資　料　7

MABINI 地域資料

One-Meter Probehole Survey of Mabini Thermal Area

F. A. Urbiztondo and D. C. Garcia

Introduction

In connection with the development of thermal areas for power generation and/or non-electrical applications, the Commission on Volcanology sent a team to conduct heat flow of Mainit Hotspring in Mabini, Batangas.

A one meter probehole survey of Mainit Hotspring and geothermal grounds was carried out from January 24 to February 18, 1978 in order to delineate the thermal area and to map the size and distribution of the thermal anomalies within the geothermal field. Just like any other geothermal field, the area consists of a hotspring, mudpools, hot grounds, steaming vents and other surface thermal manifestations.

A total of 296 probe holes were sunk and ground measurements were taken with the use of a Thermistor ranging from 0 to 200°C. A dial thermometer was utilized at 15 cm. depth for measurements of ground temperature and for the purpose of comparison and verification.

Location and Accessibility

The Mabini geothermal field is located at the southwestern part of the Calumpan Peninsula, about 12 kilometers northeast of Tingloy.

The Mainit Hotspring can be reached after an hour of backbreaking journey from Mabini town proper or after a 45-minute cruise using a motorized banca from the town of Talaga via Batangas Bay.

Field Activities

During the course of the investigation, ground temperature at one meter depth were obtained using a Takara Thermistor (0-200°C). For comparison and verification temperatures at 15 cm. depth were also taken using a dial thermometer. A regular gridline pattern at 50 m. interval was maintained throughout the survey. A clumsy one-inch diameter steel bar was used to punch a one meter depth hole on the ground along the gridline. Air temperatures were measured hourly and the mean average temperature of 30°C taken as the ambient temperature. A total of 296 holes were made. The low number of probe hole readings taken was due to the ruggedness of the topography and the hard bedrocks. Some of the holes were confined along man-made trails.

Geochemical analysis of the thermal liquids was undertaken using Hach Test Kits. However, thermal liquid samples were brought to the laboratory for a more detailed quantitative and qualitative chemical analysis.

Results and Findings

Calumpan Peninsula is highly faulted and fractured. The structures found in the area may serve as a controlling factor and channelway for descending and ascending hydrothermal fluids. The outflow of heat is obviously transported by cunduction as the discharged hot water ascending from great depth heats up the sorrounding rocks on their way to the surface.

The temperature readings taken from the field were mapped within an area approximately one and a half square kilometers. Thermal ground anomalies were found in the area of interest as shown in the attached isothermal map. However, a possible extension of thermal anomalies could be found outside the delimited area as thermal readings along the borders were still above ambient temperature.

In the northeastern part of Calumpan Peninsula, a gradual decrease in the temperature readings from 38°C to 28°C was noticed.

No attempt has been made in estimating the total conductive heat flow of the thermal area since the survey was not completed.

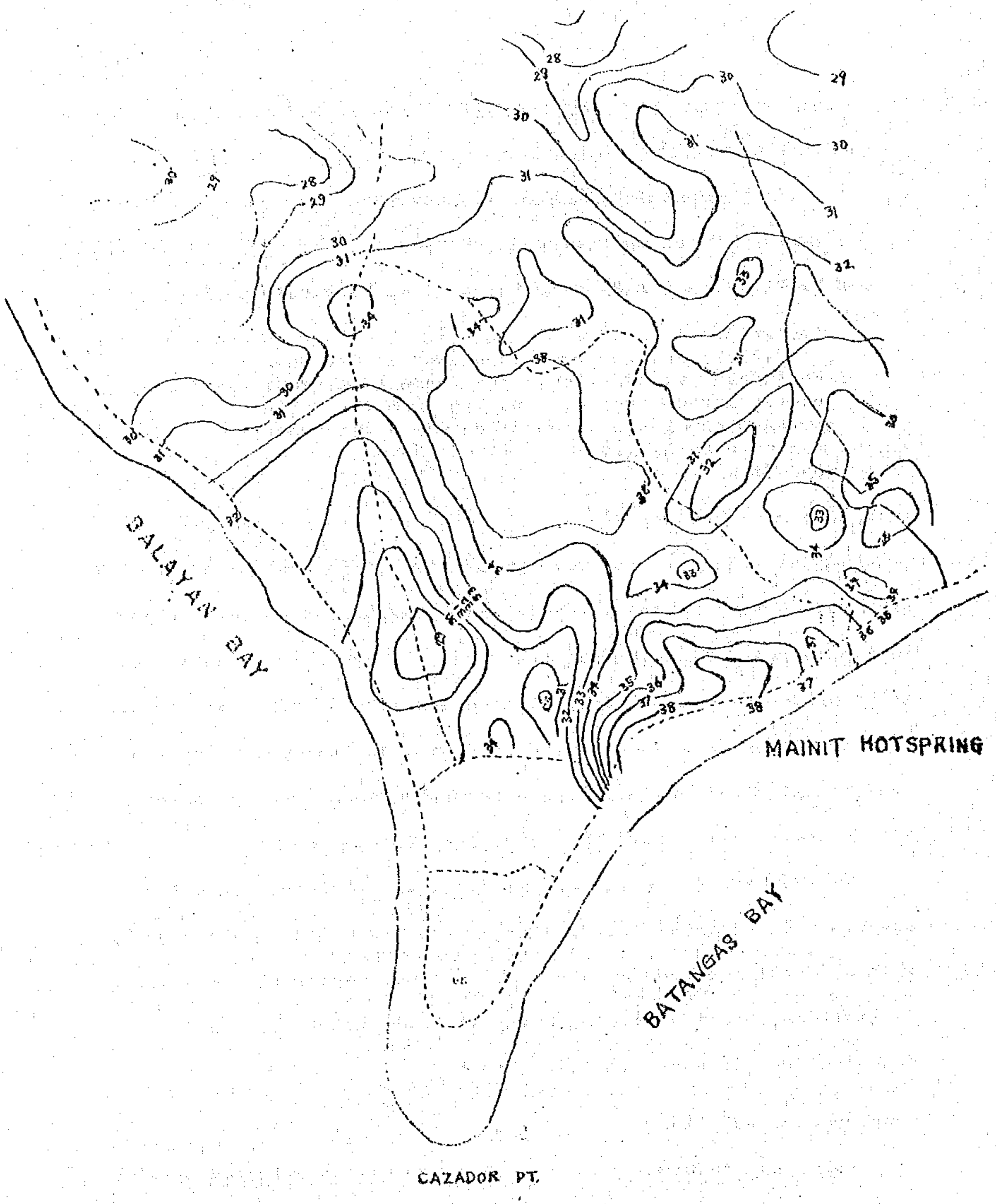
Conclusion and Recommendations

The area under study is probably controlled by fault structures wherein hot gases and thermal fluids freely escape from its source at a depth thereby heating the sorrounding rocks.

From the results gathered from the one-meter probehole survey, it seems that the Mabini geothermal field is small in its surface thermal manifestations and its land area. As the hotspring is governed by fault structures, the geology of the area should be highly considered in order to know the structural patterns, the sorrounding rock types, localizing structures and geological formation of the rocks.

Most of the low values of the temperatures are found on the upper part of the Calumpan Peninsula while the high readings are concentrated at its center. These high values which are confined at the center of the area surveyed suggest that the heat source is found beneath this anomaly.

The one-meter probehole survey has not been very extensive, thus the writers believe that further studies of the area should be made.



LEGEND: O — HOTSPRING
- - - - TRAILS

ISOTHERMAL MAP OF MABINI THERMAL AREA

PREPARED BY: COMMISSION on VOLCANOLOGY

SCALE: 1:12,500

Magnetic and Gravity Surveys in Calumpan Peninsula, Batangas

E.B. Villalva,* A.F. Oanes** and J.R. Puertollano***

Abstract

Field surveys were conducted at Calumpan Peninsula to determine areas where geothermal energy may be tapped. Results from the field surveys disclosed three areas where this energy resource is likely to be found: Mabuhayan, Solo and Mainit.

Introduction

Magnetic and gravity surveys are two of several standard geophysical techniques employed by the Commission on Volcanology in its search for geothermal resources. These surveys serve to: (1) complement in the interpretation and understanding of the area in correlation with other survey results, and (2) determine the lateral extent of the probable productive zones and thus point out favorable sites for exploratory drilling.

In the Calumpan Peninsula in Batangas Province, these two surveys were again utilized. These were conducted simultaneously, with observations made on the same occupied positions. A total of 33 stations, located strategically at 1 km. intervals, were occupied from November 16 to 23, 1978.

Geographical Relations

Calumpan Peninsula is a northeast-wouthwest oriented stretch of land lying between 120°52' and 120°58' east longitude and between 13°40' and 13°47' north latitude. Its western coasts, quite

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untouched by pollution and dotted with numerous resorts, face Balayan Bay. Its eastern coasts, flooded by pollutants issuing out from nearby refineries and, therefore, often frequented by enviromentalists, come in contact with the waves of Batangas Bay. Directly south of it is the Maricaban Island, separated from the peninsula by the so-named Maricaban Strait.

In horizontal section, the average width of the peninsula is 4 kilometers and the mean length is 9 kilometers. The municipality of Mabini comes of interest as this town is the seat of local government in the peninsula. The celebrated barangays of Mainit and Pulang Lupa, where the two hotsprings are found, are therefore under the jurisdiction of the Mabini municipal government.

The stressed condition of the earth's crust, in and around the peninsula, is shown by the high seismicity. Highly fractured rocks, some mineralized, give direct evidence that the area has undergone considerable adjustments in its geologic history.

Previous Works

The Philippine Bureau of Mines ("Mabini Gypsum Deposit," Phil. Bu. of Mines Circ. No. 19, Manila, 1956, and "Report on the General Geology and Mineral Deposits of Calumpan Peninsula and Mabini, Batangas," Ibid., Unpublished Report) has given a general account of the geology of the area. It has reported the occurrence of gypsum deposits as fracture vein fillings in prophilitized and pyritized andesites. B.C. Burgess ("The Calumpan Clay Deposit, Batangas and the Angat Clay Area, Bulacan," Phil. Bu. of Mines Report of Investigation No. 23) has published a paper on the Calumpan clay deposits. And, lately, E.M. Ruiz and A.G. Reyes, working for the Commission on Volcanology, have prepared a reconnaissance study of the peninsula. They have described the stratigraphy of the peninsula and made mention of the pre-Upper Miocene Calumpan volcanics which are overlain by the coralline, Upper Miocene-Lower Pliocene Sta. Monica Limestone. In their report, the two researchers have considered the clastic Nagiba and bioclastic Malimatok formation, both dated as Mio-Pliocene to Pliocene, as simply the Malimatok formation.

Apart from the geology of the area, one-meter probehole surveys and resistivity surveys were carried out by the Commission on Volcanology. Urbiztondo and Garcia ("One-Meter Probehole Survey of Mabini Thermal Area," COMVOL Unpublished Report) have noted thermal ground anomalies as shown in their isothermal map (not appended in this paper). Baligod, et.al., ("Preliminary Report on the Resistivity Survey of Mabini Thermal Area," COMVOL Unpublished Report), however, have not found remarkable contrasts in resistivity values in the area. The resistivity readings along the western coast proved to be low but these have been ascribed to the effect of percolating sea water.

Field Operations

Basic Principles

The magnetic method of geophysical prospecting takes into account the magnetic field intensity while the gravity method makes use of the gravity of the earth. Aguila ("Magnetic and Gravity Surveys of Surigao Geothermal Field," The COMVOL Letter, Sept.-Dec., Vol. IX, Nos. 5 & 6, 1977) has clearly described how these concepts work out in the study of geothermal areas. He has stated that hydrothermal solutions could introduce massive changes in the chemical and physical characteristics of the underground geology and that these changes provide for existing quantifiable density and magnetic contrasts, two parameters necessary for better interpretation of the geothermal area. Quoting from Meidav ("Application of Electrical Resistivity and Gravimetry in Deep Geothermal Exploration," United Nations Symposium on the Development and Utilization of Geothermal Resources, Pisa, Italy, 1970), he added that metamorphism caused by hydrothermal solution tends to increase the density of loosely consolidated formation, thus increasing its gravitational attraction. And this will be reflected on the surface as gravity high. Inversely, its magnetic property decreases or is lost when heated. And since heat is involved in hydrothermal alteration which works in the development of geothermal areas, this will be reflected on the surface as magnetic low.

When the results of the two methods are therefore superimposed, areas of gravity high and, at the same time, magnetic low would define probable geothermal reservoirs.

Instruments

A La Coste-Romberg Model Gravimeter No. 277 was used for the gravity survey. The meter has a reading accuracy of 0.01mgal and a drift rate of less than 1 mgal/month. On the other hand, a portable proton magnetometer Model GP-70 was used for the magnetic survey. This instrument in turn measures magnetic field strength in absolute terms, accurately to 1 gamma ± 15 ppm., within the range of 20,000 to 100,000 gammas. This is displayed directly in digits, making the reduction of data easier with only the diurnal variation to be corrected.

Survey Procedure

As previously done in other geothermal areas, the single loop method was employed for the two surveys. A base station, located at Barangay Pulang Lupa was tied from the Balayan Elementary School where G = 978.34709 mgal. Stations were fixed on a 1:50,000 BTSM topographic map. Elevations were determined using Paulin altimeters that are calibrated to 1 meter. For the proton magnetometer, a unit was read regularly at the base station to measure the diurnal change, and another unit was used to obtain the magnetic values of the different occupied stations.

Computations

As before, the values obtained from the proton magnetometer were corrected only for the daily variation. The reduced figures were then plotted and contoured on the base map and presented in this paper in the form of an iso-magnetic map (Plate 1).

Gravity data, on the other hand, were corrected for free-air anomaly, assuming a gravity gradient of 0.3086 mgal/meter, Bouguer effect, earth tide and drift. The tedious job of correcting the effect of terrain was skipped as the values may be too small to be considered. A density value, 2.67 g/cc, was assumed for all calculations. Earth tide is corrected from data provided by Prof. Izumi Yokoyama and drift is eliminated using a linear drift curve.

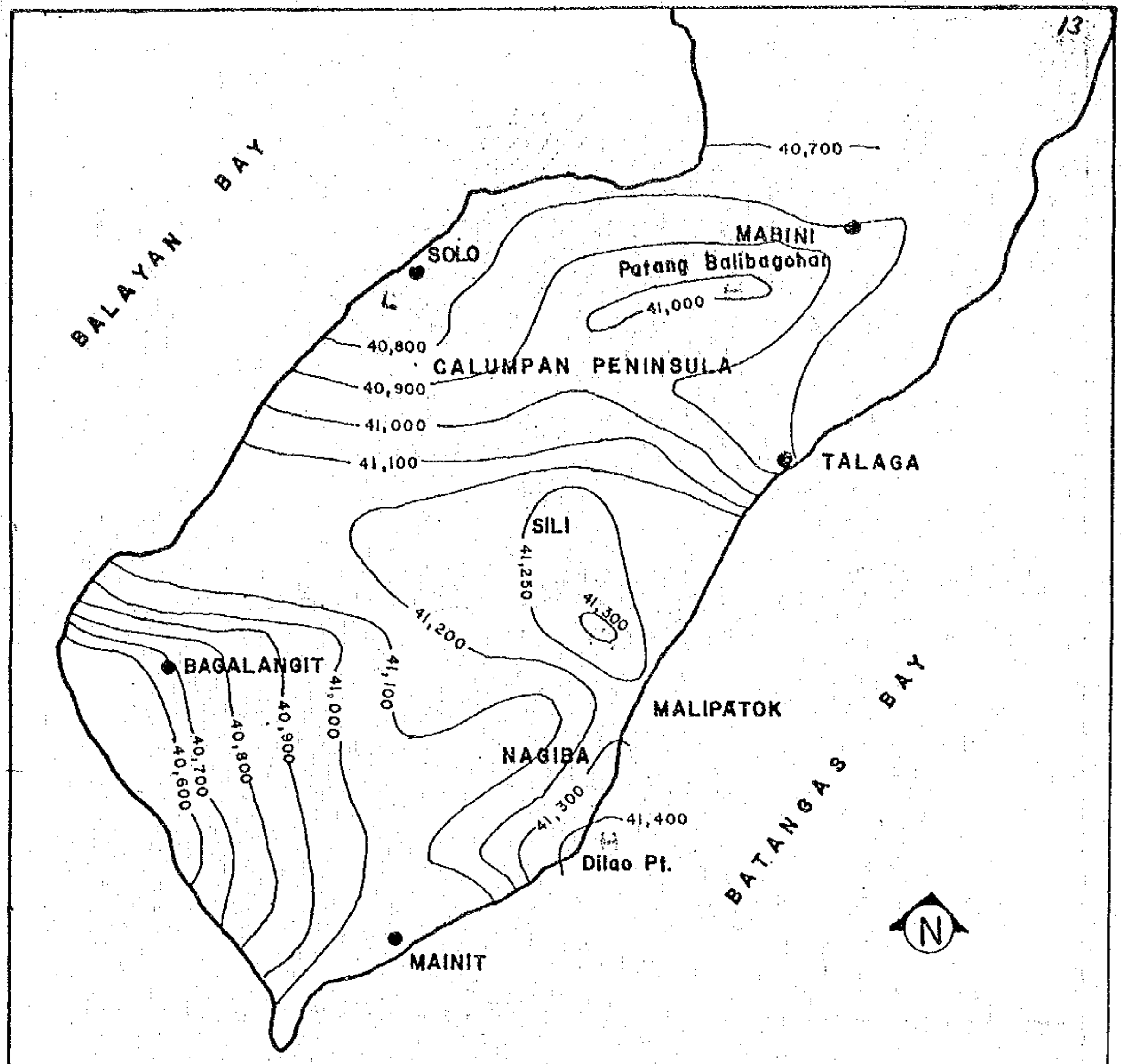
Normal gravity values are then computed using the 1967 Geodetic Reference System (GRS 67) Formula % $= 978.031846\ (1 + 0.005278895 \sin^2\phi + 0.000023462 \sin^4\phi)$ where ϕ is latitude.

Interpretation of Results

The iso-magnetic map of the peninsula shows values from a low 40,700 gammas to a high 41,400 gammas. The low values are confined to the west coast from Culut to Anilao and to the south coast from Bagalangit Pt. to Nagiba. Their presence could best be explained by correlating it with the geology: the areas are underlain by a series of andesitic intrusives and basalts associated with volcanic breccias (belonging to the Calumpan volcanics) and are direct testimonies to the idea that they have undergone volcanic activity for some time and that there have been sources of heat underneath. Their low values suggest that sufficient heat is still stored at depth, thus affecting their magnetization. An increasing trend may be seen at Dilao Point and towards the hinterland, notably, in Mt. Banoy, Sili and Patang Balibagohan. Excepting Dilao Point, these are areas covered by extensive tuff deposits, implying that volcanic activity was not central to these areas.

From the Bouguer anomaly map, however, relatively low gravity values are revealed in the areas of Mabini town proper, Pulong Anahao, Bagalangit and Dilao Point. These may be ascribed to the following: the Mabini town proper has a low-density sedimentary fill while Pulong Anahao, Bagalangit and Dilao Point are, more or less, foci of several fault lines. High gravity values, on the other hand, may be found in the vicinity of Barangays Mabuhayan and Solo. This may be due to the more massive zones of the Calumpan volcanics.

As earlier discussed, areas with geothermal interest are those that show gravity high values with corresponding magnetic low intensities. From the two superimposed maps may be noted that the areas of Mabuhayan, Solo and Mainit possess these characteristics. While Mabuhayan and Solo show no surface expressions of heat outlets, Mainit does, as marked by the presence of hotsprings on its shoreline. The absence of such thermal manifestations in the two abovementioned areas either imply that the volcanics (andesite) in these



ISO-MAGNETIC MAP OF MABINI, BATANGAS

Scale 1:50,000

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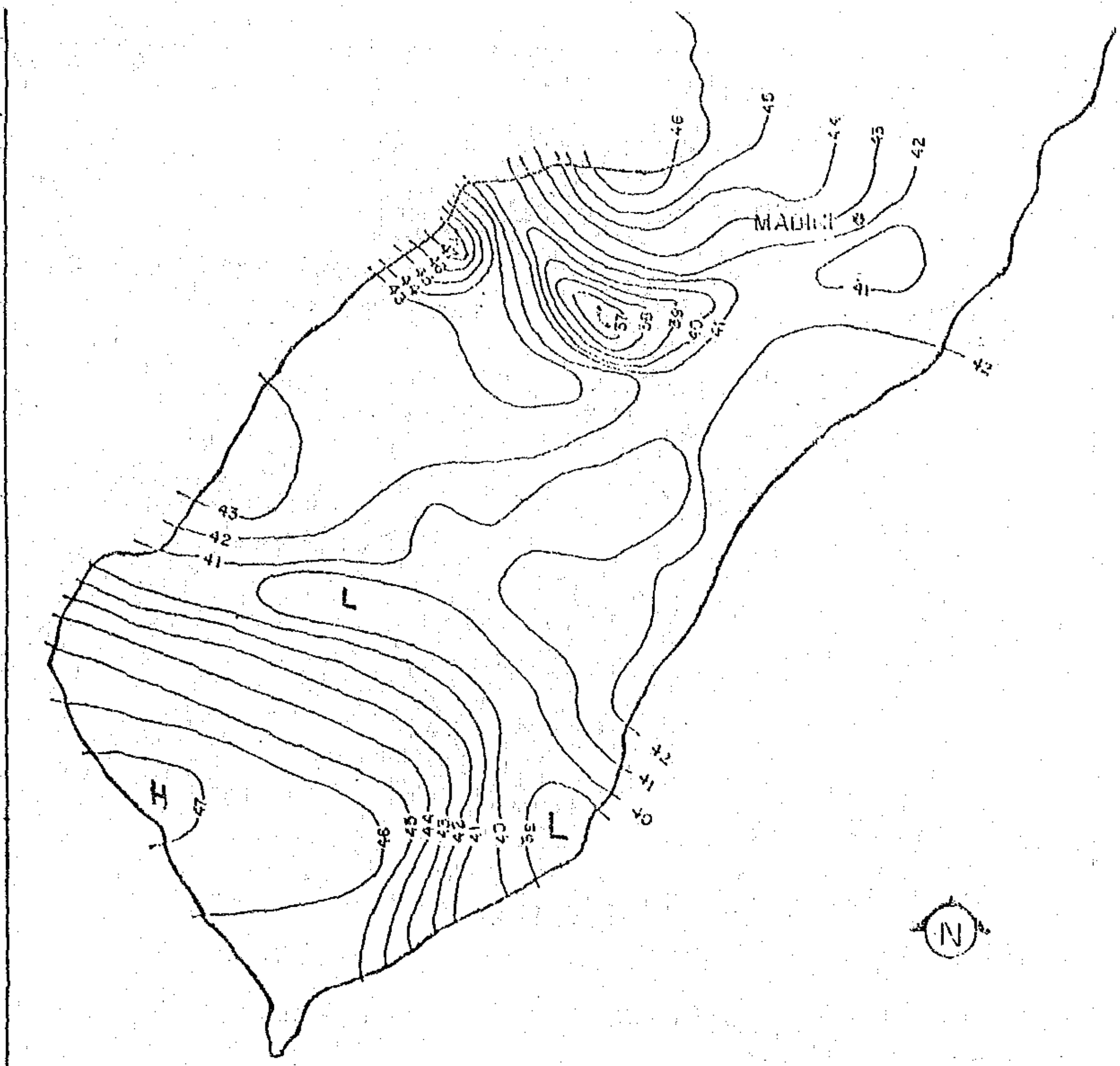

BOUGER ANOMALY MAP OF MABINI, BATANGAS

Scale 1:50,000

COMMISSION ON VOLCANOLOGY

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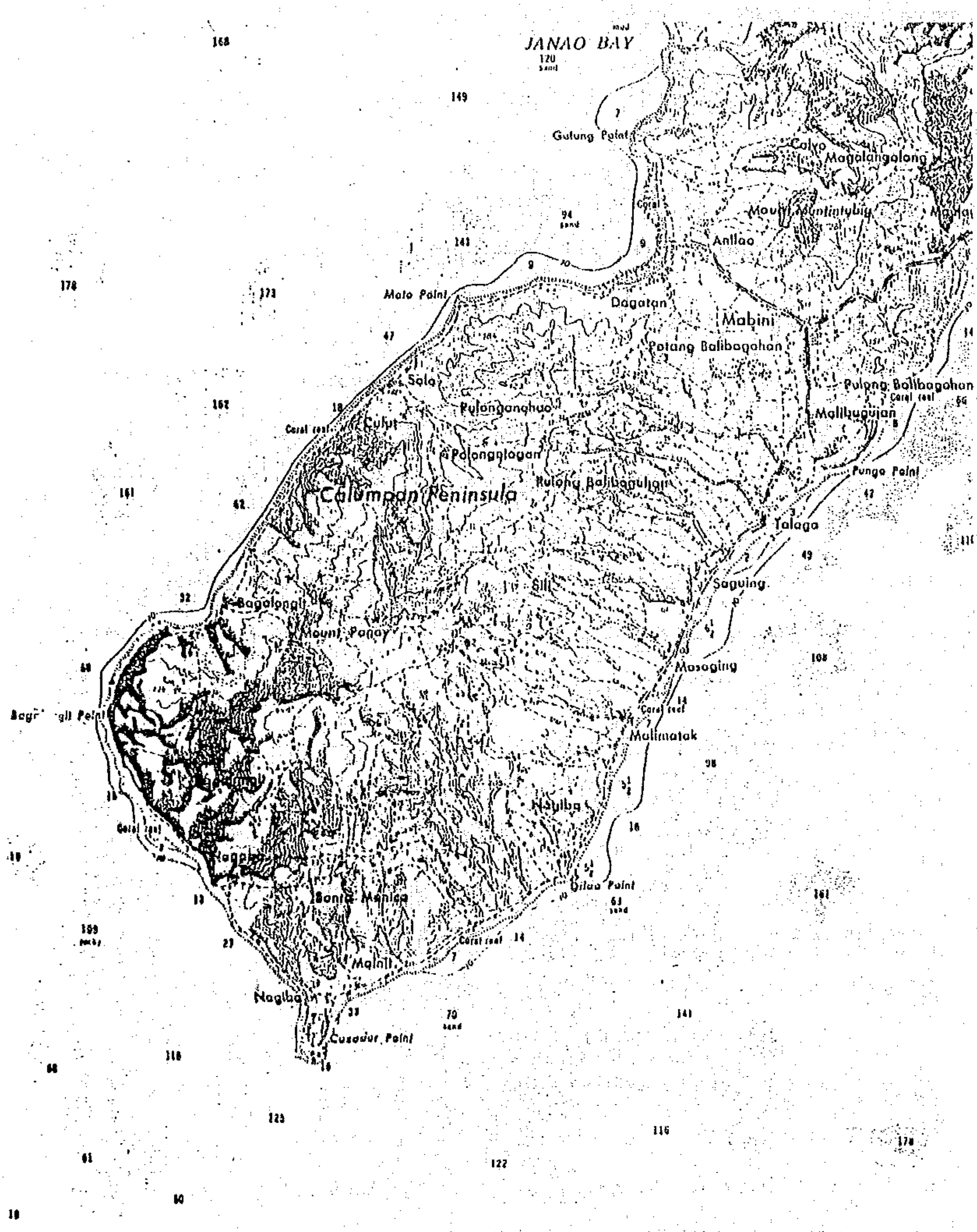


CALUMPAN PENINSULA, BATANGAS

Scale 1:50,000

Preliminary Report On The Resistivity Survey Of Mabini Thermal Area

Manuel Abear, N.C. Baligod and E. Aguas

Introduction

The Commission On Volcanology has been using resistivity method of geophysical prospecting in the studies of thermal areas throughout the archipelago in an attempt to tame one of nature's most elusive potential - geothermal energy. The unmasking of Tiwi, Tongonan and Los Baños geothermal areas coupled with the geographic location of the country are concrete proofs that we are truly in a region that harbors geothermal wealth.

The successess already attained do not stop here but instead, they serve as encouragements. Thus the quest goes on. Consequently, on January 24, 1978, the office sent a party to conduct a resistivity survey in Mabini, Batangas. It is the purpose of this paper to present the results obtained.

A McPhar Resistivity System was utilized and the collinear dipole-dipole method with an electrode separation of 300 meters was used. A current wave was sent through electrodes at the transmitter dipole and the resulting voltage was read in the receiver dipole. Instead of plotting the measured potential, the apparent resistivity was plotted using the formula:

$$p = 2\pi (V/I)(n.r)$$

where:

p - apparent resistivity

V - measured potential

I - current

n - integer

r - electrode separation

Findings and Results

The first resistivity line in the area was laid down from Mainit to Dilao Point. This line, as seen in the isoresistivity contour maps, is close to the shore. The cross section (L-1), as seen on the appendix, shows a high conductivity of the rock formation. From a depth of 300 to 750 meters, no conspicuous variation in the conductivity of the underlying formation is noted. It indicates therefore, that the resistivity of the formation along this line is generally the same in all levels (L-1, L-2, L-3 and L-4). This, however, does not readily indicate that there are no geologic changes. The phenomenon could be attributed to the proximity of the line to the shore. Sea water most probably seeped through fractures and fissures into the rocks nearby, thus making them more conductive. In view thereof, no reliable information can be extracted from it.

Line 2, on the other hand, runs from Tingloy Point to Bagalangit. A glance at the cross section reveals that the conductivity of the formation is high. Except for a few relatively highs randomly located, the resistance of the underlying formation is generally low.

Lines 3 and 4 stretch from Dilao Point to Solo and from Malimatok II to San Teodoro, respectively. These two sections cut each other. They reflect one thing in general. From these sections, one can see no sharp contrast in the rock resistances. Neither can one see a trend that would likely lead to the identification of a possible steam reservoir. It seems that throughout the depth penetrated, the rocks have relatively the same low resistances except for a few isolated occurrences of resistivity highs.

In the above discussions, we have dealt with the rock resistance along the traverse. We now look into the contour maps on which are plotted lines of equal resistivity. Unlike the above, these maps express the lateral variation of resistivity of the ground in the range depth within which the major part of the current flows.

At a depth of 300 meters (N-1), a contour map was constructed (see appendix). Like the cross sections, the resistance at this depth is generally low. There are resistivity highs but rare in occurrence and randomly located. Similarly, at a depth of 450 meters, the same general characteristics are noted. On the other hand, N-3 and N-4 at a depth of 600 and 750 meters respectively, have a slight difference from the other two lateral expressions. However, these differences can not be seriously taken into account due to the fact that the differences mentioned are not sharp.

Conclusions and Recommendations

It could be deduced from the above discussions that the spread of resistivity lines for the assessment of the area is not enough. It needs an additional number of resistivity lines traversing the area of interest to give more reliable result. Without these additional lines, the characteristics of the area for a good geothermal reservoir can not be accurately assessed.

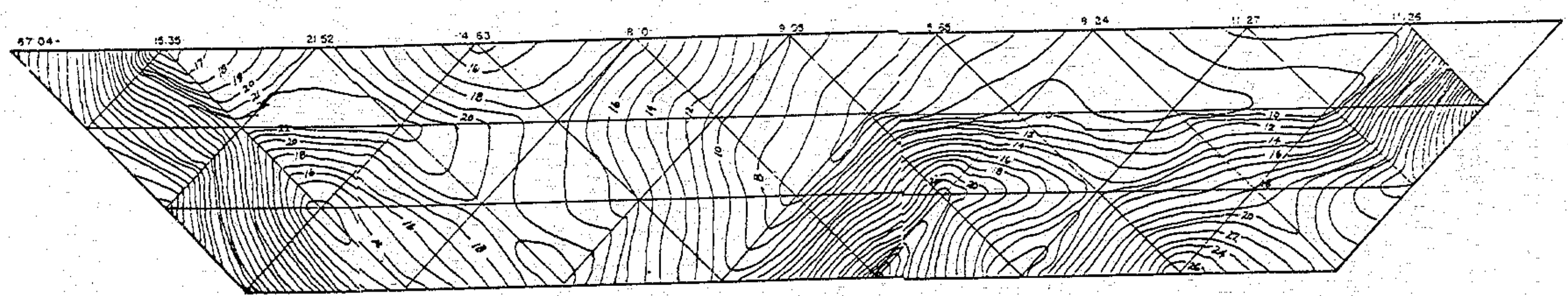
It is also recommended that a deeper penetration resistivity survey be employed.

Acknowledgment

The authors wish to convey their heartfelt thanks and profound gratitude to those who in one way or another extended their untiring help in making this report. Due thanks are also extended to the people of Mabini for their hospitality.

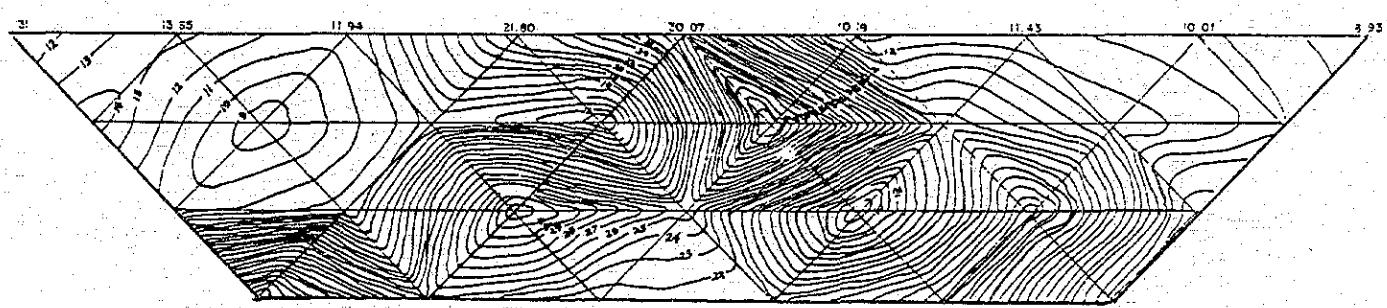
Malimatok to Solo

L-3

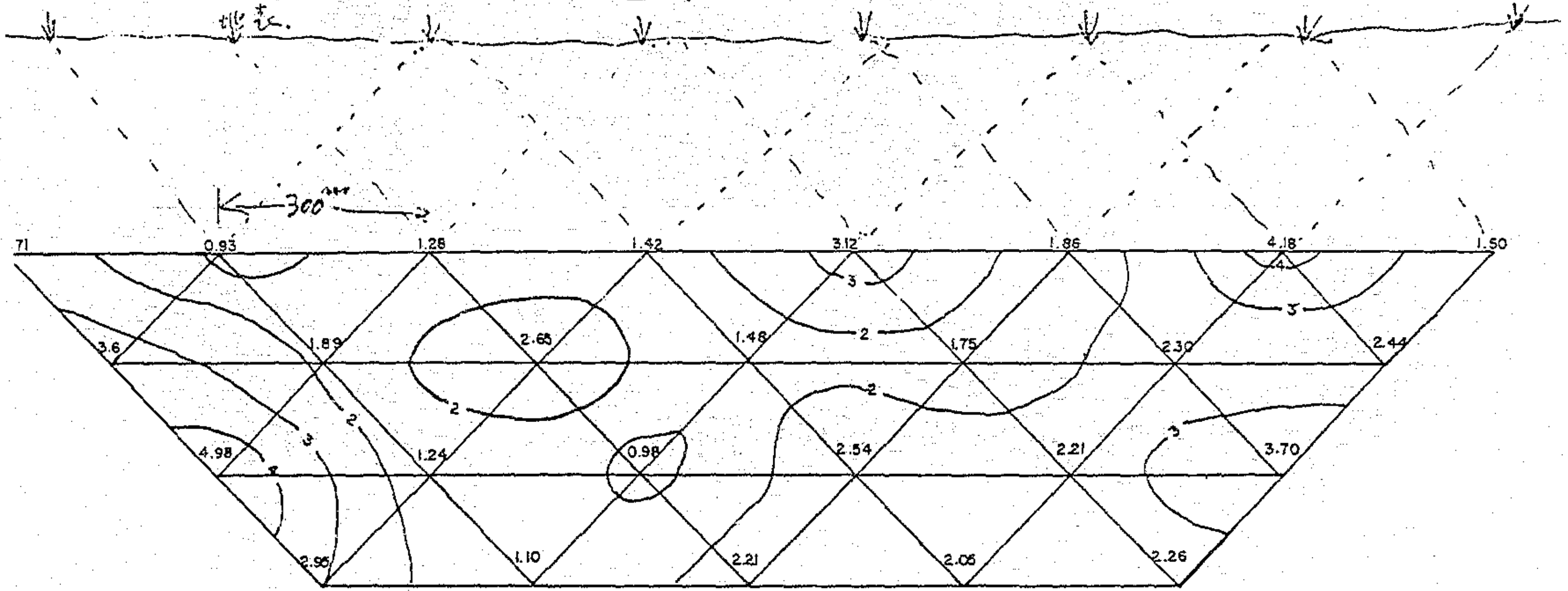


Malimatok to San Teodoro [2/]

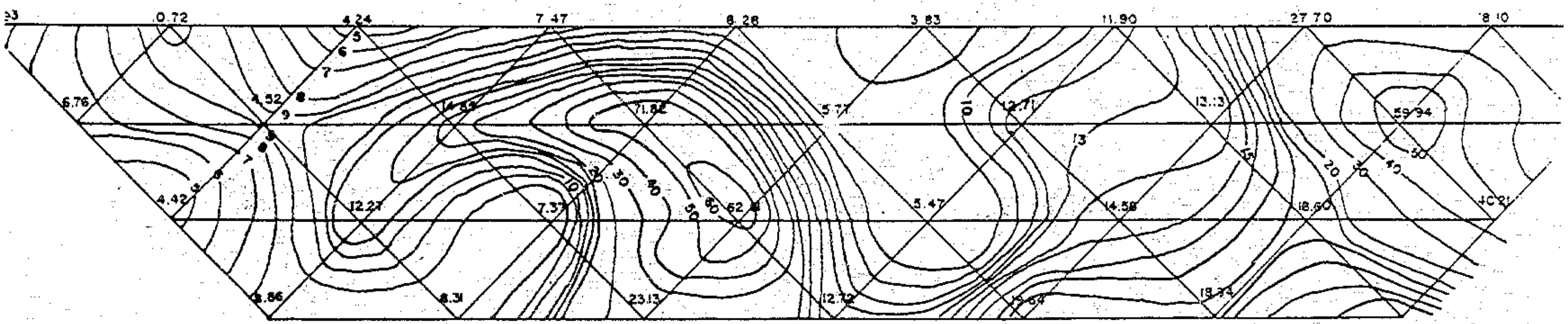
L-4

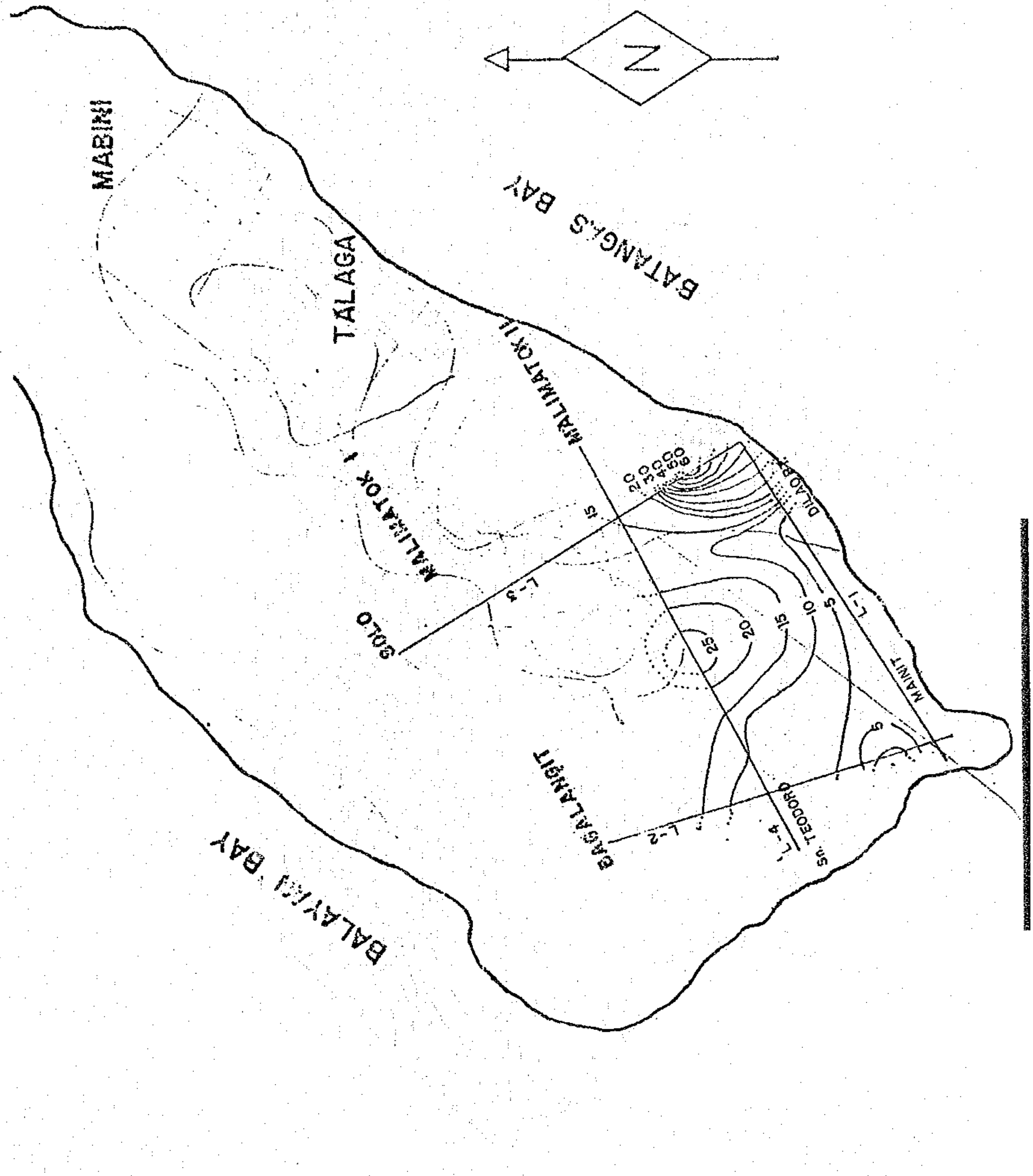


Mainit to Dilao Point
L—1



Casador Point to Bagalangit
L-2

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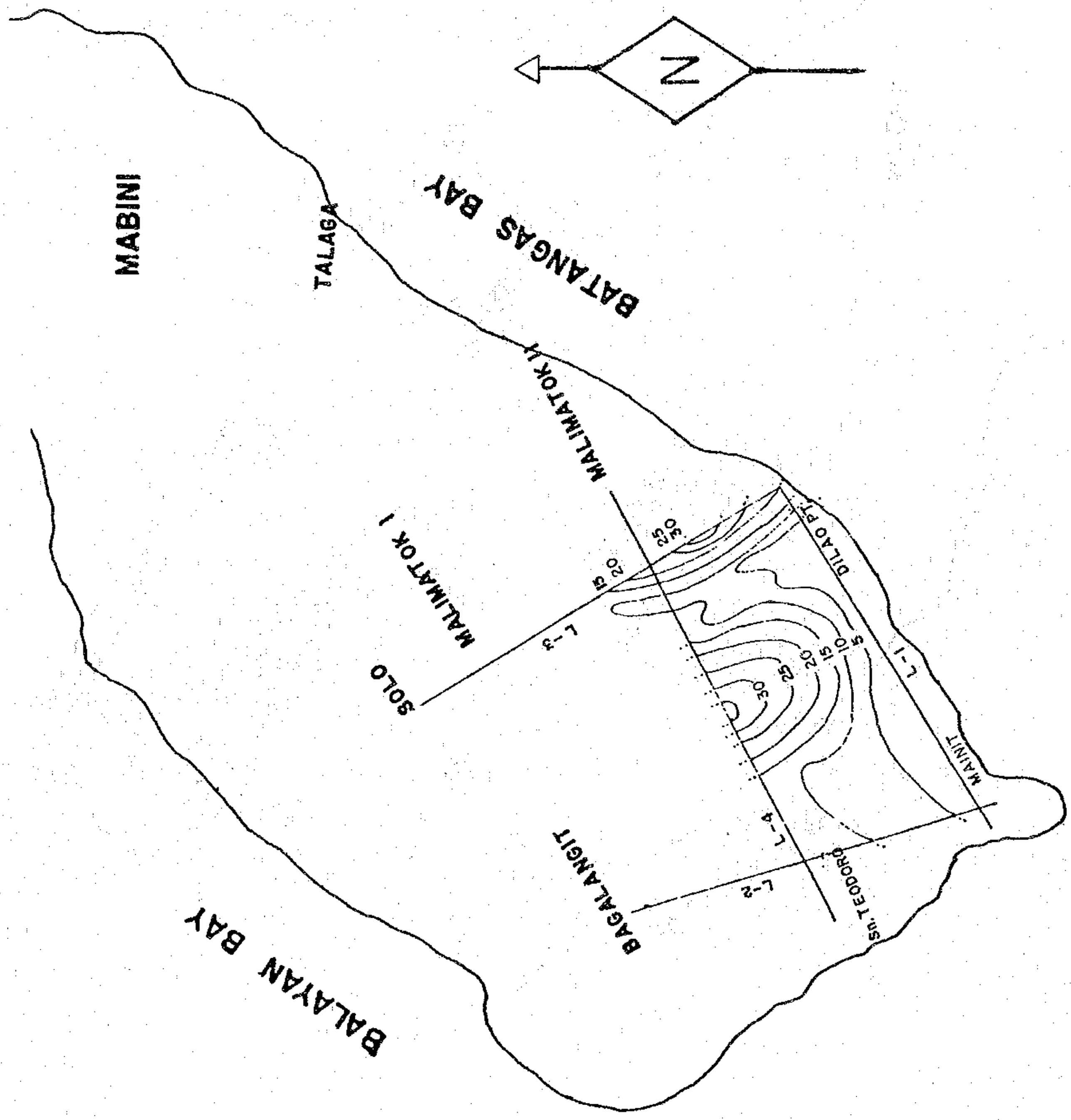
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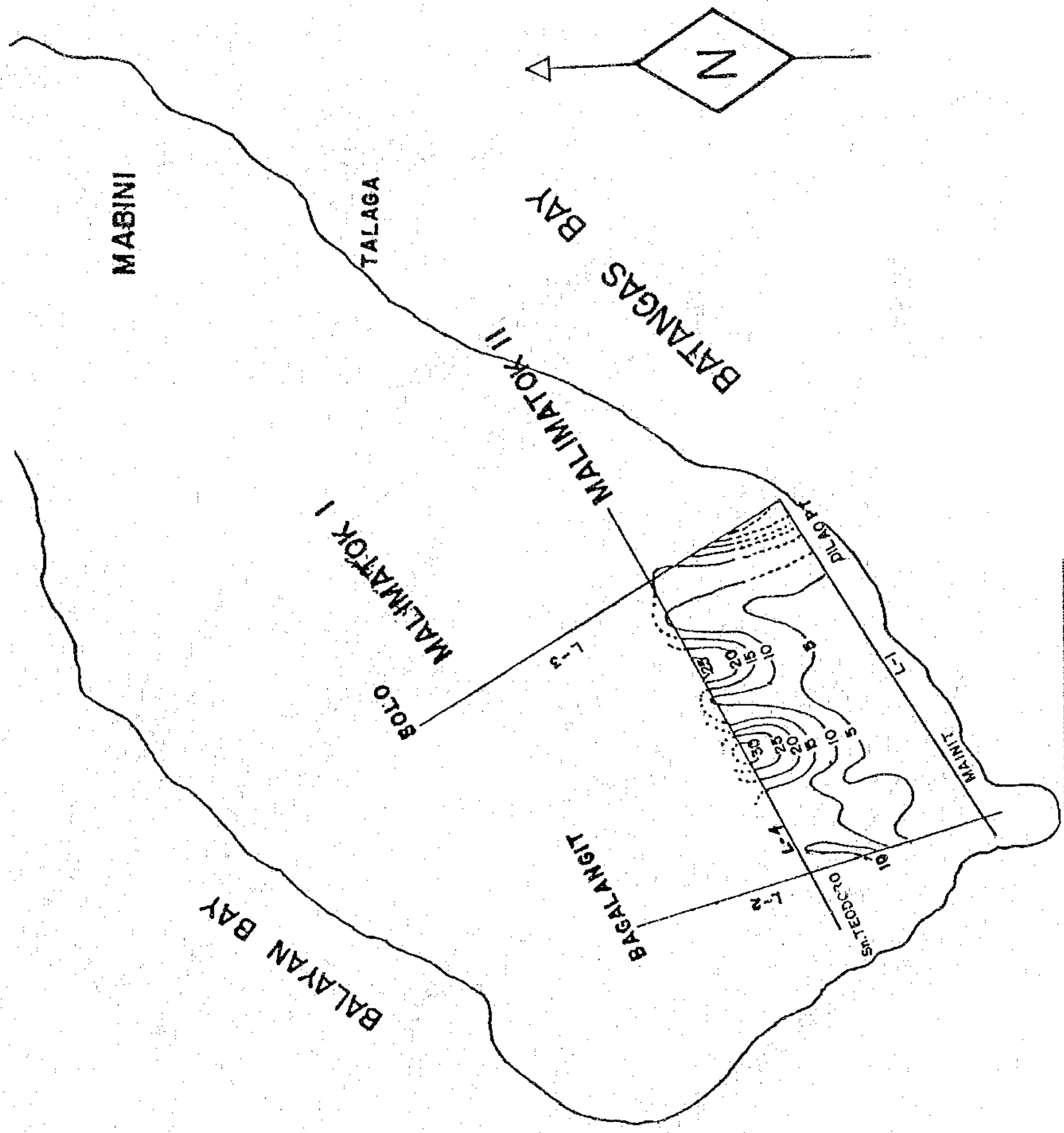
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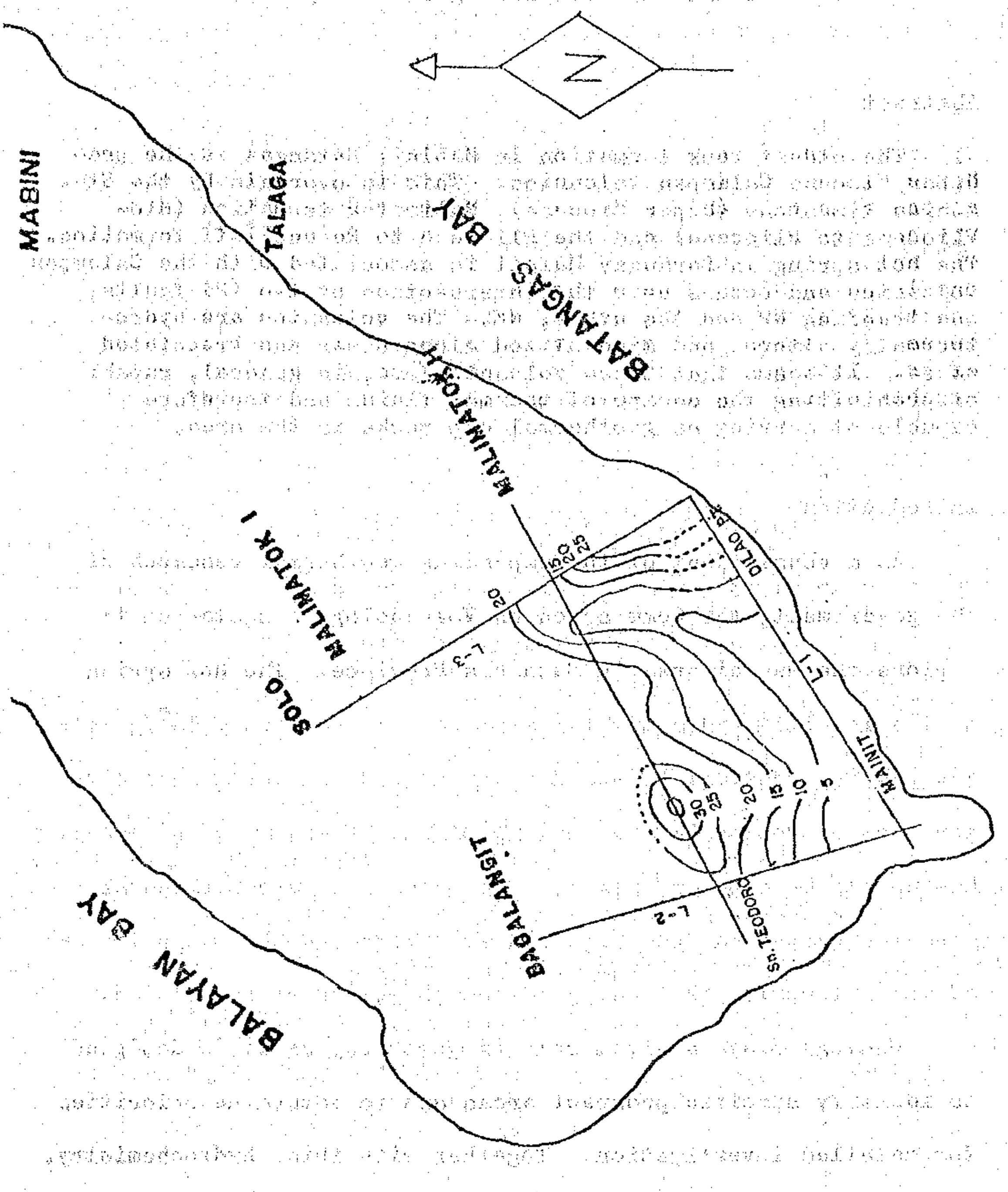
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Reconnaissance Geological Survey of Mabini, Batangas Province

Edmundo M. Ruiz and Agnes G. Reyes

Abstract

The oldest rock formation in Mabini, Batangas is the pre-Upper Miocene Calumpan Volcanics. This is overlain by the Sta. Monica limestone (Upper Miocene), Malimatok formation (Mio-Pliocene to Pliocene) and the Pliocene to Recent tuff formation. The hot spring in Barangay Mainit is associated with the Calumpan Volcanics and occurs near the intersection of two (2) faults, one trending NW and the other, NE. The volcanics are hydrothermally altered and mineralized along shear and brecciated zones. It seems that these volcanics are, in general, capable of prohibiting the escape of thermal fluids and therefore capable of serving as geothermal cap rocks in the area.

Introduction

As a constituent of the expanding geothermal research of the government, the Commission on Volcanology has started to explore the Mabini area in Batangas Province. The hot spring in the locality has a maximum surface temperature of 96°C. The area, being adjacent to the sea, is a good and economical site for a pilot geothermal saltmaking plant. Presently, the locality has no electric power, hence, it is also a good experimental area for geothermal power generation if the geothermal potential of the hot spring is found good enough for power generation.

Geology plays a vital role in geothermy as it is designed to identify specific prospect areas and to determine priorities for detailed investigation. Together with this, hydrochemistry, interpreted within the framework of regional geology and hydrogeology can also be used. Geology has had a most pronounced impact on the economics of nations. Our chief sources of power like mineral fuels have been discovered and pinpointed with the aid of geology.

During the geological survey, other teams from the Commission simultaneously conducted heat-flow measurements, one-meter probehole temperature measurements, geochemical analyses of water samples, and resistivity surveys in the area. The results of these surveys, however, are not included in this paper.

The prime purpose of this report is to present the results and findings obtained from the geological survey. This geologic survey is a part of the systematic geothermal exploration presently being undertaken by the Commission. After the completion of the exploratory surveys it can be ascertained whether or not the hot spring in the area can be used for small scale power generation using the known French technology or if the area warrants drilling for power generation.

Location and Accessibility

The province of Batangas, which surrounds Taal Volcano, is located on the southwestern part of Luzon Island. The province, whose present seat of government is Batangas City, occupies an area of 3,166 square kilometers. It has a large network of transportation facilities that ensures an economical and efficient movement of people, products, and services within and even outside the province. The road condition is comparatively better than those of other provinces. All towns and almost all barangays are accessible by roads.

Batangas is bounded on the north by the province of Cavite, on the east by the provinces of Laguna and Quezon, on the south by the Verde Island Passage which separates it from the northern tip of Mindoro Island and on the west by the China Sea.

Mabini, named after a Filipino hero, Apolinario Mabini, popularly known as the "Sublime Paralytic," is one of the 32 municipalities which comprise the province of Batangas. It lies on the southern portion of the province, west of Batangas City.

The hot spring under consideration is located in Mainit, a shoreline barangay situated within the territorial boundaries of the municipality of Mabini. The hot spring is accessible from the Mabini townproper either by roads which vary from paved, second class roads to dusty, rugged, feeder roads, or by sea using motorized banca originating from Talaga, another shoreline barangay of Mabini.

Barangay Mainit is approximately 15 kilometers (road distance) from Mabini townproper. It is advisable, however, to visit the locality using motorized banca especially during good weather as it is faster and more convenient than using land vehicles due to poor road conditions right after Talaga. From Batangas City, Mabini is 15 kilometers (road distance) away and only about 45 minutes ride using public utility vehicles.

Physiography, Drainage, and Climate

The Mainit thermal area, a part of the Calumpan Peninsula, lies on the elongated southwest trending portion of Batangas province. It is characterized by a moderate to rolling topography with elevations ranging from 30 meters to 501 meters above the sea level in Mt. Panay.

Also present is the marked linearity of the coastlines and the parallelism of the central ridges with the axial trend of the peninsula.

The central portion of the peninsula exhibits radial drainage pattern originating from the base of Mt. Panay trending in all directions from north to south. Saluyan River, the biggest of all the drainage systems in the area and located in the southeastern portion of the peninsula, flows to the southeast direction and drains towards Batangas Bay.

Banana is the dominant plant cover of the southern slope of the central cordillera although patches of coconut orchards are also maintained in the area generally. In areas not yet reached by roads, tall grass, ipil-ipil trees, and thorny bushes, locally called "aroma" abound. Second growth forests remain in the less hospitable and steeper-sloped places.

Characteristic dry season prevails over the area from November to April and wet for the rest of the year. Maximum precipitation occurs in July and August with an average rainfall of 275 millimeters while the minimum occurs in February and March at 25 millimeters. Highest temperature (84°F) is observed during the months of April and May while the lowest (79°F) is in January.

Predominantly, the soil in the area is volcanic tuff which is characterized by a relatively deep soil and rather soft bedrock. It has a texture that ranges from a sandy loam to clay and is suitable for upland crops such as citrus.

Stratigraphy

The oldest rock exposures at the Mabini thermal area are the Calumpan Volcanics, which have been dated Pre-Upper Miocene. These are unconformably overlain by the coralline Sta. Monica limestone which has a probable age range of Upper Miocene to Lower Pliocene.

The intertonguing clastic Nagiba and bioclastic Malimatok formations, both dated as the Mio-Pliocene to Pliocene, are referred to in this paper as the Malimatok formation.

A tuffaceous rock unit has been given probable age range of Pliocene to Recent by a previous investigation. Recent deposits include fluvial and beach deposits.

Calumpan Volcanics

The Calumpan Volcanics are widely distributed throughout Mabini, appearing to be overlain by the limestone formation which has been dated Upper Miocene to Lower Pliocene. These are composed of a series of andesitic extrusives and minor basalt associated with pyroclastic-related rocks like volcanic breccias.

The andesites of the Calumpan Volcanics range from fine-grained to porphyritic, with phenocrysts of feldspar, biotite and hornblende. When fresh and unaltered, these extrusives vary in color from light gray to nearly black, weathering to reddish. Usually the andesites have vague flow-bandings and/or contain inclusions, e.g., stringers of a seemingly more basic material and pebble-sized rock masses merging with the matrix of the rock.

Volcanic breccias are produced by volcanic disruption and are defined as rocks "composed predominantly of angular rock fragments greater than 2 millimeters in size, the brecciation or emplacement or both, of which was the result of volcanic action." (Parsons). The volcanic breccias associated with the extrusives in Mabini are unsorted and poorly stratified. These seem to be monolithic with a fragment to groundmass ratio of about 1:2. The angular to sub-rounded fragments of andesite range from pebble to boulder-sized. Variations in the andesitic fragments sometimes occur, e.g., texture (fine-grained to porphyritic; vesicular to partly amygdaloidal) and color (dark gray to reddish).

Frequently, the groundmass is weathered greenish while the fragments remain relatively fresh. It is composed of a fragmental material of the same composition as the fragments, consisting of lithic material and crystals of biotite and hornblende with fine-grained interstitial material which is clayey and looks like devitrified glass. These volcanic breccias seem to grade into an epiclastic facies.

Throughout the locale, the Calumpan volcanics are fractured; appearing brecciated in some outcrops. Prominent fractures trend S60°E and N55°E. It seems that cataclastic deformation was followed by the introduction of hydrothermal fluids which altered the volcanics along brecciated and/or shear zones and also brought in mineralization. Alterations such as feldspathization, silicification, pyritization and prophylitization occur.

Gypsum seems to occur as fracture vein fillings in prophilitized and pyritized andesite. Veins of gypsum 50 feet thick have reported (Phil. Bu. of Mines Circ. #19). These deposits occur as colorless transparent crystals, sometimes containing clastic inclusions; as massive fine-grained varieties and as earthy dull-colored rock probably with impurities of clay.

The feldspathized andesite usually has a white matrix with laths of feldspar prominent while the dark ferromagnesian minerals have been altered. Commonly, these rocks are altered to a white kaolin-like clay. When the andesite is pyritized, such clay becomes dull gray in color.

Various alterations and mineralizations of the Calumpan Volcanics would provide an interesting study in geothermy.

Sta. Monica Limestone

These massive coralline limestones uncomformably overlie the Calumpan Volcanics. Generally, the so-called Sta. Monica limestones are massive calcirudites with bioclasts of huge coral heads, some coral fragments, algae, and orbitoidal foraminifera. Occassionally, boulders of andesites are found embedded in the limestone.

Fresh rocks are white, quite dense and hard. These weather to a dull pink, becoming soft, porous and marly. The inherent character of the clasts provides primary porosity and permeability while later fracturing provides secondary openings.

Malimatoc Formation

The generally flat-lying Malimatoc formation consists of intertonguing clastic and limestone members. The clastic member is composed of tuffaceous shale and lensoid conglomerate with clasts of pebble to cobble-sized volcanic fragments.

The limestone member consists of calcarenites and calcirudites. Crystal fragments of feldspar, quartz and ferromagnesian minerals together with coral and lithic fragments cemented by a calcareous matrix compose the calcarenites. On the other hand, the calcirudites consist of coral fragments, algae, foraminifera, silicate minerals, lithic fragments, e.g., andesite and basalt fragments, and shells of gastropods and pelecypods. Some of these limestones look like coquina, being composed largely of molluscan fossils embedded in a matrix with about 20% diorite pebbles.

Tuff

The Calumpan Peninsula appears to be blanketed by horizontally lying grayish tuff with varying thickness. A probable age range of Pliocene to Recent has been given by a previous investigation.

This tuff formation has been found to overlie the Malimatoc limestone uncomformably. Tuffaceous beds, measuring about two feet in thickness, grade from conglomeratic tuff to indurated ash deposits. Fragments of the conglomeratic tuff consist of pebble-sized volcanic cinders, black basalt, and altered red basalts.

An interesting layer within these beds contains abundant mudball pisolites or accretionary lapilli averaging about 0.7 cm. These pisolites are generally spheroidal and when cracked open, show concentric accretions of tuff around black glassy basaltic nuclei. This layer seems to be widespread in Mabini.

Recent Deposits

The most recent deposits are unconsolidated alluvial and beach deposits. The alluvial and beach deposits are silty to gravelly rock materials, e.g., andesite, basalt, volcanic cinders and limestone.

Structures

The Calumpan Peninsula, wherein the Mabini thermal area is situated, juts out as an elongated land mass into the Balayan and Batangas bays. Its axis trends NE-SW.

A strong correlation between structures and topography in the area is evinced by the marked linearity of the coastline and the parallelism of the central ridges with the axial trend of the peninsula.

A number of evidences pointing to the presence of faulting in the area have been observed:

1. The area is highly fractured with prominent fractures trending S60°E, NS, and N60°E. East-west fractures are less frequent. The NS fractures have high dip angles while those trending SE and NE dip about 50°.
2. Gouge-lade SE-trending fractures have been observed on the east side of the peninsula.
3. The general parallelism of creeks (SE-trending) as viewed from topographic maps.
4. Steep river banks.
5. Waterfalls at Saluyan River and at Catacbakan Creek have been found while a cold spring gushing out of fractured

andesite occurs near Barangay Solo.

The area has been inadequately studied by the field party and the faults plotted on the map are mostly merely inferred.

Conclusions and Recommendations

The stratigraphy and the structural make-up of the Mabini thermal area encourage further study of the area.

The Pre-Upper Miocene Calumpan Volcanics could serve as the caprock. Fractures on these extrusives had served as venues for hydrothermal alteration and mineralization prior to Upper Miocene. Since hydrothermal alteration had occurred, a source of hot mineralizing fluids, perhaps a magmatic chamber, or an intrusive body. It is possible that this heat source is still extant and the presence of the hotspring on the volcanics could be one of its manifestations. It is also possible that the heat source is different from that which produced the Pre-Upper Miocene thermal metamorphism.

In view of this, we wish to recommend the following:

1) A detailed geological survey of the area should be conducted to find out the following:
   a) the structures and other geologic parameters which control the surficial geothermal manifestations;
   b) delineate the various alterations of the extrusives;
   c) the source of the Pre-Upper Miocene volcanics and the

Pliocene to Recent tuff; and,

d) to pinpoint specific areas for exploratory drilling.

2) Aerial photographs of the area should be obtained before the next geologic survey.

3) Magnetic and gravity surveys should be conducted in the area to give additional data deemed necessary for the proper evaluation of the area's geothermal potential.

Acknowledgment

In behalf of the Commission on Volcanology, we wish to convey our most profound gratitude to Mr. Bonifacio Ilagan, Barangay Captain of Mainit, Mabini, Batangas for the invaluable assistance extended to us during the duration of the survey. Thanks is also due to Honorable Mayor Basilio Calangi of Mabini who, without his help, our survey could not have been a successful one.

Appendix

Table 1: Stratigraphic Sequence

Age	Formation	Description	Environment of Deposition
Recent	Alluvium	silts, gravels and sands	Terestrial
Pliocene to Recent	Tuff	bedded tuff	Marine to Terrestrial
Mio-Plio-cene to Pliocene	Malimatoc	intercalated tuffa-ceous shale and bioclastic limes-tone	Marine
Upper Miocene	Sta. Monica Formation	Coralline limestone	Marine
Pre-Upper Miocene	Calumpan	Andesite extrusives volcanic breccias	Terrestrial to Marine

Table 2: Tentative Megascopic Analysis of Rock Samples Prior to Microscopic Study

SAMPLE NO.	LOCALITY	FORMATION	DESCRIPTION
SR-1	Saluyan River	Calumpan Volcanics	Red Andesite
SR-2	"	Sta. Monica Limestone	Coralline limestone
SR-4	"	Malimatoc	Bioclastic limestone with predominating clasts of molluscan fossils
ST-1	Bry. San Teodoro	Calumpan Volcanics	Gray andesite
ST-2	"	Malimatoc	Bioclastic limestone
M-3	Brgy. Mainit	Calumpan Volcanics	Volcanic breccia with angular fragments of dark gray andesite
M-4	"	"	Green altered andesite with epidote, chlorite, fs, cp, py, and fracture fillings of $CaSO_4.2H_2O$
M-6	"	"	Gypsum variety Satin spar
M(II)-1	Brgy. MalimatocII	Malimatoc	Bioclastic limestone
An-1	Brgy. Dagatan	Calumpan Volcanics	Red andesite
An-2	"	"	Green altered and.
An-3	"	"	Feldspathized and.
An-4	Brgy. Solo	"	Gray Biotite-hblde and.
An-5	Brgy. Pulut	"	Green and. (altered) with epidote, chl, prominent fs.
M(I)-1	Brgy. Malimatoc	"	White altered feldspathized and. weathering to white clay

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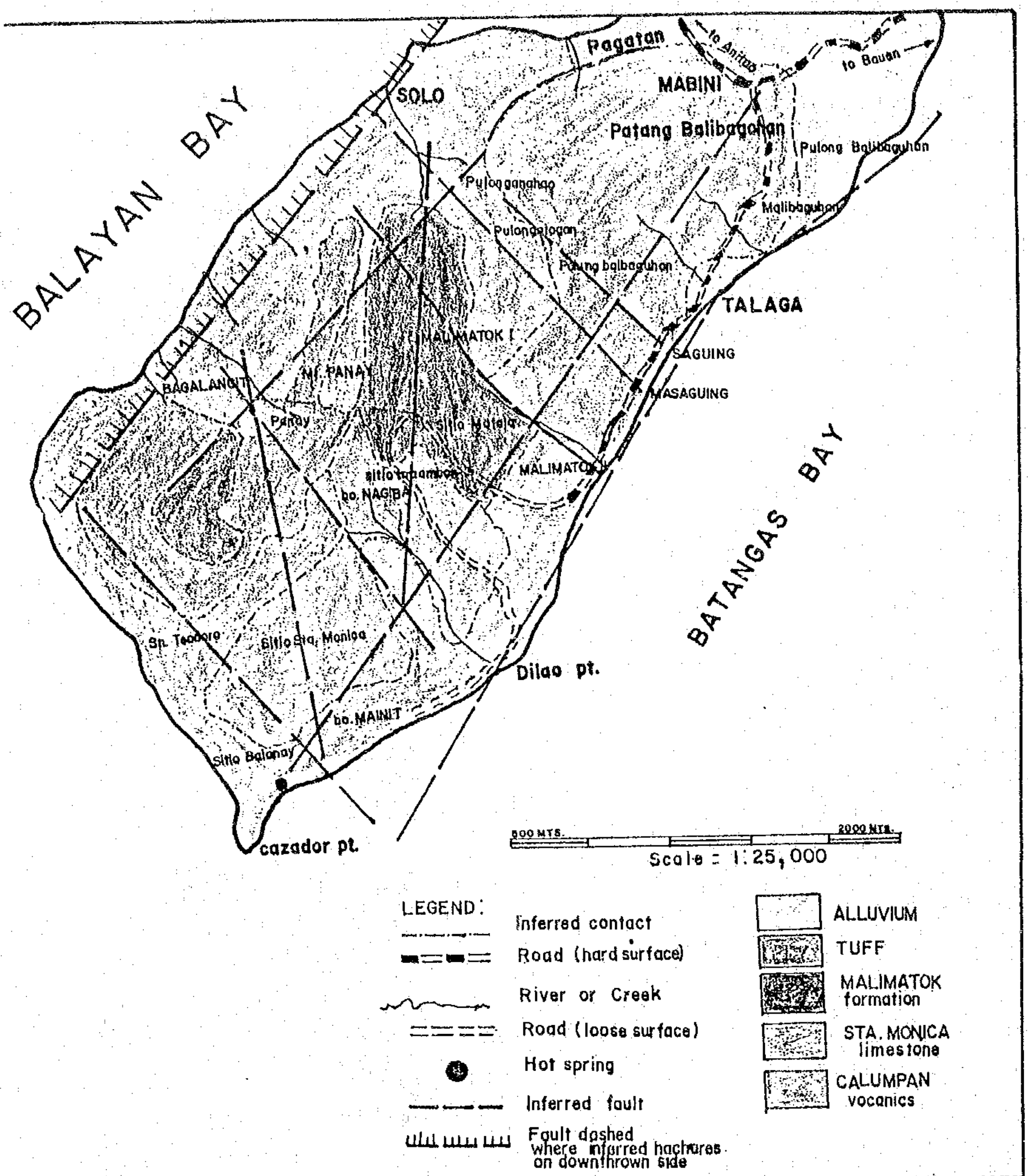

MAP OF MABINI, BATANGAS
(RECON - GEOLOGICAL MAP)

Prepared by:
COMMISSION ON VOLCANOLOGY

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

JAPAN INTERNATIONAL COOPERATION AGENCY

L E G E N D

- ROUTE FOR SURVEY
- ALTERATION ZONE
- HOT SPRING
- × × × OFFSHORE HOT SPRING

Fig. 7.5 ROUTE MAP IN MABINI AREA

JICA