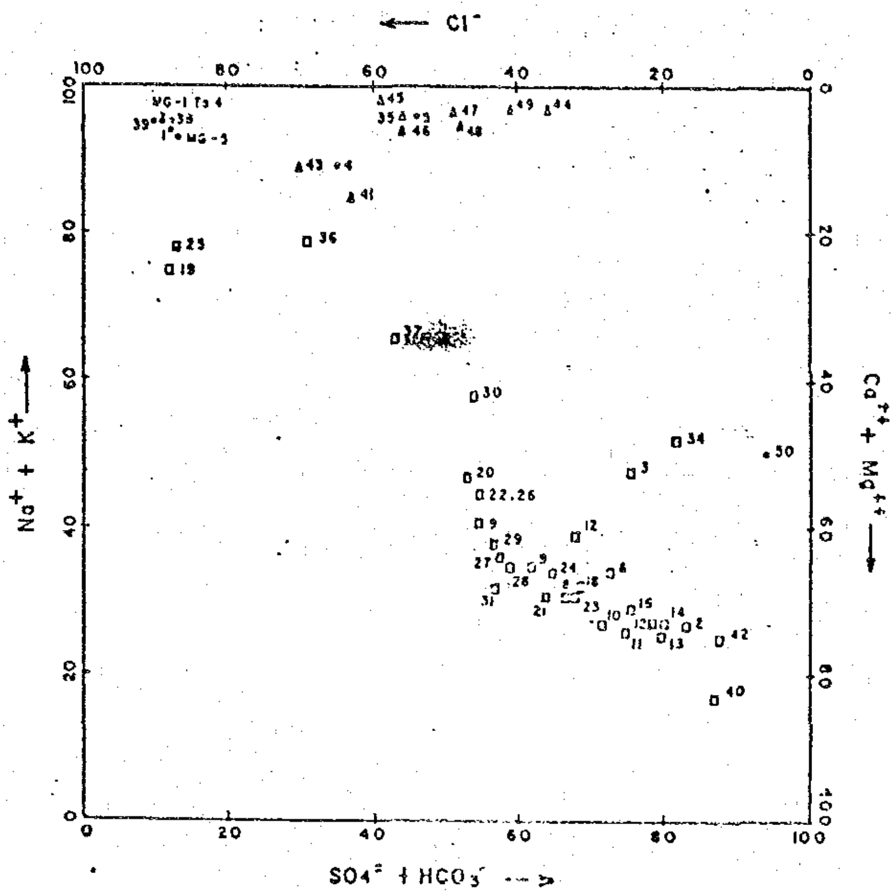
The water flowing from the shallow artesian wells drilled in Nauhan flood plain give peculiar chemical characteristics. It is sodium-chloride-carbonate type water with slightly basic pH and contains total dissolved solids of 700-1,000 ppm. Only sample -43 from a well located close to the base of Mount Nauhan has a salinity of 1,800 ppm with high boron content about 16 ppm. Inasmuch as the monovalent cations generally predominate over the bivalent ones, the Cl/HCO_3 ratio varies, from 4:1 to 1:2. This strong dispersion as reflected by the Cl/HCO_3 is difficult to explain by the simple process of surface water dilution.

3.4.3 Discussion of the Results

The significant chemical similarity between Montelago thermal springs as represented by sample -4 and -43 from the water well of San Matias Hatchery (Plate 1005 and Table I) suggests that the waters emerging into the thermal area and water wells are derived from the same source. The similarity is confirmed by the ionic ratios shown on Table II with particular to Cl/B and the Na/Cl + HCO_3 ratios. The source is supposedly water-dominated and has a sodium chloride composition, high boron content, neutral pH and salinity of about 1 gram per liter. The location and depth of the reservoir are still unknown. The fact that the lakeshore thermal springs and the artesian wells are 10 kilometers apart, it is a conjecture that the possible source area of upswelling of the hydrothermal fluid lies between the alluvial flat and Montelago thermal area. Therefore, the widespread occurrence of similar composition of waters can be brought about by lateral flow of the hot fluids which is primarily controlled either by deep fractures and/or by shallow aquifer. Silica precipitation is likely to have taken place in the course of upflowing to the surface. This is indicated by the low silica content of the springs which appear to be inconsistent in comparison with the other chemical characteristics of the water (Figure 2).

It was mentioned earlier that the water from the wells of Nauhan town proper has chemical composition that is difficult to explain by simple admixture of surface and sodium-chloride type waters. The fluctuating carbonate content in the water could be the effect of the admixture of sodium-chloride and sodium bicarbonate waters coupled by shallow groundwater dilution. The sodium bicarbonate water possibly has its source from the western mountain range of Central Mindoro where the metamorphic complex outcrops. In this connection, the Nauhan flood plain could be the collecting basin for the mixing of sodium bicarbonate water coming from the west and the northward lateral flow of sodium chloride water upflowing from the geothermal system.

In Table II the geothermometer determinations are shown. The temperature of the source of the hot fluid based on quartz conductive cooling are quite low and unreliable due to possible early precipitation of silica in the course of upflowing of the hot fluids to the surface. However, the metal ion ratios give more consistent results, particularly the Na-K-Ca. The indicated base temperature of the hot fluid is in the range of 180°C-220°C (Figure 3). This marginal temperature derived from the metal ion ratios could be the minimum base temperature of the source. By experience in the three geothermal fields in the country such as Tiwi in Albay, Tongonan in Leyte and Mak-Ban in Laguna, the reservoir temperature measured from the production wells turned out to be higher than what was expected from the metallic cation geothermometers of the thermal springs. It is therefore too immature at this stage to evaluate the Nauhan geothermal area as a commercial or a marginal geothermal field on the basis of base temperature of the reservoir fluid.



• - HOTSPRING

□ - SURFACE DRAINAGE AND COLD SPRING

Δ - WELL

FIG. I

SQUARE DIAGRAM OF MONTELAGO WATERS

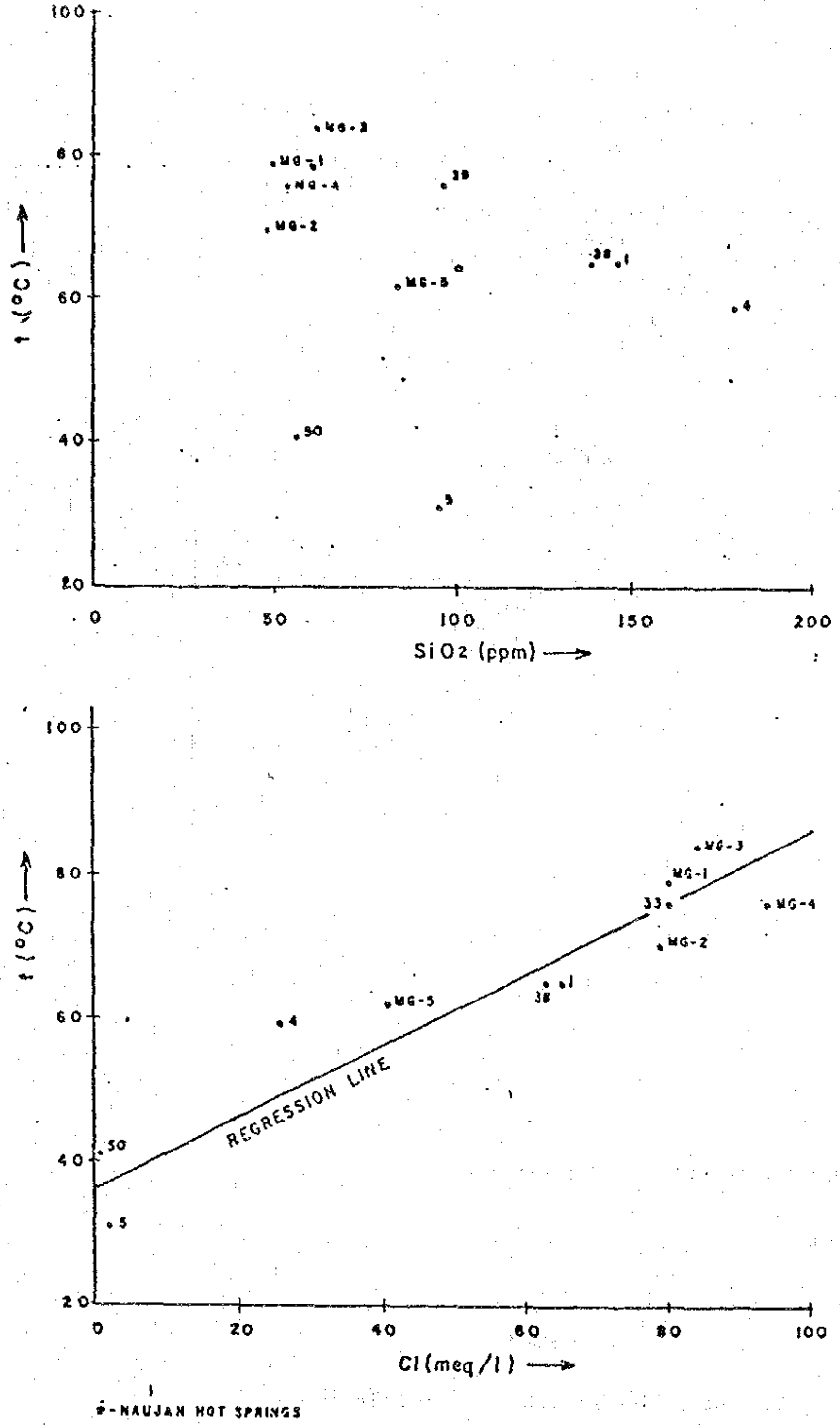


FIG. 2

t°/Cl AND t°/SiO2 RELATIONSHIP FOR THE MONTELAGO SPRINGS

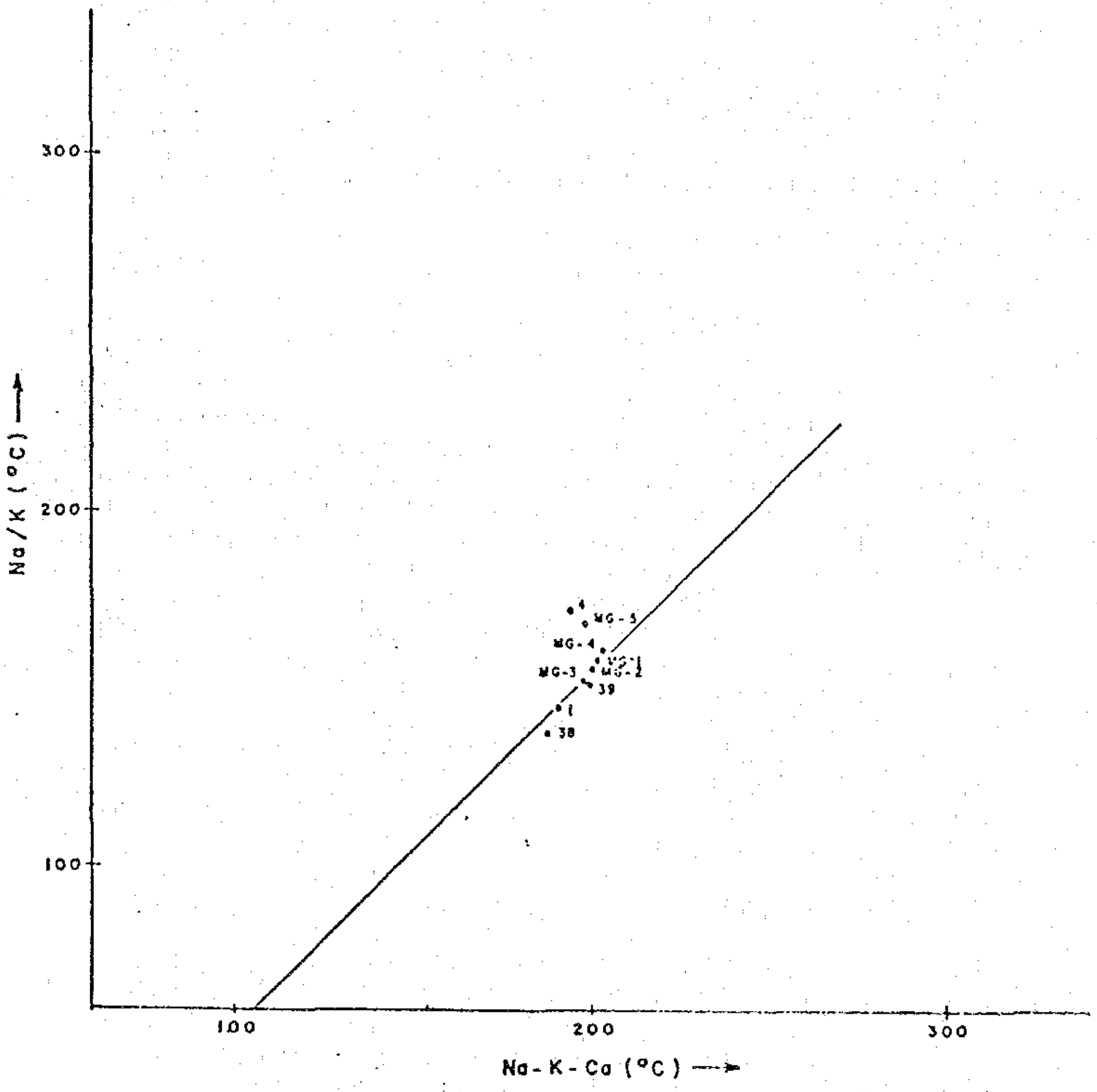


FIG. 3

RELATION BETWEEN Na/K AND Na-K-Ca GEOTHERMOMETERS

3.5 Geoelectrical Survey

A total of 31 vertical soundings spaced at one kilometer apart were carried out over three northwest parallel lines. The resistivity lines passed along Mount Pola and were extended further northwest toward the flood plain of Butas River (Plate 1003).

The Schlumberger array was used in all the soundings with maximum current electrode spacing (AB/2) ranging from 1,000 meters depending on the features of the apparent resistivity curve derived from each sounding. Due to inclement weather occuring in the area during the course of the survey relatively large current leakages were encountered causing some errors on the apparent resistivity curves, especially at depths of ≥ 500 meters. Leakage was primarily internal perhaps brought about by high humidity inasmuch as the voltage and current circuits were incorporated in one measuring instrument. Corrections for leakages were applied to the curve but the methods appeared not to be very applicable to minimize the errors caused by current leakage. Dubious resistivity curves are along stations L1-48NW, L1-35NW, L2-46NW and L2-31NW. However, except for the aforesaid stations, the quality of the georesistivity soundings undertaken in the area was done within a reasonable accuracy for a preliminary geophysical evaluation on the sub-surface condition of the area.

3.5.1 Preliminary Interpretation

Plate 1004 shows the resistivity profile of the area. The interpretation is still preliminary.

Three resistivity units are easily distinguished:

1. The high resistivity (> 50 ohm-m.) layer which assumes 50 to 100 meters thick from the surface possibly is a reflection of the overlying young Nauhan volcanics and the old volcanics of Mount Pola. To the north of the resistivity line, the value reaches a maximum of 150-500 ohm-m. across the Dome hill of Mount Nauhan which is considered the youngest volcanic cone in the area.

2. Moderate resistivity (20 ~ 50 ohm-m.) gets thicker to the northwest and varies in thickness

from 100 meters to 700 meters below the surface. This layer of moderate resistivity represents a wide layer of slightly to moderately altered volcanic flows. However, the background of the resistivity in the area can be considered in the range of 10-20 ohm-m. which appears as a reflection of moderate to intense hydrothermal alteration zone.

3. Low resistivity (< 50 ~ 10 ohm-m.), partially referable to the presence of intense hydrothermal alteration zone and/or hydrothermal fluids. This layer appears to be getting thicker with maximum plunge to the northwest at less than 45°. The low resistivity anomaly is being sandwiched by two moderate resistivity layers on its footwall and hanging wall approaching almost equal magnitude in the range of 15 ~ 25 ohm-m. The bottom of the low resistivity layer has not been reached with a penetration of > 1000 meters at the northwest vicinity of Mount Nauhan.

The low resistivity encountered northwest of Line-1 is probably influenced by thick clay layer of the alluvial flat coupled by large influx of shallow groundwater in the surroundings which could mask the nature of the layer below the alluvium. For both Lines 1 and 2, it is somewhat difficult to delineate the boundary of low values caused by alteration and those by superficial clay. It is interesting to note that the existence of widespread moderate to low resistivity anomaly in the area can be brought about by several factors. It is worth to mention that the low resistivity zone occurs at the northwest sector of Mount Nauhan and coincides with the localization of the younger Quaternary biotite-hornblende andesite (Nauhan rock suite). This postulates an idea of the probable existence of channelways and active hydrothermal system within the vicinity of Mount Nauhan. Plates 1005, 1006, 1007 and 1008, show the planar distribution of isoresistivity in the area at different depths, i.e., 200 meters, 500 meters, 750 meters and 1000 meters below the ground surface. The low resistivity anomaly (< 5 ~ 10 ohm-m.) located north of Dome hill assumes an almost vertical conduit which possibly reflects an intersection of a NW and NE fractures; one as a radial fracture originating from the main crater of Mount Nauhan and the second as a conjugate fracture of the regional northwest trending volcanic rift zone. Below the 500 meters penetration, a sea of moderately low anomaly of 10-25 ohm-m has isolated the resistivity "highs" into islands. Such occurrence of widespread moderately low anomaly in the area could be a reflection of an advancing hydrothermal alteration brought about by large upswelling and underground lateral flow of hydrothermal fluid in the area which are primarily controlled by system of fractures dissecting the Nauhan volcano.

No	TYPE	t°C	pH	COND	Na	K	Ca	Mg	Cl	SO_4	HCO_3	CO_3	Li	As	B	SiO_2
MG-1	Hot Spring	79	7.5		2000 86.990	164 4.194	85.5 4.266	12.5 1.027	2850 80.378	484 10.076	656 10.750	ND	5.55 0.799	3.00 0.120	74.5	51.0
MG-2	- do -	70	7.5		2060 89.600	160 4.092	85.5 4.266	13.1 1.077	2810 79.251	491 10.222	665 10.898	ND	5.82 0.838	3.25 0.130	75.8	49.0
MG-3	- do -	84	7.6		2180 94.819	164 4.194	88.6 4.421	14.1 1.159	2990 84.327	511 10.638	692 11.341	ND	6.01 0.865	3.75 0.150	79	62.9
MG-4	- do -	76	7.8		2400 104.388	195 4.987	103 5.139	12.2 0.995	3340 94.198	676 14.073	660 10.816	ND	6.31 0.909	4.50 0.180	92.3	55.2
MG-5	- do -	62	7.6		1100 47.844	96 2.455	56.2 2.804	12.8 1.052	1450 40.894	263 5.475	418 6.850	ND	3.16 0.455	1.25 0.050	29.0	85.4
1	- do -	65°	6.6	8638	1755 76.34	122 3.12	75.5 3.77	11.5 0.95	2291 64.61	328 6.82	676 11.09	ND	5.0 0.72	NA	55	147
2	River		7.6	264	10.4 0.45	4.00 0.10	18.0 0.90	7.37 0.61	17.0 0.48	66.0 1.37	55.0 0.90	ND	ND	NA	0.22	53.3
3	- do -		6.4	226	14.8 0.64	4.75 0.12	10.0 0.50	3.75 0.31	17.0 0.48	37.4 0.78	46.8 0.77	ND	ND	NA	0.43	51
4	Hot Spring	59	6.4	4529	771 33.54	69.4 1.78	54.5 2.72	17.7 1.46	925 26.09	115 2.39	712 11.68	ND	1.90 0.27	NA	26.2	179
5	- do -	31	5.1	553	45.6 1.98	4.96 0.13	23.0 1.45	8.39 0.69	63.8 1.80	1516 0.32	191 3.13	ND	ND	NA	0.22	96.5
6	River		7.2	272	15.4 0.71	4.27 0.11	22.6 1.13	5.82 0.48	21.3 0.60	57.7 1.20	27.5 0.45	ND	ND	ND	0.17	35.8
7	- do -		6.4	176	11.6 0.50	5.09 0.13	11.8 0.59	3.81 0.31	28.4 0.80	10.2 0.21	47.1 0.77	ND	ND	ND	0.23	35.5
8	Cold Spring		6.8	393	20.2 0.88	5.27 0.13	25.5 1.27	11.5 0.95	35.5 1.00	10.4 0.22	110.0 1.80	ND	ND	ND	0.17	93.0
9	- do -		6.5	376	22.7 0.99	5.36 0.14	23.8 1.19	10.7 0.88	42.5 1.20	9.63 0.20	110.0 1.80	ND	ND	ND	0.17	95.7

TABLE

CHEMICAL ANALYSES

3-17.a

No	TYPE	t°C	pH	COND	Na	K	Ca	Mg	Cl	SO_4	HCO_3	CO_3	Li	As	B	SiO_2
10	Lake		7.6	223	9.25 0.402	4.77 0.121	5.55 0.277	13.9 1.143	16.3 0.459	2.92 0.061	67.4 1.104	ND	ND	ND	0.22	23.4
11	- do -		8.2	221	8.90 0.387	4.34 0.111	5.20 0.259	13.8 1.135	15.6 0.439	3.33 0.069	77.8 1.275	ND	ND	ND	0.22	23.0
12	- do -		7.6	221	9.15 0.397	4.34 0.111	5.09 0.254	13.9 1.143	16.0 0.451	3.33 0.069	98.5 1.614	ND	ND	ND	0.22	22.5
13	- do -		7.6	221	9.05 0.393	4.34 0.111	5.32 0.265	14.2 1.167	15.6 0.439	6.67 0.138	98.5 1.614	ND	ND	ND	0.22	25.3
14	- do -		8.2	217	9.40 0.408	4.34 0.111	5.79 0.289	13.7 1.126	16.7 0.470	3.75 0.078	104 1.704	ND	ND	ND	0.22	26.7
15	Sea		8.2	35988	8190 356.225	330 8.439	838 41.816	1044 85.555	16310 459.992	2470 51.422	119 1.950	ND	ND	ND	3.46	5.22
16	Cold Spring		7.4	273	13.9 0.604	1.44 0.036	16.5 0.823	8.94 0.735	21.3 0.600	20.6 0.428	91.5 1.499	ND	ND	ND	0.22	74.3
17	River		7.2	156	8.94 0.388	1.92 0.049	9.06 0.452	3.05 0.251	17.7 0.499	15.2 0.316	45.8 0.751	ND	ND	ND	0.16	46.8
18	- do -		7.3	215	10.8 0.469	2.88 0.073	13.8 0.688	5.54 0.455	21.3 0.600	7.90 0.164	73.2 1.199	ND	ND	ND	0.22	72.5
19	- do -		7.2	5132	670 29.141	30.0 0.767	56.3 2.809	86.0 7.072	1362 38.412	182 3.789	73.2 1.199	ND	ND	ND	0.16	57.7
20	- do -		6.5	559	42.8 1.861	5.76 0.147	22.5 1.122	13.8 1.134	78.0 2.199	21.0 0.437	124.0 2.032	ND	ND	ND	0.22	104
21	- do -		6.5	147	6.71 0.219	4.08 0.104	8.50 0.424	3.39 0.278	21.3 0.600	15.2 0.316	45.8 0.751	ND	ND	ND	0.22	41.7
22	Cold Spring		6.7	501	37.0 1.609	6.72 0.171	23.0 1.147	12.2 1.003	70.9 1.999	21.0 0.437	124.0 2.032	ND	ND	ND	0.22	105.0
23	River		7.3	177	7.57 0.329	4.32 0.110	11.0 0.549	5.09 0.418	213 0.600	14.2 0.295	59.5 0.975	ND	ND	ND	0.43	61.5

TABLE I (Cont'd)
MONTELAGO

3-17.b

No.	TYPE	t °C	pH	COND	Na	K	Ca	Mg	Cl	SO_4	HCO_3	CO_3	Li	As	B	SiO_2
24	River		7.1	154	7.22 0.314	336 0.085	8.50 0.424	4.30 0.353	21.3 0.600	13.6 0.283	50.3 0.824	ND	ND	ND	0.27	51.4
25	- do -		7.2	7330	1020 44.365	64.8 1.657	67.5 3.368	116.0 9.539	1929 54.403	262 5.454	151.0 2.474	ND	ND	ND	0.76	45.1
26	- do -		6.0	145.0	7.22 0.314	1.68 0.042	5.50 0.274	2.04 0.167	21.3 0.600	10.0 0.208	32.0 0.524	ND	ND	ND	0.22	49.3
27	- do -		7.1	118	6.19 0.269	1.68 0.042	7.00 0.349	2.38 0.195	21.3 0.600	10.6 0.220	36.6 0.599	ND	ND	ND	0.27	53.2
28	- do -		7.3	128	6.19 0.269	2.40 0.061	7.75 0.386	2.60 0.213	21.3 0.600	8.40 0.175	41.8 0.685	ND	ND	ND	0.22	56.5
29	- do -		7.4	138	6.88 0.299	3.84 0.098	8.25 0.412	2.72 0.223	21.3 0.600	4.80 0.099	41.8 0.685	ND	ND	ND	0.27	57.7
30	- do -		3.6	270	9.82 0.427	3.74 0.096	3.86 0.193	2.26 0.186	26.2 0.739	42.0 0.874	ND	ND	ND	ND	0.34	34.2
31	- do -		7.2	206	10.8 0.469	3.98 0.102	17.4 0.868	3.96 0.326	14.2 0.400	18.5 0.385	9.15 0.150	ND	ND	ND	0.18	69.4
32	Sea	25	6.9	35772	11170 508.181	496 12.685	405 20.209	1285 105.674	18300 516.116	2575 53.609	148 2.425	ND	0.16 0.023	ND	42.7	1.62
33	- do -	44	7.3	34212	10580 481.339	421 10.767	445 22.205	1140 93.749	16670 470.145	2425 50.486	340 5.572	ND	0.36 0.052	0.36	5.9	18.5
34	River	22	7.0	125	6.95 0.316	3.94 0.101	3.84 0.192	2.29 0.188	9.22 0.260	11.0 0.229	57.4 0.941	ND	0.014 0.002	ND	0.11	31.8
35	Well	28	8.04	1097	182 8.280	22.7 0.580	2.88 0.144	3.00 0.247	210 5.923	10.8 0.225	268 4.392	ND	0.028 0.004	ND	0.12	51.2
36	Lake	25	7.0	1127	153 5.961	15.9 0.407	15.0 0.748	14.4 1.184	248 6.994	30.0 0.624	155 2.540	ND	0.43 0.062	0.50	5.08	22.4
37	- do -	26	7.10	674	70.6 3.211	7.23 0.185	11.2 0.559	14.4 1.184	126 3.553	15.0 0.312	143 2.343	ND	0.20 0.029	0.20	2.44	17.5

TABLE I (Cont'd)

..NTELAGO

3-17.c

No.	TYPE	t°C	pH	COND.	Na	K	Ca	Mg	Cl	SO_4	HCO_3	CO_3	Li	As	B	S.C.
38	Spring	65	6.7	8503	1910 83.075	123 3.146	80.1 3.997	11.5 0.946	2230 62.893	330 6.870	670 10.980	ND	4.57 0.658	5.00	47.8	140
39	- do -	76	7.2	10364	2350 106.913	175 4.476	95.4 4.760	15.2 1.250	2840 80.097	525 10.930	579 9.489	ND	5.38 0.775	6.00	63.1	98.3
40	Lake	26	7.7	229	6.09 0.277	1.10 0.028	6.39 0.319	14.4 1.184	11.3 0.319	2.00 0.042	120 1.966	ND	0.014 0.002		0.11	4.40
41	Well	33	7.8	1469	212 9.645	40.0 1.023	12.5 0.624	14.4 1.184	305 8.602	22.5 0.468	275 4.507	ND	0.043 0.006	0.04	0.42	6.81
42	River		7.5	298	12.3 0.535	1.49 0.038	24.0 1.197	6.65 0.547	13.1 0.369	36.8 0.766	124 2.032	ND	ND	0.06	0.10	46.3
43	Well	32	7.6	3199	515 22.400	41.1 1.051	23.9 1.192	19.3 1.587	674 19.009	109 2.269	363 5.948	ND	0.29 0.042	0.06	16.3	59.8
44	- do -	31.5	8.04	1172	207 9.003	24.4 0.624	1.60 0.080	2.19 0.180	152 4.287	16.6 0.345	442 7.243	ND	ND	0.04	0.81	37.6
45	- do -	32.5	7.9	1795	303 13.179	30.4 0.778	1.60 0.080	3.26 0.268	319 8.997	39.9 0.831	337 5.522	N D	ND	ND	0.51	51.5
46	- do -	33	7.8	1562	251 10.917	31.5 0.806	8.00 0.399	4.29 0.352	275 7.756	31.2 0.649	335 5.490	ND	ND	0.06	0.41	53.7
47	-do -	33	7.6	1140	190 8.264	24.4 0.624	2.56 0.128	2.85 0.234	191.0 5.386	16.7 0.348	318 5.211	ND	ND	ND	0.41	50.2
48	- do -	31	8.4	1204	207 9.003	23.6 0.604	4.16 0.207	3.60 0.296	197 5.556	16.5 0.343	352 5.768	ND	ND	0.02	0.41	41.8
49	- do -	33	7.8	992	150.0 6.524	15.3 0.391	2.88 0.144	0.98 0.080	136 3.835	21.5 0.447	308 5.047	ND	ND	ND	0.41	35.4
50	Spring	41	7.6	558	53.1 2.31	3.93 0.10	42.2 2.11	3.18 0.26	12.8 0.36	73.1 1.52	251 4.12	ND	ND	ND	0.21	57.0

TABLE I (Cont'd)

MONTELAGO

SAMPLE NO.	TYPE	LOCATION	t°C	IONIC RATIOS				TEMPERATURE ESTIMATE (°C)		
				Cl / B (ppm)	Na / K (meq/l)	Na / Ca (meq/l)	Na/(Cl+HCO₃) (meq/l)	SiO₂ (Conductive)	Na/K	Na-K-Ca
MG-1	Spring	Nauhan Lake	79	38	20.7	20.4	0.95	103	159	202
MG-2	-do-	- do -	70	37	21.9	21.0	0.99	101	156	200
MG-3	-do-	- do -	84	38	22.6	21.4	0.99	113	153	198
MG-4	-do	- do -	76	36	20.9	20.3	0.99	107	161	203
MG-5	-do-	- do -	62	38	19.5	17.1	1.00	129	169	193
1	-do-	- do -	65	42	24.5	20.2	1.01	160	145	191
4	-do-	Seashore	59	35	18.8	12.3	0.89	172	172	193
5	-do-	- do -	31	290	15.2	1.36	0.40	135	194	<100
41	Well	Nauhan town	33	726	7.8	15.5	0.74	<100	272	228
43	-do-	San Matias Hatchery	32	41	21.3	18.8	0.90	110	159	187
44	-do-	Nauhan town	32	188	14.4	112.5	0.78	<100	204	219
46	-do-	- do -	31	480	14.1	43.5	0.80	<100	200	207

TABLE II

SIGNIFICANT ION RATIOS AND GEOTHERMOMETER DETERMINATIONS OF SPRINGS AND WATER WELLS

MONTELAGO

4 FUTURE WORK PROGRAM

4.1 Activities

The purpose of the pre-feasibility study to be conducted in the Nauhan geothermal area are: (1) to define the geothermal model from the point of view of geologic setting, depth and physical-chemical characteristics of the geothermal field; and (2) to determine the target for deep exploration drilling.

The bulk of the proposed activity will be concentrated on Mount Nauhan and its northwestern sector because all significant physical-chemical indications have pinpointed this area as the best potential part of the geothermal area.

The following operations are envisioned to be undertaken in the course of pre-feasibility study:

a. Photogeologic Interpretation. The whole volcanic chain has to be photogeologically studied utilizing the existing aerial photos of 1:40,000 scale. The interpretation intends to clarify the volcano-structural pattern in order to locate the zones of maximum secondary permeability by the method of fracture analysis.

b. Geological-Hydrogeological Mapping. Detailed mapping will be undertaken on the northern half of the area with emphasis on the volcanological features and tectonic condition of the area. Semi-detailed geologic survey will be carried out in the hilly range southwest of Lake Nauhan in order to get additional information on the character of the presumed basement of the volcanic chain (Tertiary marine-clastics and metamorphic complex) and their hydrogeological characteristics.

c. Geochemical Survey. A systematic field chemical analysis for ammonia has to be carried out over the whole area (50-100 samples) to determine any possible steam leakages from the reservoir. About 10 water samples will likewise be collected from hot and cold water points for isotope analyses in order to achieve a better understanding on the hydrological cycle and on the thermodynamic processes taking place underground.

d. Georesistivity Survey. Additional 10 to 20 vertical soundings will be carried out along Lines 1, 2 and 3 towards the alluvial flat, northwest of Mount Nauhan where the trend of the low resistivity anomaly appears to be migrating.

e. Magnetometer Survey. A total vertical magnetic intensity survey will be carried out along the same georesistivity lines using a proton magnetometer. The survey is essentially aimed to provide data on the hidden deep structures and the lithologic contrast between hornblende-pyroxene of Mount Pola, hornblende-biotite andesite of Montelago and biotite-hornblende andesite of Mount Nauhan. It is likewise designed to extrapolate the contact between the recent volcanics and the underlying sedimentary basement rock. Moreover, shallow underground heating effect may also be reflected by its magnetic intensity profile.

f. Shallow Gradient Hole Drilling. Fifteen gradient holes at an average depth of 150-200 meters will be drilled in the area to the north of Lake Nauhan. Some of the holes will be located on the northern tip of Mount Nauhan and a few in the alluvial flat, while others along the central portion located between Mount Pola and Mount Nauhan. It is difficult to assess the effect of the presence of a confined body of water (Lake Nauhan and artesian aquifer) on the measurements of thermal gradients. The holes to be drilled on the alluvial plain probably shall have deeper penetration more than 150 meters to get a reliable thermal gradient. The decision, however, is a case to case basis depending on the outcome of the sub-surface geology of the drill site. Any thermal fluid encountered in the holes will be sampled and analyzed.

g. Evaluation of the Results. All the results gathered from the preceeding operations will be evaluated in order to come into a final decision if the area warrants an extension of the exploration to the feasibility stage and to pinpoint the sites for the driling of deep exploration wells.

4.2 Proposed Sites of Shallow Gradient Holes

On the basis of the preliminary results of georesistivity survey conducted in the area, 16 shallow gradient holes are programmed within the area of Mount Nauhan where a low resistivity anomaly trending northwest was delineated by the three resistivity lines.

The coordinates of the proposed shallow gradient holes with an average depth of 150-200 meters are as follows:

	NORTHING	EASTING
NDH-1	13°-17.35'	121°-19.73'
NDH-2	13°-16.87'	121°-19.33'
NDH-3	13°-16.97'	121°-18.62'
NDH-4	13°-17.17'	121°-18.01'
NDH-5	13°-16.40'	121°-18.28'
NDH-6	13°-16.87'	121°-20.23'
NDH-7	13°-16.25'	121°-20.05'
NDH-8	13°-16.22'	121°-19.48'
NDH-9	13°-16.23'	121°-20.87'
NDH-10	13°-15.53'	121°-21.60'
NDH-11	13°-15.08'	121°-22.05'
NDH-12	13°-14.25'	121°-22.53'
NDH-13	13°-13.43'	121°-22.70'
NDH-14	13°-14.68'	121°-21.57'
NDH-15	13°-14.67'	121°-20.80'
NDH-16	13°-15.35'	121°-20.05'

APPENDIX II

B I B L I O G R A P H Y

DATUIN, R. and UY, F. 1978. Quaternary Volcanism and Volcanic Rocks of the Philippines. (in press). 8 pp.

PREGLARO, C. 1977. Seismic Zones in the Philippines, publ. by PAGASA Seismological Observation Div. 13 pp.

TRONCALES, A.C. 1979. Regional Geologic Setting of Philippine Geothermal Areas (in press). First Philippine Geo-Energy Symposium-Journal of the Geological Society of the Philippines.

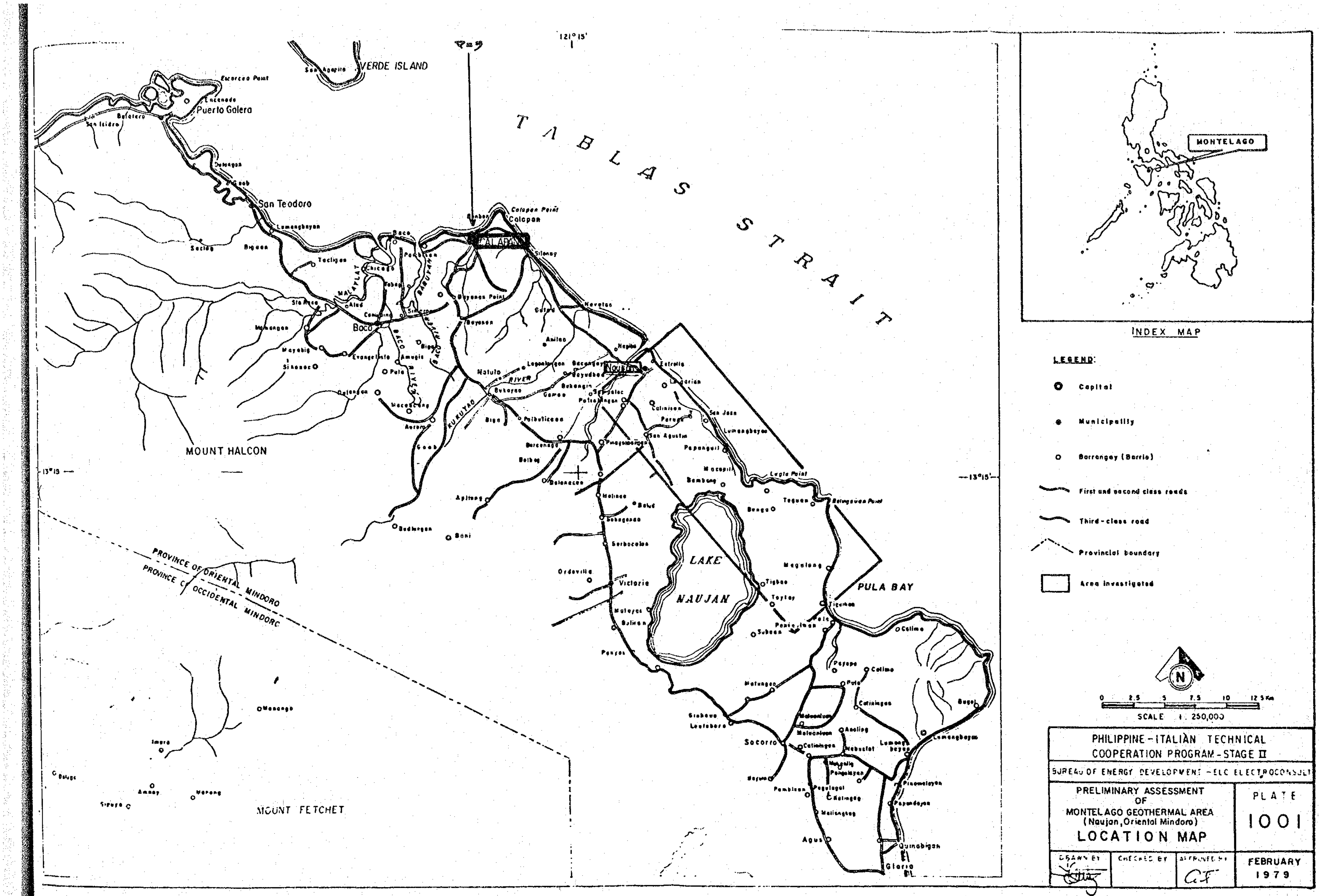
DRAWINGS

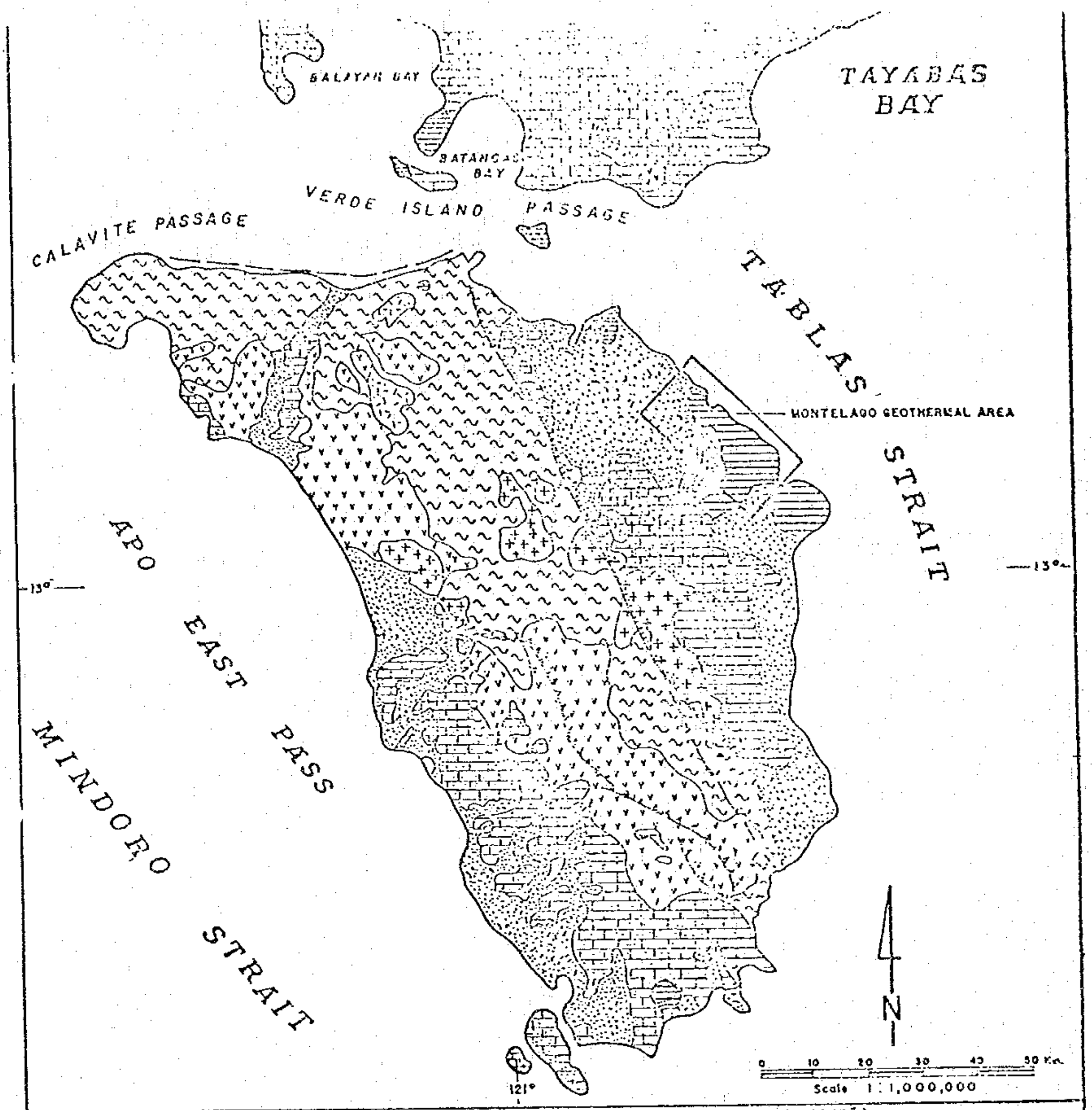
DATUIN, R. and UY, F. 1978. Quaternary Volcanism and Volcanic Rocks of the Philippines. (in press). 8 pp.

PREGLARO, C. 1977. Seismic Zones in the Philippines, publ. by PAGASA Seismological Observation Div. 13 pp.

TRONCALES, A.C. 1979. Regional Geologic Setting of Philippine Geothermal Areas (in press). First Philippine Geo-Energy Symposium-Journal of the Geological Society of the Philippines.

DRAWINGS


121°15'
VERDE ISLAND
Puerto Galera
San Teodoro
Calapan
TABLAS STRAIT
MOUNT HALCON
13°15'
Boco
Naujan
LAKE NAUJAN
PULA BAY
Victoria
Socorro
PROVINCE OF ORIENTAL MINDORO
PROVINCE OF OCCIDENTAL MINDORO
MOUNT FETCHET
MONTELAGO
INDEX MAP
LEGEND:
Capital
Municipality
Barangay (Barrio)
First and second class roads
Third-class road
Provincial boundary
Area investigated
N
SCALE 1 : 250,000
PHILIPPINE-ITALIAN TECHNICAL COOPERATION PROGRAM-STAGE II
BUREAU OF ENERGY DEVELOPMENT - ELC ELECTROCONSULT
PRELIMINARY ASSESSMENT OF MONTELAGO GEOTHERMAL AREA (Naujan, Oriental Mindoro)
LOCATION MAP
PLATE 1001
DRAWN BY
CHECKED BY
APPROVED BY
FEBRUARY 1979



(Simplified from "Geological Map of the Philippines, Bureau of Mines, Manila, 1963")

LEGEND:

- RECENT
- PLIO-QUATERNARY - Volcanics
- OLIGOCENE-PLEISTOCENE - Clastics
- NEOGENE DIORITE
- CRETACEOUS-PALEOGENE - Undifferentiated ultramafic complex.
- CRETACEOUS-PALEOGENE UNDIFFERENTIATED VOLCANICS
- PRE-JURASSIC (BASEMENT COMPLEX)

PHILIPPINE-ITALIAN TECHNICAL COOPERATION PROGRAM-STAGE II

BUREAU OF ENERGY DEVELOPMENT - ELC ELECTROCONSULT

PRELIMINARY ASSESSMENT OF MONTELAGO GEOTHERMAL AREA (Naujan, Oriental Mindoro)

REGIONAL GEOLOGIC MAP

PLATE 1002-A

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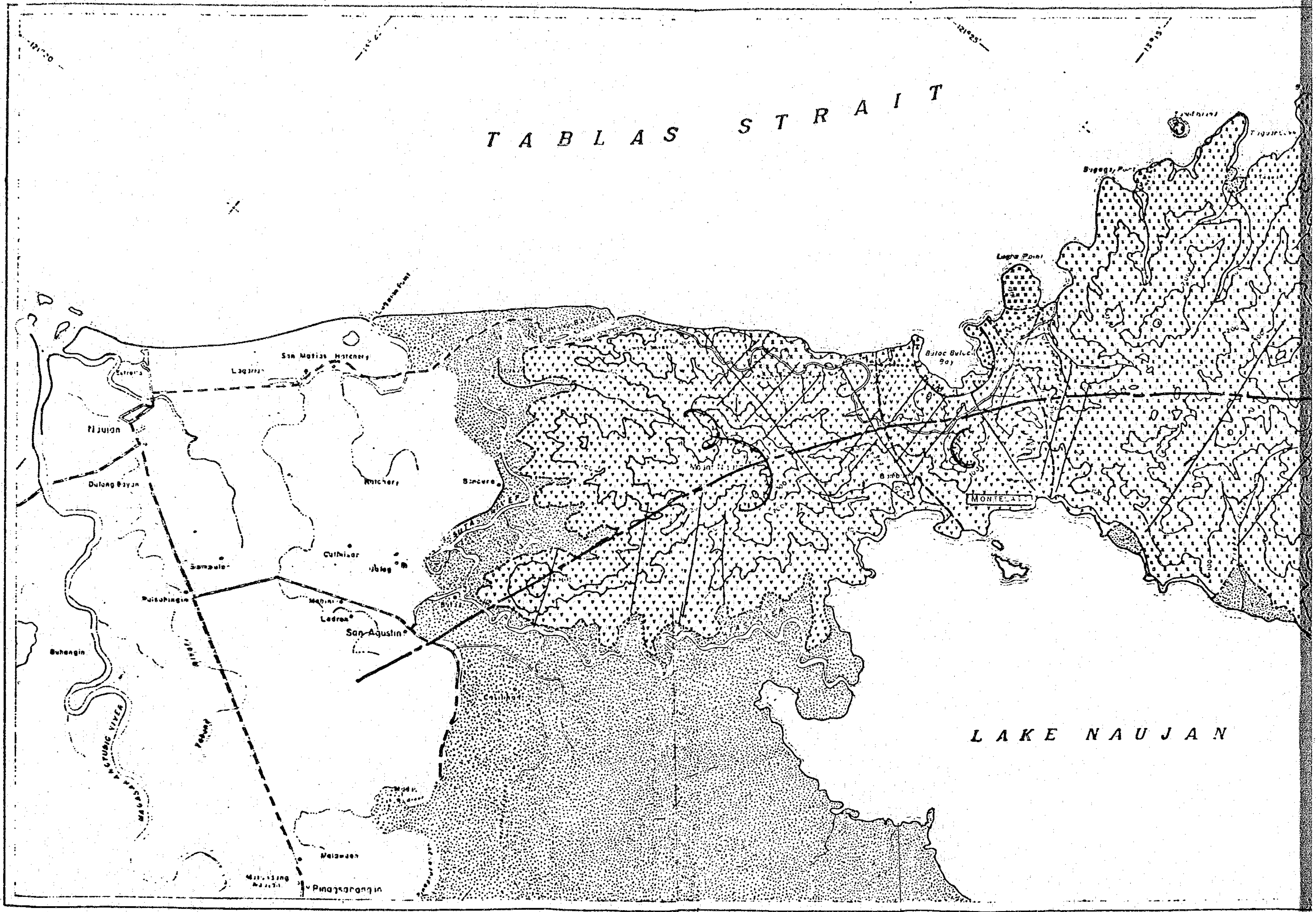
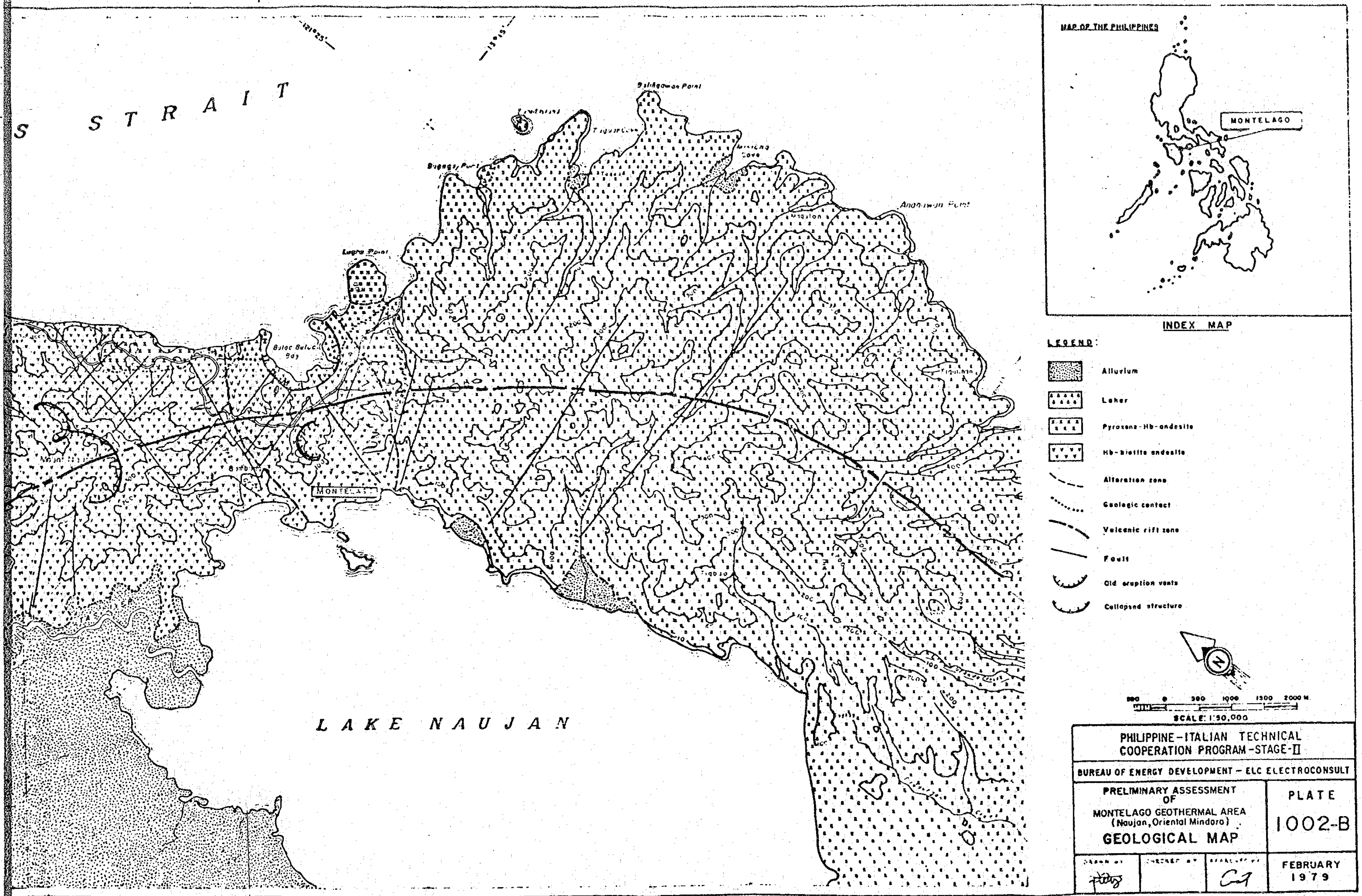
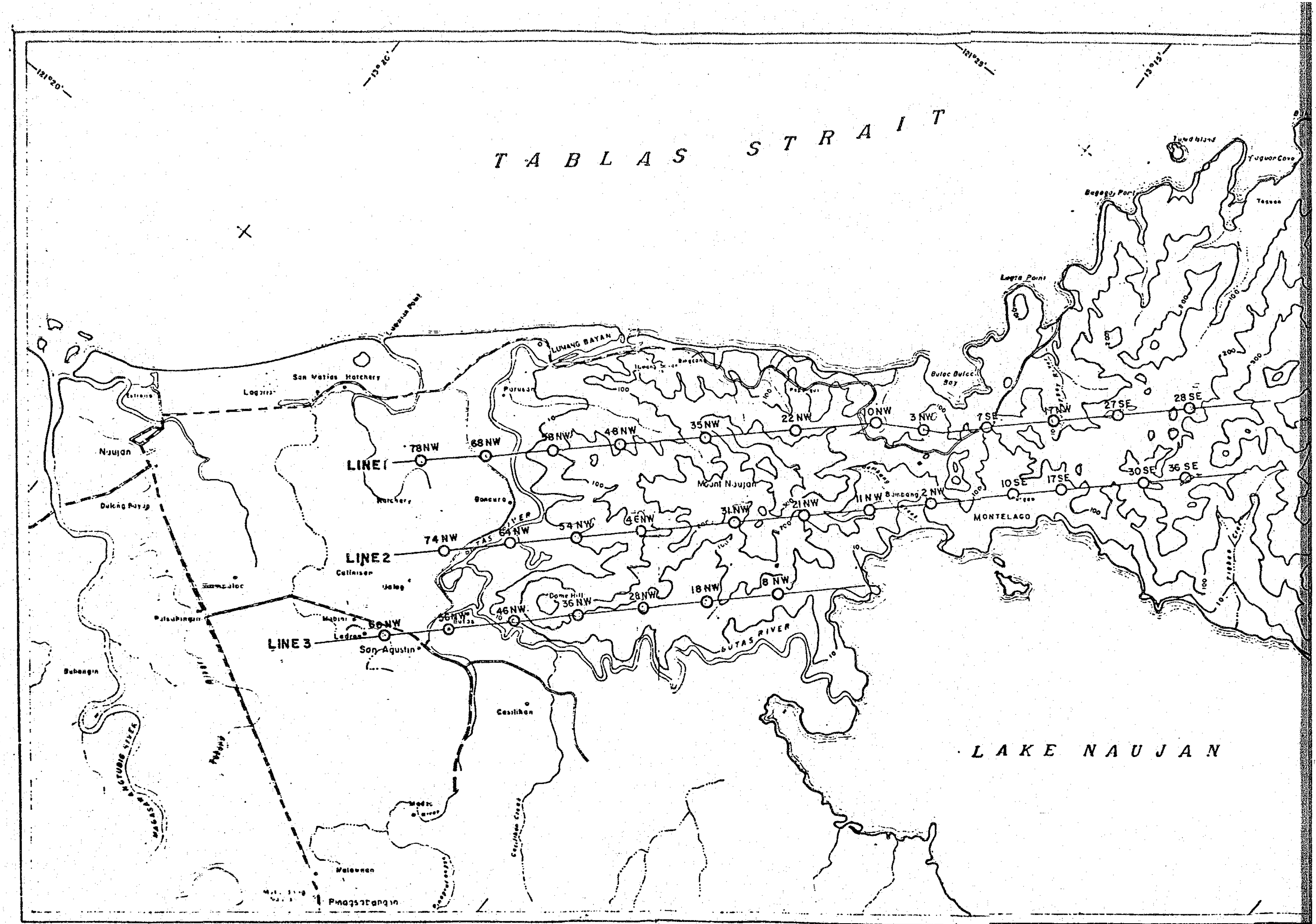
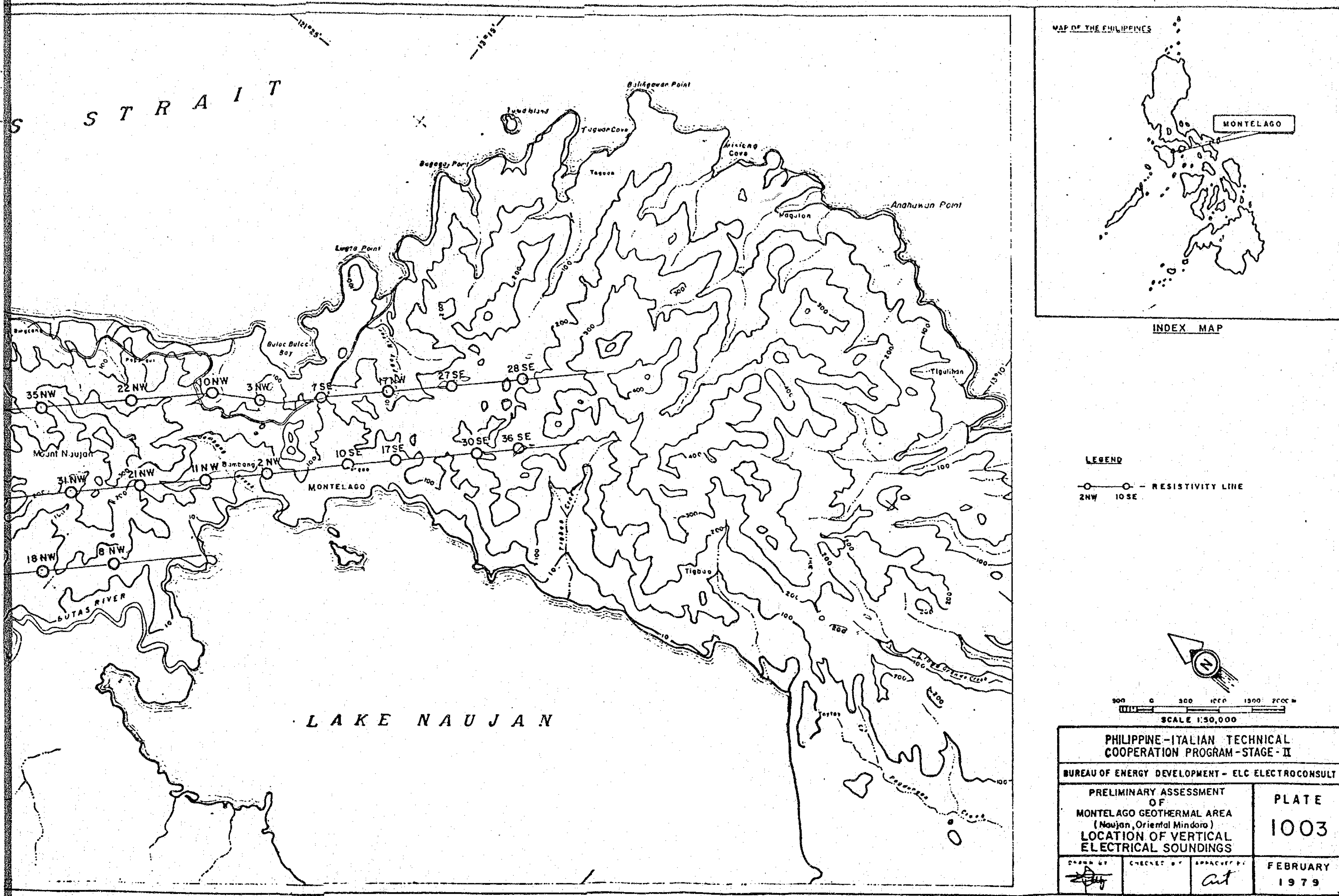
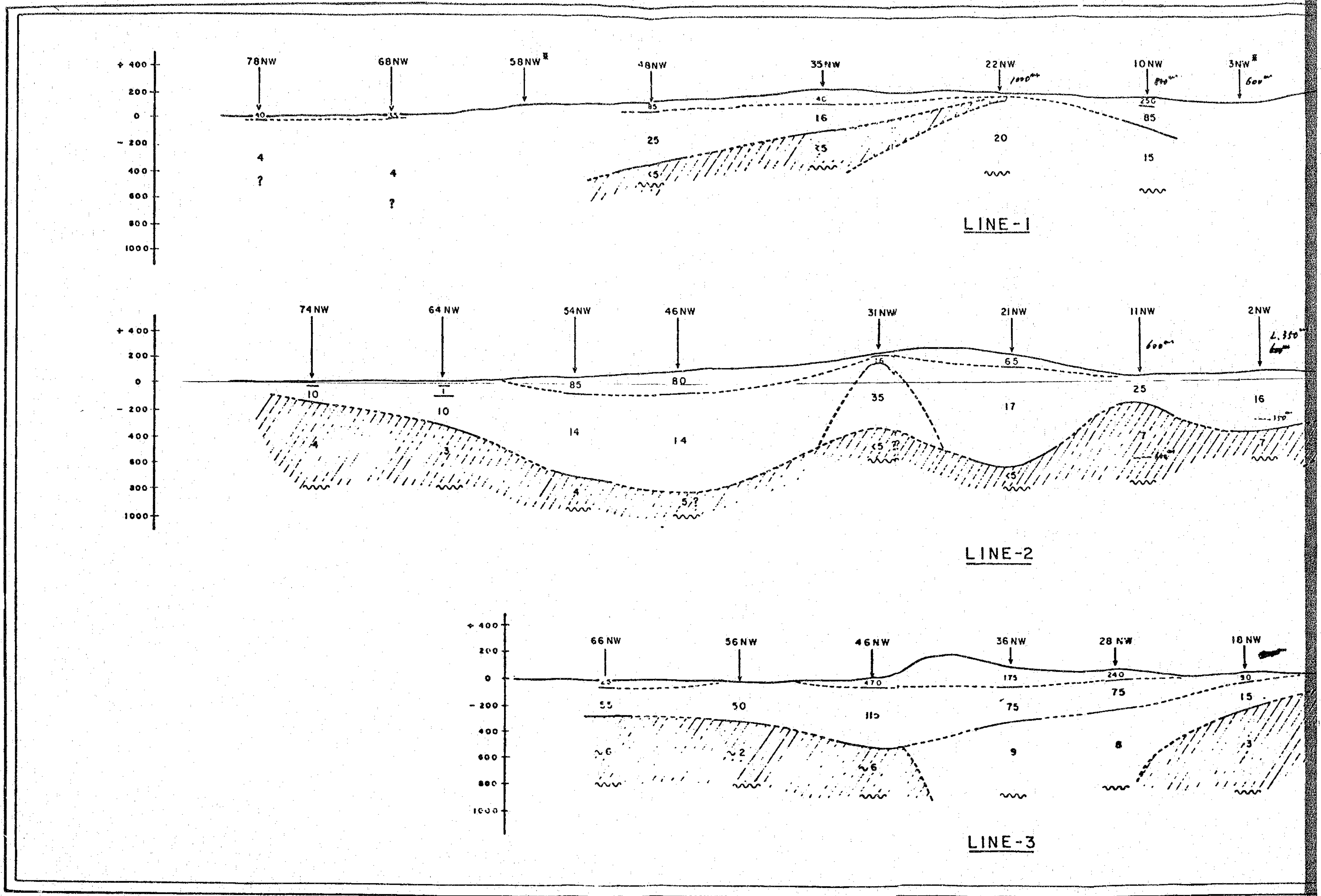

TABLAS STRAIT
LAKE NAUJAN
Naujan
Dulong Bayan
Sampaloc
Pulohingin
Buhangin
San Agustin
Ladrón
Malabrigo
Cuthisan
Bancuro
Hatchery
San Matias Hatchery
Estrera
Malawaan
Pinagsabangin
Lagra Point
Baloc Baloc Bay
Bugaay Point
MONTELAGO
Caburao

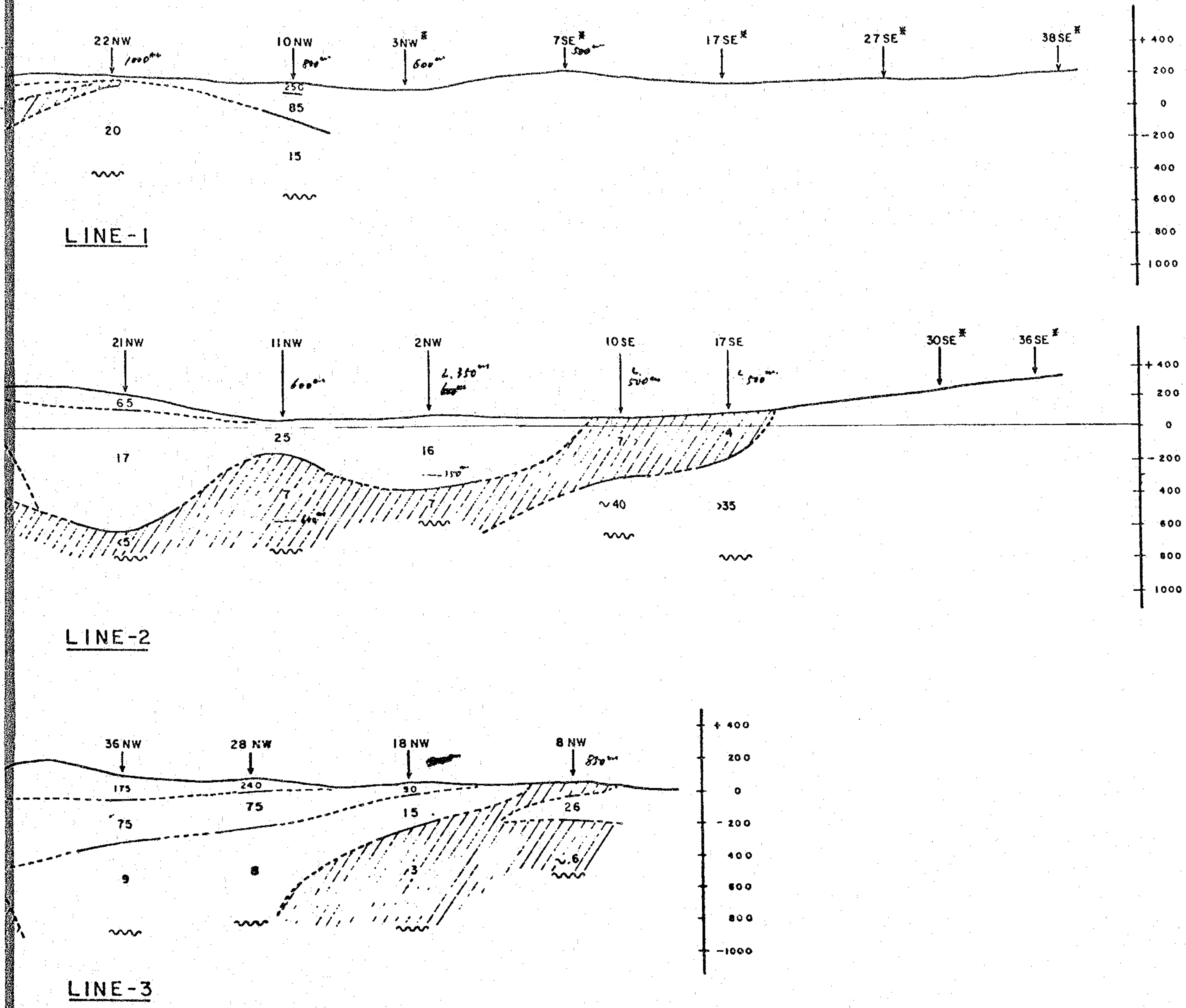

S STRAIT
LAKE NAUJAN
MONTELAGO
Anahawan Point
Lugra Point
MAP OF THE PHILIPPINES
MONTELAGO
INDEX MAP
LEGEND:
Alluvium
Lahar
Pyroxene-Hb-andesite
Hb-biotite andesite
Alteration zone
Geologic contact
Volcanic rift zone
Fault
Old eruption vents
Collapsed structure
SCALE: 1:50,000
PHILIPPINE-ITALIAN TECHNICAL COOPERATION PROGRAM-STAGE-II
BUREAU OF ENERGY DEVELOPMENT – ELC ELECTROCONSULT
PRELIMINARY ASSESSMENT OF MONTELAGO GEOTHERMAL AREA (Naujan, Oriental Mindoro)
GEOLOGICAL MAP
PLATE
1002-B
FEBRUARY 1979


TABLAS STRAIT
LAKE NAUJAN
LINE 1
LINE 2
LINE 3
78NW
68NW
58NW
48NW
35NW
22NW
10NW
3NW
7SE
17NW
27SE
28SE
74NW
64NW
54NW
46NW
31NW
21NW
11NW
2NW
10SE
17SE
30SE
36SE
56NW
46NW
36NW
28NW
18NW
8NW
Mount Naujan
MONTELAGO
BUTAS RIVER
San Agustin
Naujan
LUMANG BAYAN
San Matias Hatchery
Castilhon
Pinagsabangan
Malawaan
Bulac Bulac Bay
Lagta Point
Bagong Port
Tugwan Cove
Dome Hill
Bancuro
Hatchery
Duking Buyap
Bubangin
Calinisan
Ledres
Balite


S T R A I T
LAKE NAUJAN
MONTELAGO
Mount Naujan
BUTAS RIVER
Bulac Bulac Bay
Lugta Point
Bagaguy Point
Balingawan Point
Tugdan Cove
Anahawan Point
Tiguihan
Tigbao
35 NW
22 NW
10 NW
3 NW
7 SE
17 NW
27 SE
28 SE
31 NW
21 NW
11 NW
2 NW
10 SE
17 SE
30 SE
36 SE
18 NW
8 NW
MAP OF THE PHILIPPINES
MONTELAGO
INDEX MAP
LEGEND
2NW 10SE - RESISTIVITY LINE
SCALE 1:50,000
PHILIPPINE-ITALIAN TECHNICAL COOPERATION PROGRAM-STAGE-II
BUREAU OF ENERGY DEVELOPMENT - ELC ELECTROCONSULT
PRELIMINARY ASSESSMENT OF MONTELAGO GEOTHERMAL AREA
(Naujan, Oriental Mindoro)
LOCATION OF VERTICAL ELECTRICAL SOUNDINGS
PLATE
1003
FEBRUARY
1979



78NW
68NW
58NW
48NW
35NW
22NW
10NW
3NW
LINE-1
74NW
64NW
54NW
46NW
31NW
21NW
11NW
2NW
LINE-2
66NW
56NW
46NW
36NW
28NW
18NW
LINE-3

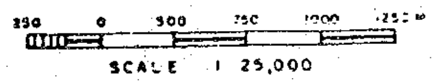


LEGEND

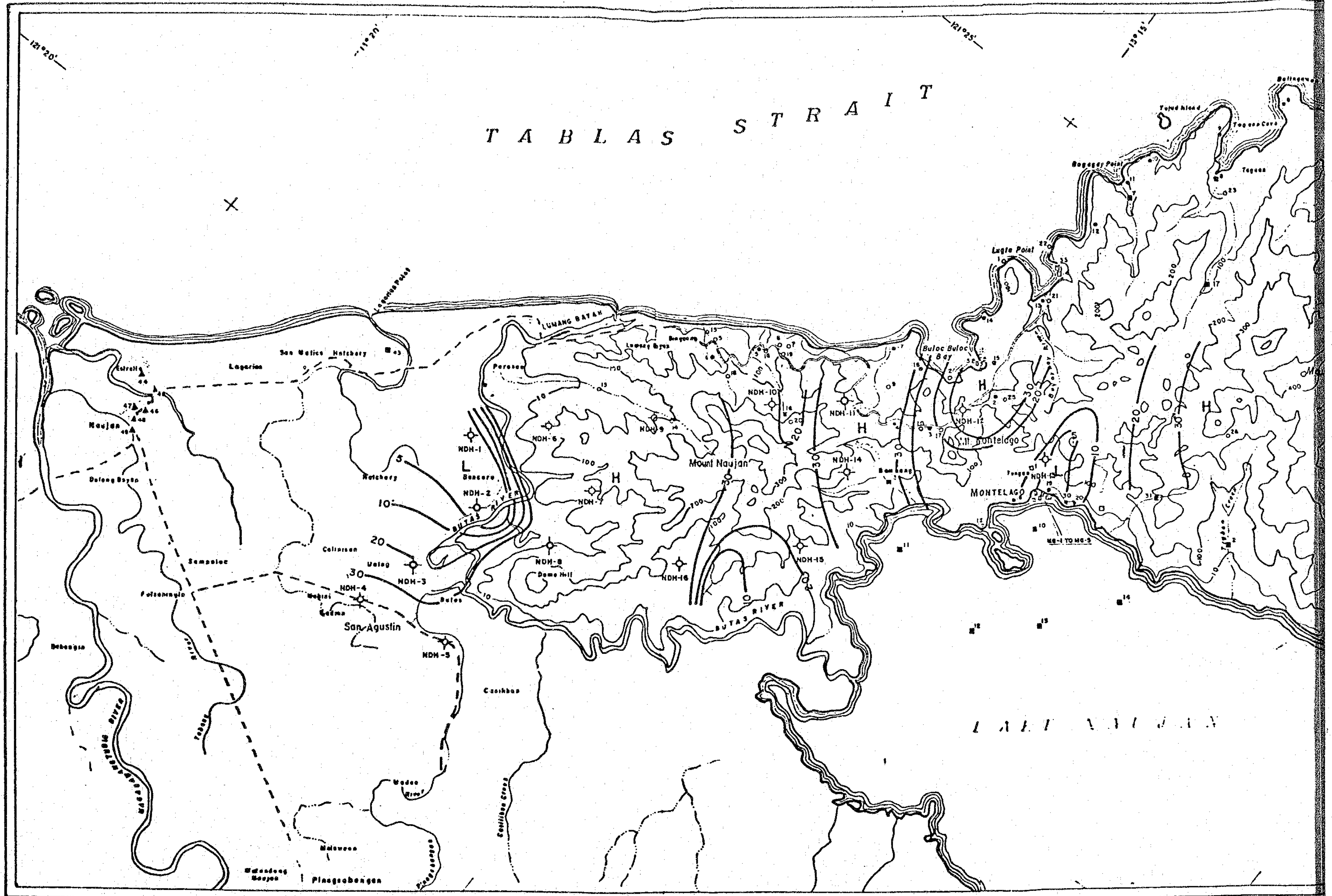
↓	VERTICAL ELECTRICAL SOUNDING
10	RESISTIVITY IN OHM METERS
———	CONTACT OF RESISTIVITY
- - - - -	CONTACT OF RESISTIVITY, DOUBTFUL
∿∿∿	PENETRATION DEPTH
(hatched)	LOW RESISTIVITY ZONE (MAINLY < 8 Ω-M)

* Note:

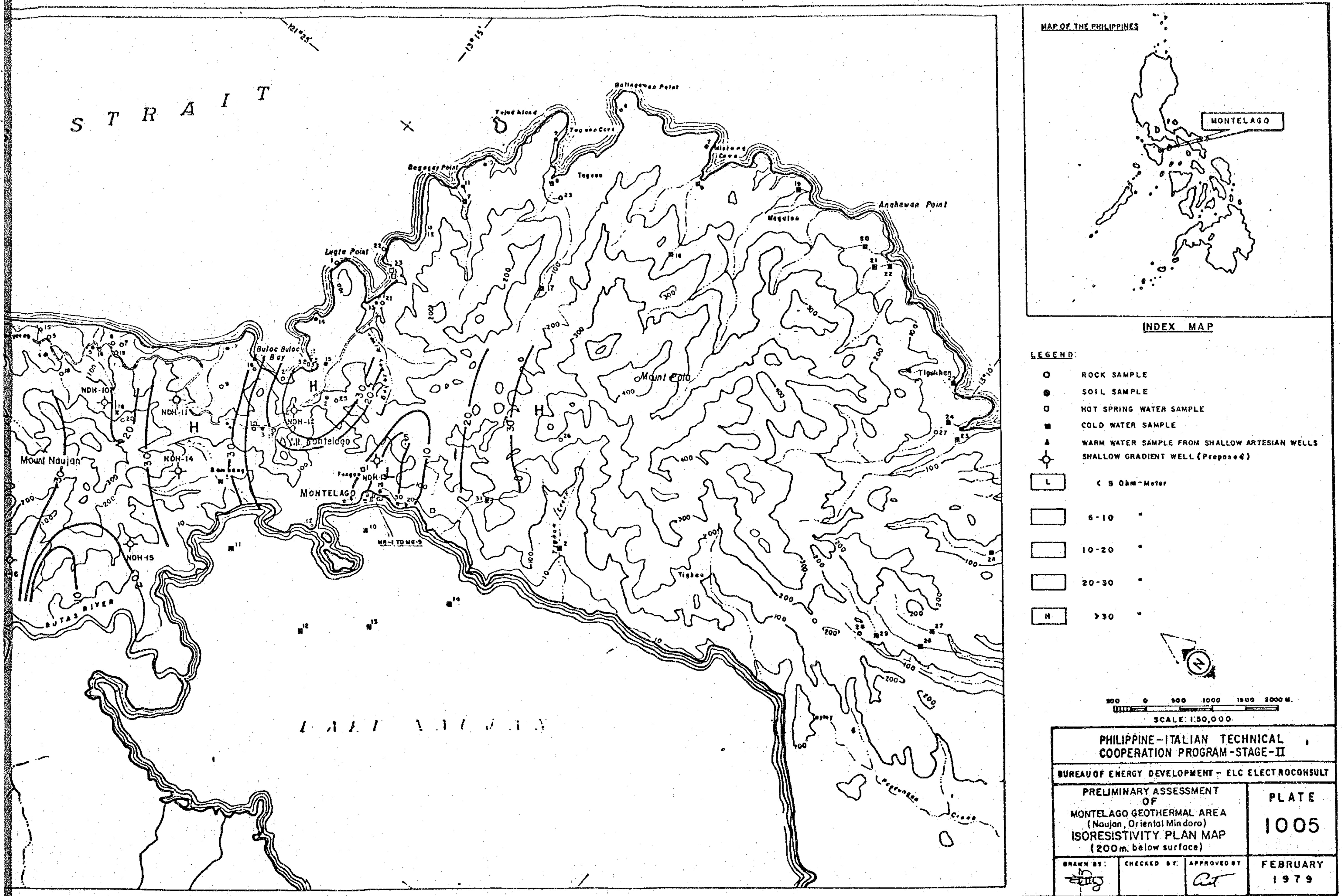
SE soundings for Lines 1 & 2 suggest complex geological structures and need expert geophysical interpretation. However, none of these soundings present low resistivity layers. L1-58NW also needs expert geophysical interpretation.



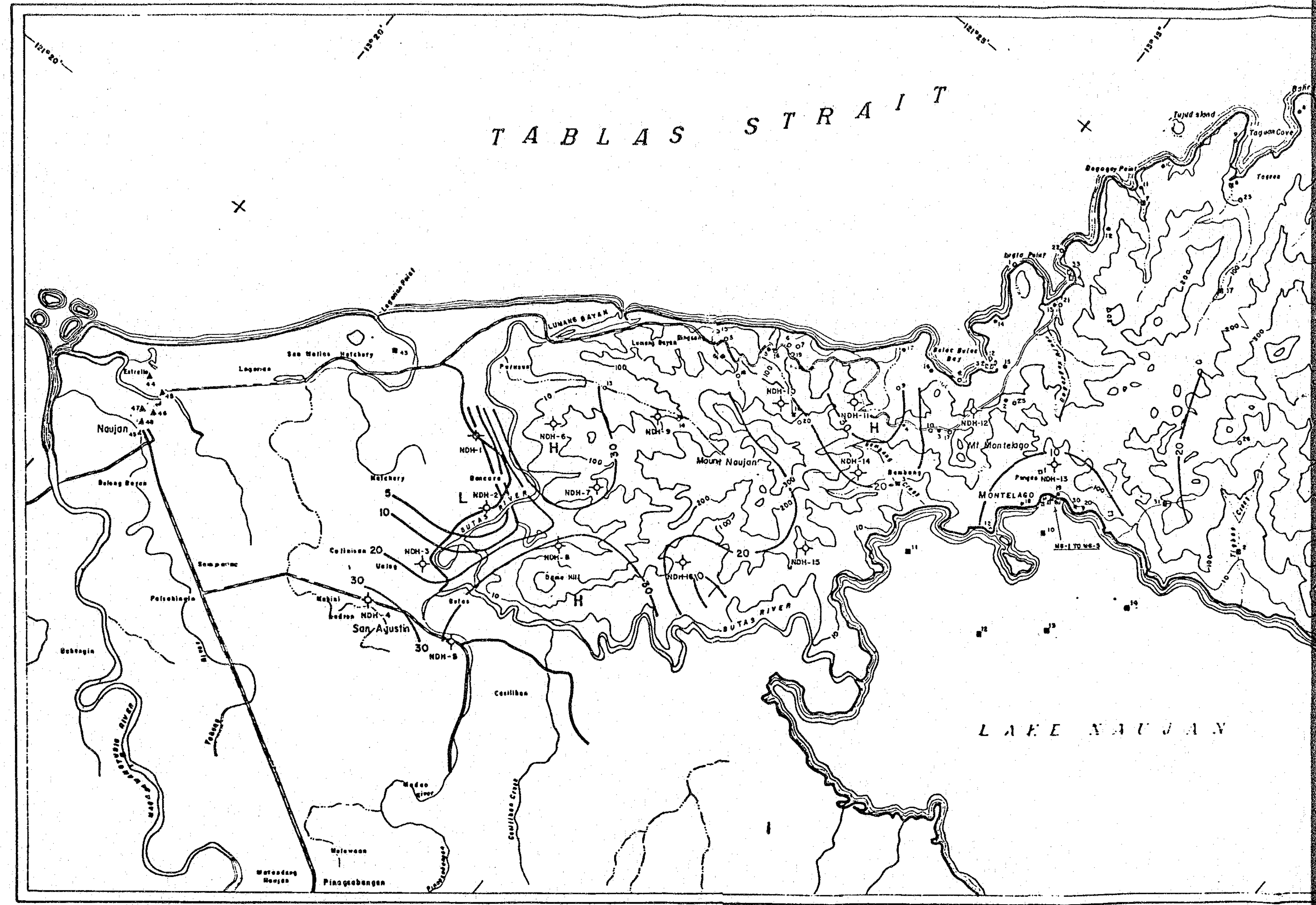
PHILIPPINE-ITALIAN TECHNICAL COOPERATION PROGRAM-STAGE II	
BUREAU OF ENERGY DEVELOPMENT - ELC ELECTROCONSULT	
PRELIMINARY ASSESSMENT OF MONTELAGO GEOTHERMAL AREA (Naujan, Oriental Mindoro) VERTICAL ELECTRICAL SOUNDINGS PROFILE	PLATE 1004
DRAWN BY / CHECKED BY. / APPROVED BY.	FEBRUARY 1979

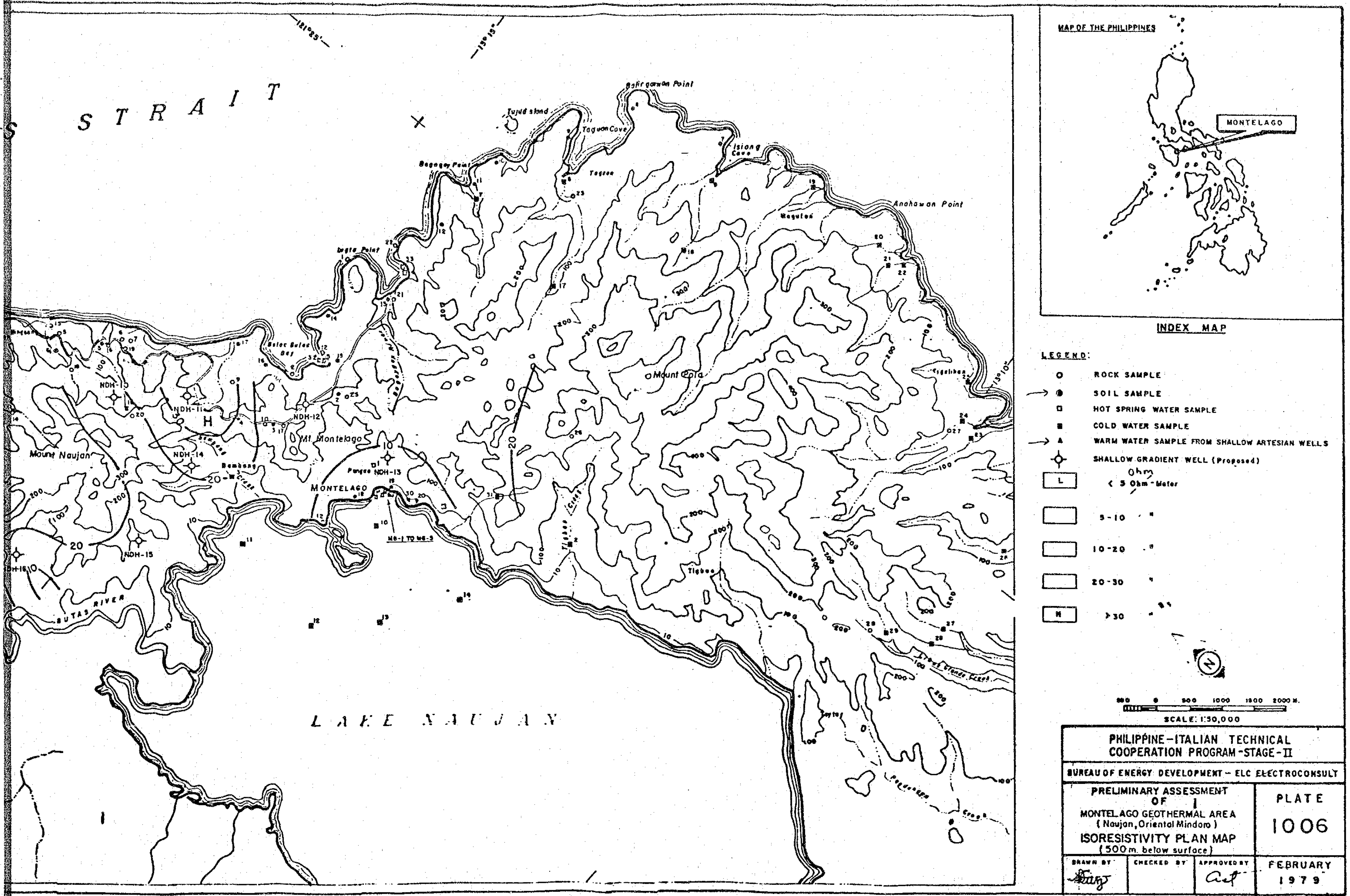


121°20'
121°25'
13°15'
TABLAS STRAIT
Naujan
San Agustin
Mount Naujan
MONTELAGO
BUTAS RIVER
Dome Hill
Lagte Point
Bagagay Point
Buloc Buloc Bay
NDH-1
NDH-2
NDH-3
NDH-4
NDH-5
NDH-6
NDH-7
NDH-8
NDH-9
NDH-10
NDH-11
NDH-12
NDH-13
NDH-14
NDH-15
NDH-16
MG-1 TO MG-5

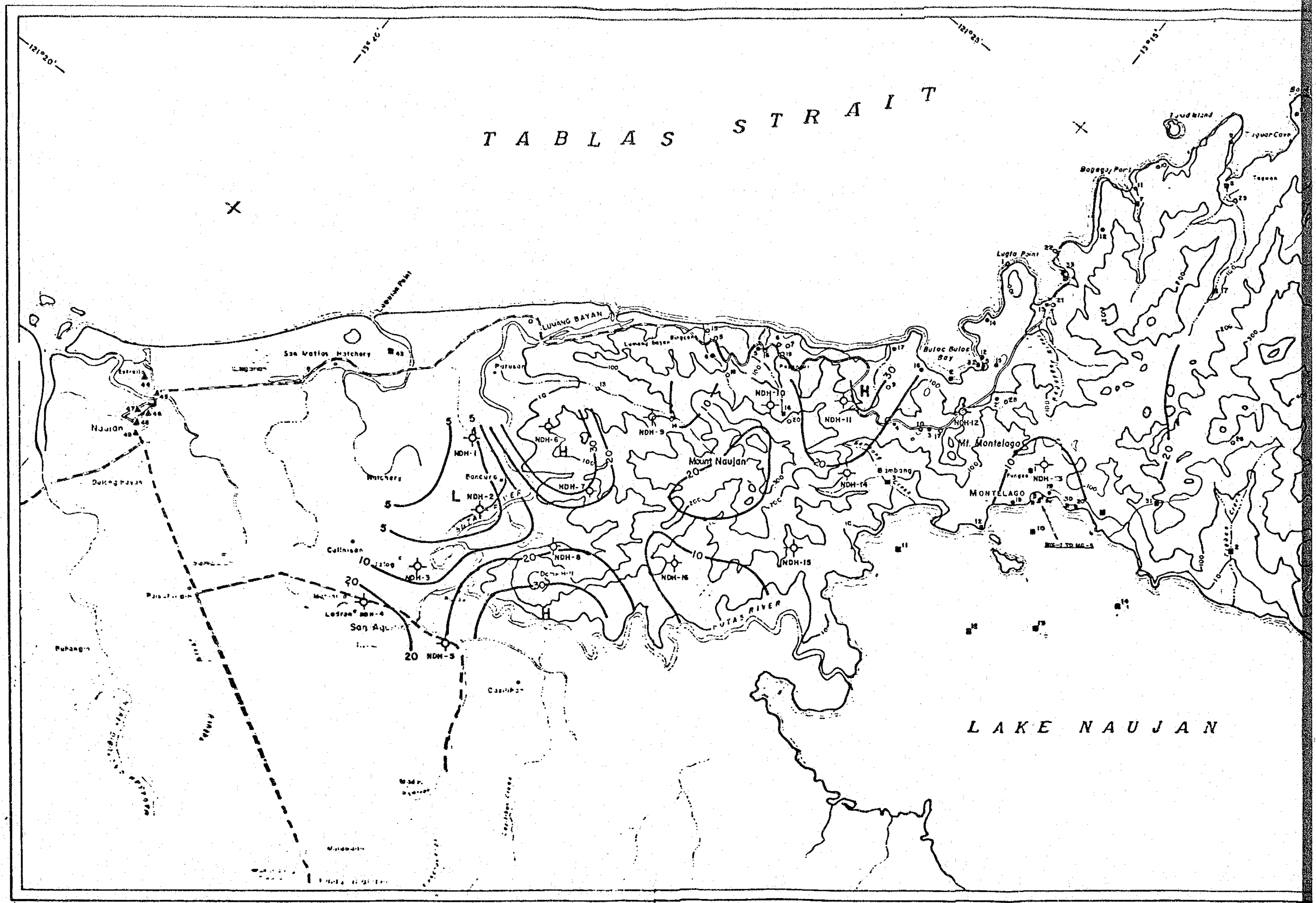


STRAIT
Mount Naujan
Mount Dela
MONTELAGO
Montelago
Bulac Bulac Bay
Lugta Point
Bagagay Point
Tagaso
Magaloa
Anahawan Point
Tigbao
Tigbao Creek
BUTAS RIVER
Pedungan Creek
NDH-10
NDH-11
NDH-12
NDH-13
NDH-14
NDH-15
MAP OF THE PHILIPPINES
MONTELAGO
INDEX MAP
LEGEND:
ROCK SAMPLE
SOIL SAMPLE
HOT SPRING WATER SAMPLE
COLD WATER SAMPLE
WARM WATER SAMPLE FROM SHALLOW ARTESIAN WELLS
SHALLOW GRADIENT WELL (Proposed)
L < 5 Ohm-Meter
5-10 "
10-20 "
20-30 "
H >30 "
500 0 500 1000 1500 2000 M.
SCALE: 1:50,000
PHILIPPINE-ITALIAN TECHNICAL COOPERATION PROGRAM-STAGE-II
BUREAU OF ENERGY DEVELOPMENT – ELC ELECTROCONSULT
PRELIMINARY ASSESSMENT OF MONTELAGO GEOTHERMAL AREA (Naujan, Oriental Mindoro)
ISORESISTIVITY PLAN MAP (200m. below surface)
PLATE 1005
DRAWN BY:
CHECKED BY:
APPROVED BY
FEBRUARY 1979

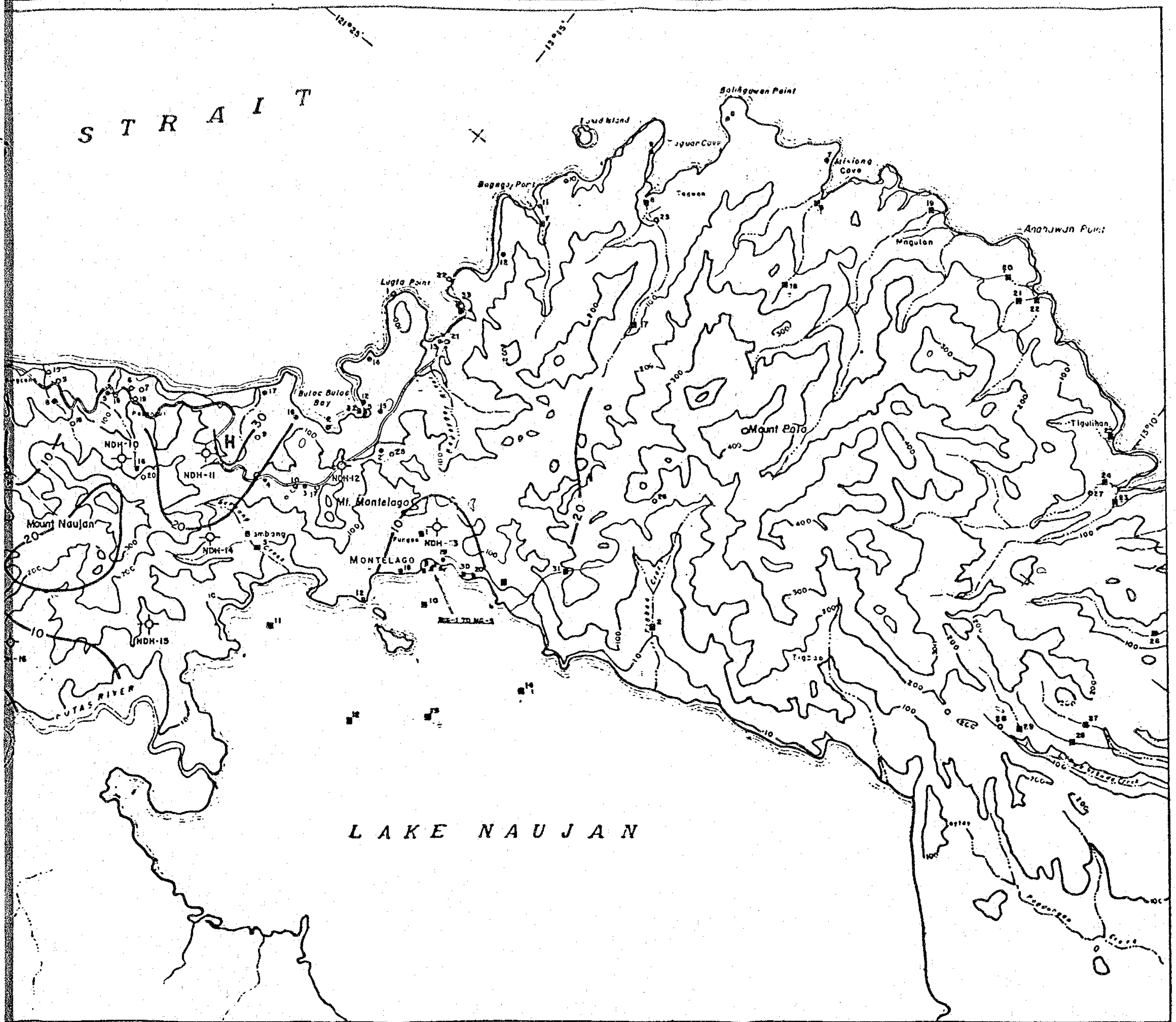

TABLAS STRAIT
LAKE NAUJAN
Naujan
San Agustin
Mount Naujan
Mt Montelago
MONTELAGO
Dome Hill
BUTAS RIVER
LUMANG BAYAN
NDH-1
NDH-2
NDH-3
NDH-4
NDH-5
NDH-6
NDH-7
NDH-8
NDH-9
NDH-10
NDH-11
NDH-12
NDH-13
NDH-14
NDH-15
NDH-16
Tujud Island
Tagaan Cove
Bagaoay Point
Estrella
Lagarian
San Mollos Hatchery
Hatchery
Bancuro
Malaya
Sampaloc
Pulsahingin
Buhangin
Butas
Caslilian
Bambang
Pungao
Pinagsabangan
Malawaan

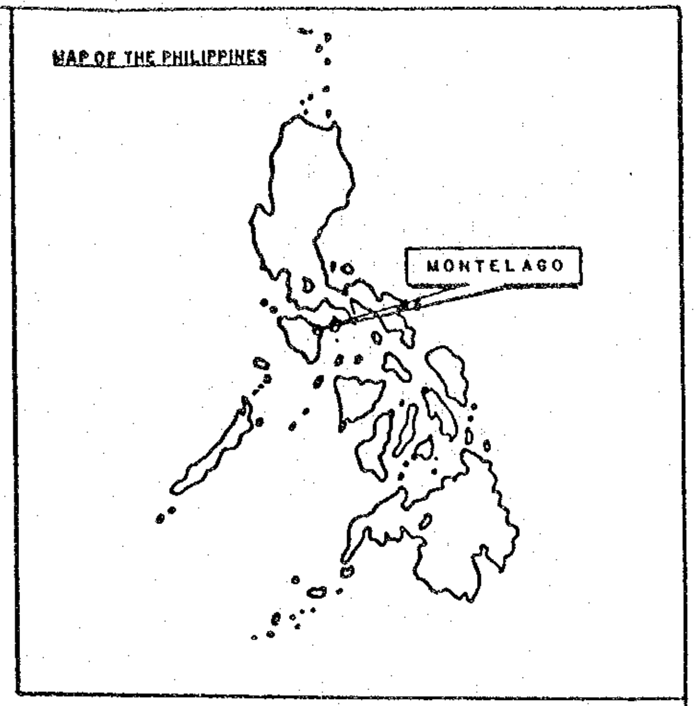


MAP OF THE PHILIPPINES
MONTELAGO
INDEX MAP
LEGEND:
ROCK SAMPLE
SOIL SAMPLE
HOT SPRING WATER SAMPLE
COLD WATER SAMPLE
WARM WATER SAMPLE FROM SHALLOW ARTESIAN WELLS
SHALLOW GRADIENT WELL (Proposed)
< 5 Ohm-Meter
5-10
10-20
20-30
>30
SCALE: 1:50,000
PHILIPPINE-ITALIAN TECHNICAL COOPERATION PROGRAM-STAGE-II
BUREAU OF ENERGY DEVELOPMENT - ELC ELECTROCONSULT
PRELIMINARY ASSESSMENT OF MONTELAGO GEOTHERMAL AREA
(Naujan, Oriental Mindoro)
ISORESISTIVITY PLAN MAP
(500 m. below surface)
PLATE
1006
DRAWN BY
CHECKED BY
APPROVED BY
FEBRUARY 1979
STRAIT
LAKE NAUJAN
Mount Naujan
Mt. Montelago
MONTELAGO
Mount Pola
Anahawan Point
Tagaon Cove
Isiong Cove
Bagangay Point
Butas River
Tigbao



TABLAS STRAIT
LAKE NAUJAN
LUMANG BAYAN
San Mateo Hatchery
Naujan
Estrella
Mount Naujan
Mt. Montelago
MONTELAGO
Bulac Bulac Bay
Lugta Point
Bagagoy Point
Dome Hill
San Agustin
Calinisan
Bancuro
Hatchery
BUTAS RIVER
Bambang
NDH-1
NDH-2
NDH-3
NDH-4
NDH-5
NDH-6
NDH-7
NDH-8
NDH-9
NDH-10
NDH-11
NDH-12
NDH-13
NDH-14
NDH-15
NDH-16
Ladrao
Purusan
Pungao





INDEX MAP

LEGEND:

- ○ ROCK SAMPLE
- ● SOIL SAMPLE
- ■ HOT SPRING WATER SAMPLE
- ■ COLD WATER SAMPLE
- ▲ WARM WATER SAMPLE FROM SHALLOW ARTESIAN WELLS
- ⌖ SHALLOW GRADIENT WELL (Proposed)

L	< 5 Ohm-Meter
	5-10 "
	10-20 "
	20-30 "
H	> 30 "

500 0 500 1000 1500 2000 M.

SCALE: 1:50,000

PHILIPPINE–ITALIAN TECHNICAL COOPERATION PROGRAM - STAGE - II

BUREAU OF ENERGY DEVELOPMENT – ELC ELECTROCONSULT

PRELIMINARY ASSESSMENT OF MONTELAGO GEOTHERMAL AREA (Naujan, Oriental Mindoro)

ISORESISTIVITY PLAN MAP (750 m. below surface)

PLATE 1007

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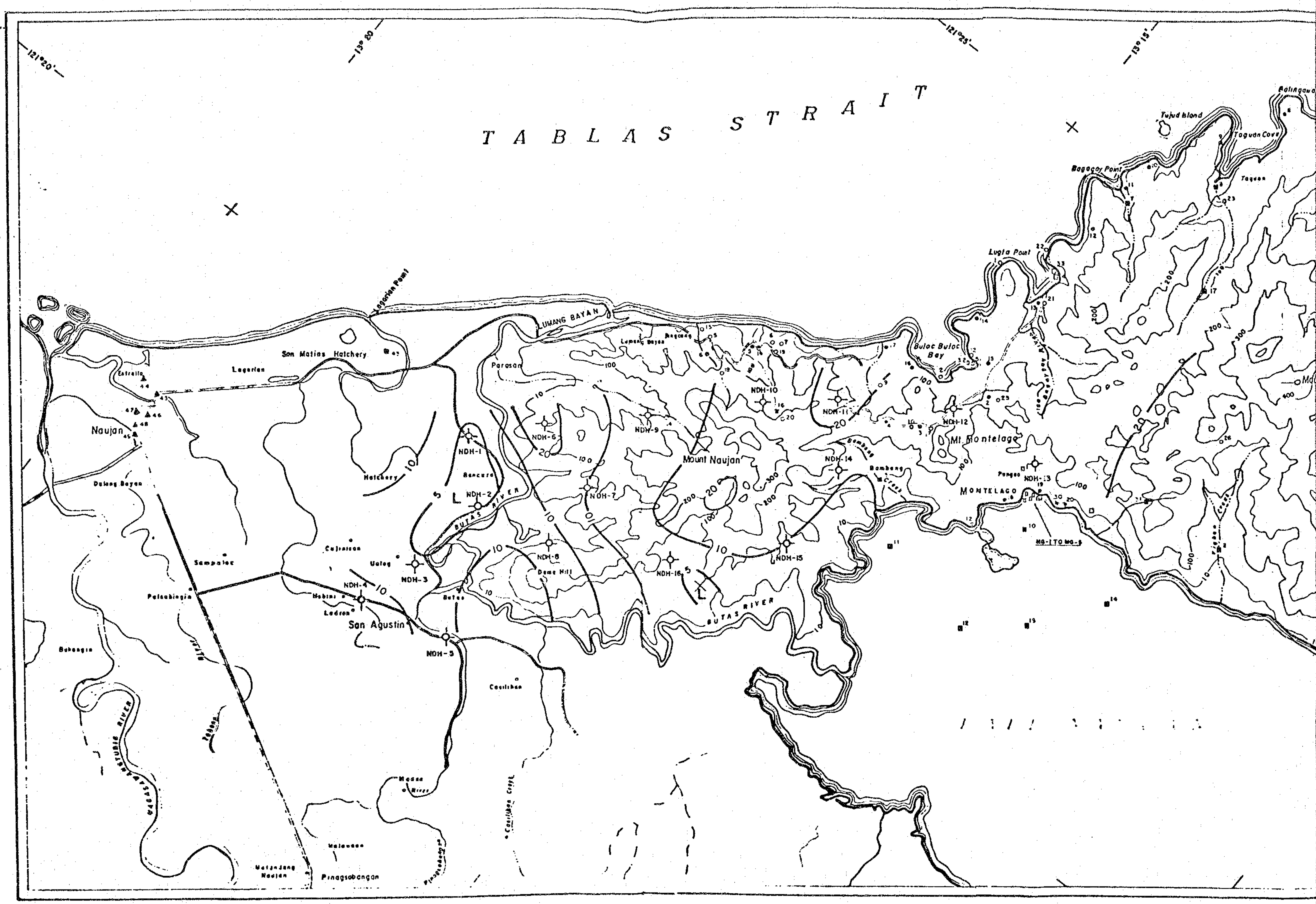
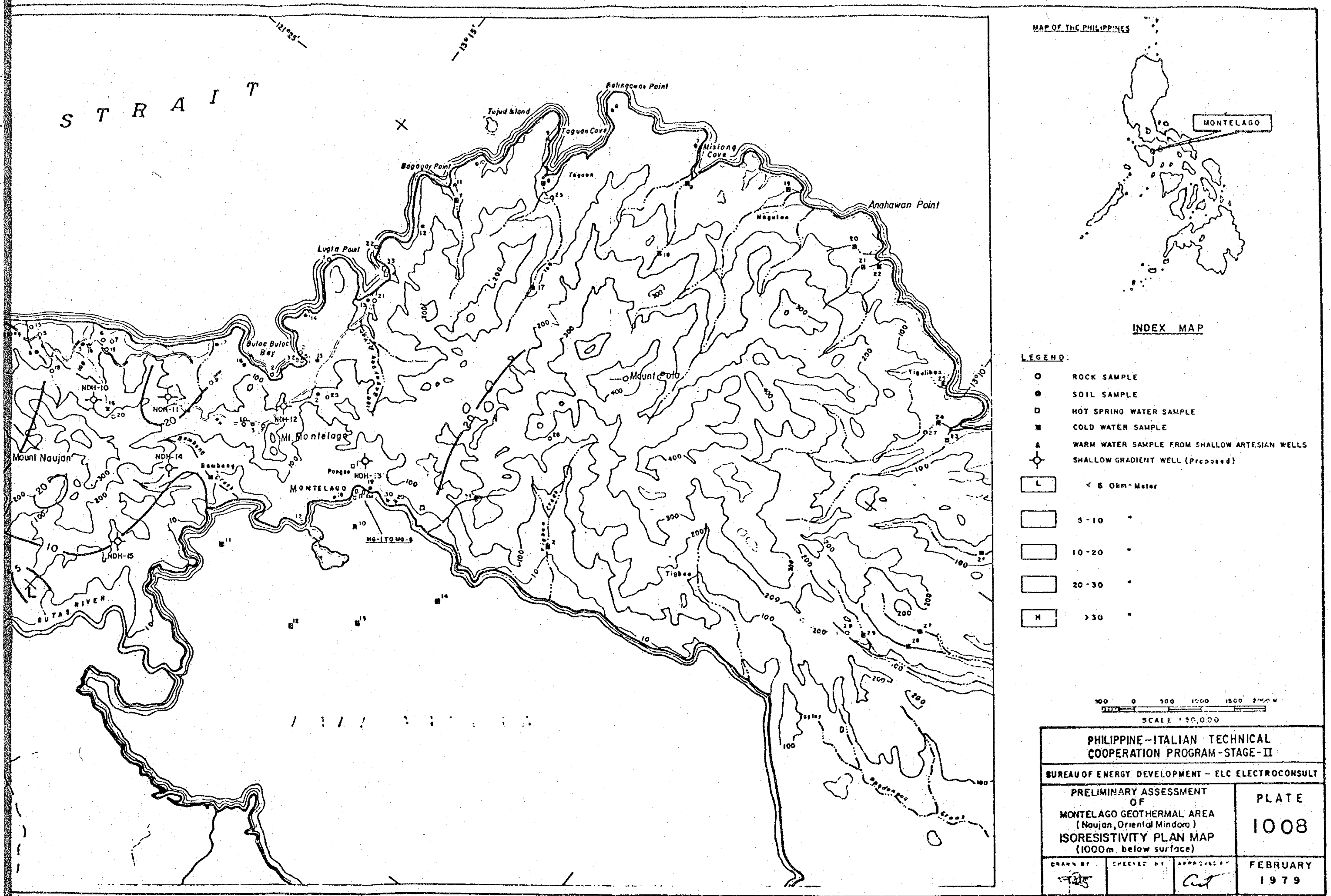


TABLAS STRAIT
121°20'
13°20'
121°25'
13°15'
Lagarian Point
LUMANG BAYAN
San Matias Hatchery
Lagarian
Estrella
Naujan
Dalong Bayan
Sampaloc
Paitabingin
Bahangin
Parasan
Hatchery
Bancuro
NDH-1
NDH-2
NDH-3
NDH-4
NDH-5
NDH-6
NDH-7
NDH-8
NDH-9
NDH-10
NDH-11
NDH-12
NDH-13
NDH-14
NDH-15
NDH-16
Calsican
Ualog
Dome Hill
Mount Naujan
BUTAS RIVER
Butas
San Agustin
Ladron
Casiliban
Mt. Montelago
MONTELAGO
Pangao
Bambang Creek
Buloc Buloc Bay
Lugta Point
Bagacay Point
Tujud Island
Taguan Cove
Taguan
Pinagsabangan
Malawaan


STRAIT
Balingawas Point
Tujud Island
Taguan Cove
Taguan
Bagagay Point
Misiong Cove
Anahawan Point
Lugta Point
Buloc Buloc Bay
Mount Cato
Mt. Montelago
Mount Naujan
MONTELAGO
Bambang Creek
Pongao
Naguion
Tigbao
BUTAS RIVER
NDH-10
NDH-11
NDH-12
NDH-13
NDH-14
NDH-15
MAP OF THE PHILIPPINES
MONTELAGO
INDEX MAP
LEGEND:
ROCK SAMPLE
SOIL SAMPLE
HOT SPRING WATER SAMPLE
COLD WATER SAMPLE
WARM WATER SAMPLE FROM SHALLOW ARTESIAN WELLS
SHALLOW GRADIENT WELL (Proposed)
L < 5 Ohm-Meter
5 - 10
10 - 20
20 - 30
H > 30
SCALE 1:50,000
PHILIPPINE-ITALIAN TECHNICAL COOPERATION PROGRAM-STAGE-II
BUREAU OF ENERGY DEVELOPMENT – ELC ELECTROCONSULT
PRELIMINARY ASSESSMENT OF MONTELAGO GEOTHERMAL AREA (Naujan, Oriental Mindoro)
ISORESISTIVITY PLAN MAP (1000m. below surface)
PLATE
1008
DRAWN BY
CHECKED BY
APPROVED BY
FEBRUARY 1979

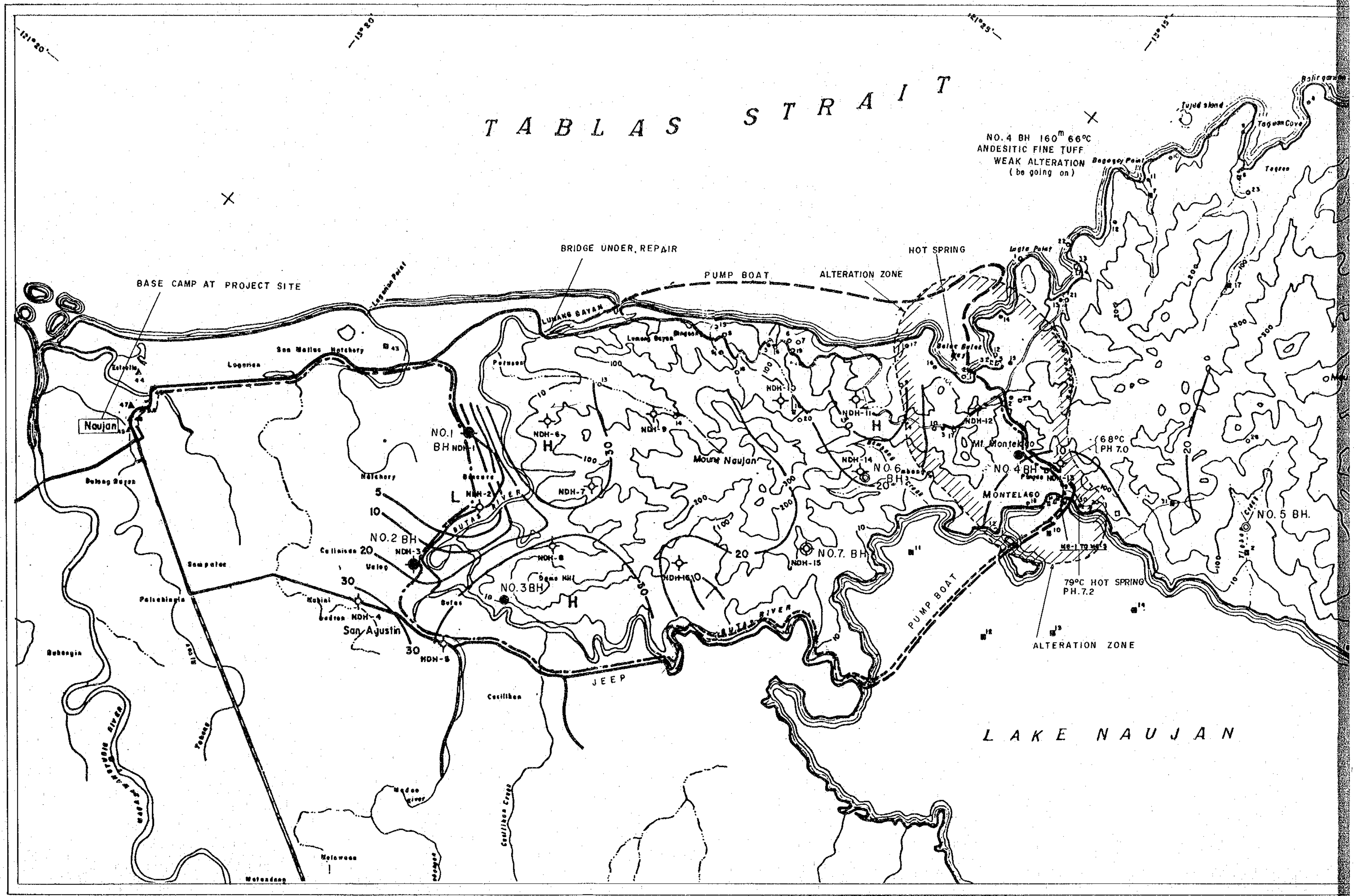
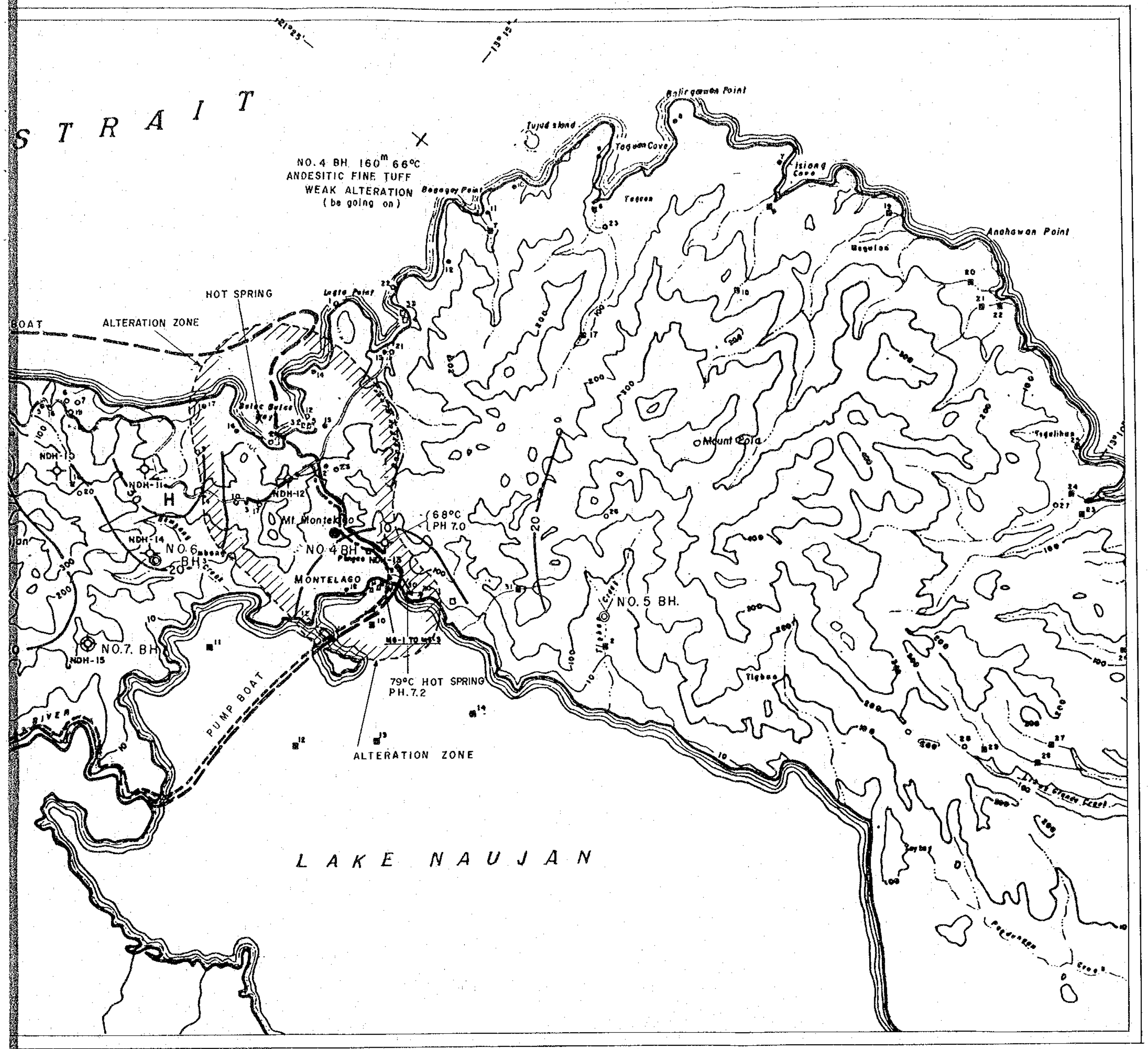


Fig6. 2 ROUTE MAP IN MONTELAGO AREA



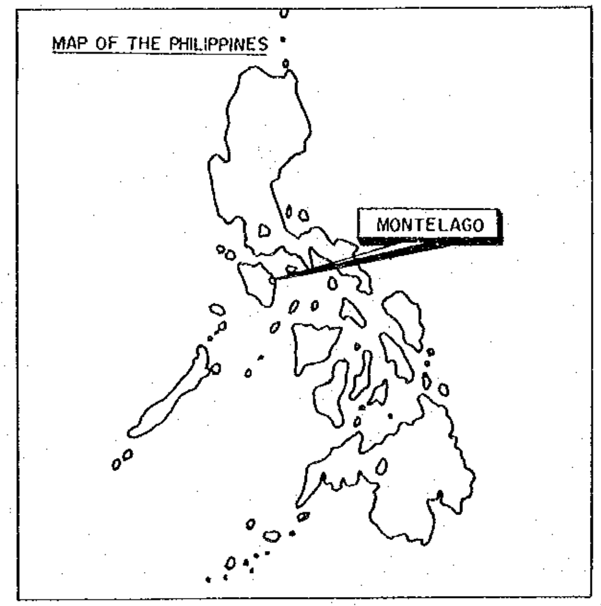
PRELIMINARY SURVEY FOR THE GEOTHERMAL DEVELOPMENT PLAN IN THE REPUBLIC OF THE PHILIPPINES

JAPAN INTERNATIONAL COOPERATION AGENCY

LEGEND

- ROUTE, MARCH, 13 '80
- 〃 , 〃 , 14 '80
- GRADIENT HOLE (PROPOSED)
- GRADIENT HOLE (EXECUTED)
- ROCK SAMPLE
- SOIL SAMPLE
- HOT SPRING WATER SAMPLE
- COLD WATER SAMPLE
- WARM WATER SAMPLE FROM SHALLOW ARTESIAN WELLS
- SHALLOW GRADIENT WELL (proposed)
- CONTOUR OF ISORESISTIVITY (500m below surface)
- H HIGH RESISTIVITY ANOMALY
- L LOW RESISTIVITY ANOMALY

500 0 500 1000 1500 2000 M
SCALE 1 : 50,000



INDEX MAP

Fig 6. 2 ROUTE MAP IN MONTELAGO AREA (after BED's original data)