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Notes on the Thermal Fields of Talasea, Pangalu, and Kasiloli, New Britain, TPNG

by

R.F. Heming and I.E. Smith

NOTES ON THE THERMAL FIELDS OF TALASEA, PANGALU AND KASILOLI, NEW BRITAIN, T.P.N.G.

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SUMMARY

The Talasea, Pangalu, and Kasiloli thermal fields are associated with a belt of Quaternary to Recent volcanic activity extending along the north coast of New Britain.

The Talasea and Pangalu fields occur around Garua Harbour in the central Willaumez Peninsula; they contain geysers, high pressure fumaroles, hot springs, and mud pots. Letter symbols are used to distinguish individual thermal areas within the fields. Activity in the Talasea and Pangalu fields appears to have declined over the past 13 years.

The Kasiloli thermal field lies at the base of the Hoskins Peninsula. It consists of 3 distinct areas, two of which are described in this report. Kasiloli No. 1 is a shallow depressed area about 50,000 square metres in area, containing a geyser, some very active boiling springs, hot and warm springs, mud pools, and gas vents. Activity is variable, but a recent increase in the level of activity is indicated. Kasiloli No. 2 is a decadent thermal area of about 1,000 square metres, containing a few pools of bubbling mud and some gas vents.

The chemical analyses of 19 water samples from the Talasea, Pangalu and Kasiloli fields are tabulated and summarised in total ion/pH and total ion/temperature plots.

INTRODUCTION

Thermal fields containing geysers, boiling springs, and mud pools occur at Talasea, Pangalu, and Kasiloli in central New Britain (Fig. 1). The thermal activity is associated with the Quaternary to Recent volcanic belt extending along the north coast of New Britain. In this report, descriptions of the Talasea (R.F.H.), Pangalu (R.F.H.), and Kasiloli (I.E.S.) thermal fields are presented. Chemical analyses of the thermal waters in the fields are given in Appendix 1.

TALASEA AND PANGALU THERMAL FIELDS

INTRODUCTION

The Talasea and Pangalu thermal fields occur around the shores of Garua Harbour in the central part of the Willaumez Peninsula (Fig. 1). Thermal activity was first investigated by Fisher (1939, followed by Reynolds (1954). The area was revisited during April, 1967, to investigate a number of previously undescribed thermal areas noted on aerial photographs and to collect data for inclusion in a report to the 23rd International Geological Congress (Prague).

Thermal manifestations in the area comprise geysers, high pressure fumaroles, hot springs, and mud pots. Reynolds (1954) referred to separate areas of thermal activity as zones, and used letter symbols to distinguish them. In this report Reynolds' lettering system is adopted, and is extended to the previously undescribed areas.

The zones on the southern side of Garua Harbour are situated near the edges of lava flows. Those on the northern side of the harbour do not show any specific relationship with one another or with the volcanic centres in the area. Zones E, G and F (Fig. 2) occur close to volcanic centres; Zones H, I, and J (Fig. 2) show a north-north-easterly alignment in flat lying country west of Pangalu.

GEOLOGICAL SETTING

The Willaumez Peninsula is composed almost entirely of volcanic material. Volcanic peaks and lava flows form the high ground behind Talasea sub district headquarters and Bitokara Mission, and extend inland to Mount Schleuther (349 metres). Most of this area is composed of stumpy obsidian flows, although banded basalt crops out between Zones A and C near Talasea. To the north is a flat lying area of uplifted coral and volcanic detritus on which the Talasea airstrip is situated. Farther northwards extinct volcanic peaks, rising to 615 metres above sea level, form the backbone of the peninsula extending to Mount Bola.

TALASEA THERMAL FIELD

The Talasea Thermal Field consists of five zones of activity (K, A, B, C, D - Figs 2 and 3), extending inland south-eastward from Talasea.

Zones A to D are arranged around the edge of a basalt flow cropping out between Zone A and Zone D. All are apparently due to heated water emerging from the base of the flow. In Zones C and D, heated water and gases rise through cracks in an altered basalt thickly coated by a ferruginous deposit which in most places is overlain by a coastal marsh deposit.

Other thermal areas probably exist about four kilometres south-west of Mount Schleuther (Fig. 1), but none were definitely identified on the aerial photographs.

Zone K

This zone contains two small areas of activity close to the track leading to Bola village. Activity occurs along a narrow depression in weathered obsidian. The south-eastern area contains a number of small bubbling pools surrounded by a thin sinter crust. Temperatures in the pools ranged from 77°C to 95°C. The temperature measured at a small fumarole in the southern part of the area was 98°C.

The north-western area is of similar size, and displays similar phenomena to the south-eastern one; in addition it contains a powerful fumarole which, judging from mud spatter on the surrounding vegetation, has ejected mud to a height of 3 metres above the orifice. The highest measured temperature in this area was 96°C.

There is less sinter in the north-western area, and both areas smell strongly of hydrogen sulphide.

Zone A

This zone consists of two areas, each displaying slightly different forms of activity.

The northernmost one, situated in thick forest, is less than 30 metres in diameter, and contains mud pots, muddy pools, and fumaroles; gas ebullition occurs in the pools. Temperatures ranged from 40°C in the pools, through 50°C in pots of viscous mud, to a maximum of 87°C in a fumarole which had mud spatter around the orifice.

The second area, situated a short distance to the south, lies in a stream bed near the edge of an outcrop of basalt lava. It is about 15 metres long and 6 metres wide. The floor of the area is covered by a sinter crust, stained red and green in places, through which protrude boulders of altered basalt. Pools and springs abound. Gas ebullition occurs at a high rate in the pools, which are vigorously disturbed, and along the stream bed. The smell of hydrogen sulphide pervades the area.

The eastern part, close to where the stream leaves the thermal area, is the least active part. Temperatures of 87°C and 88°C were recorded here.

The central and western parts of the area are more active, and contain a number of vigorously boiling pools and springs whose temperatures range from 85°C to 94°C. A fumarole breaking through an outcrop of weathered basalt at the edge of the area had a temperature of 67°C.

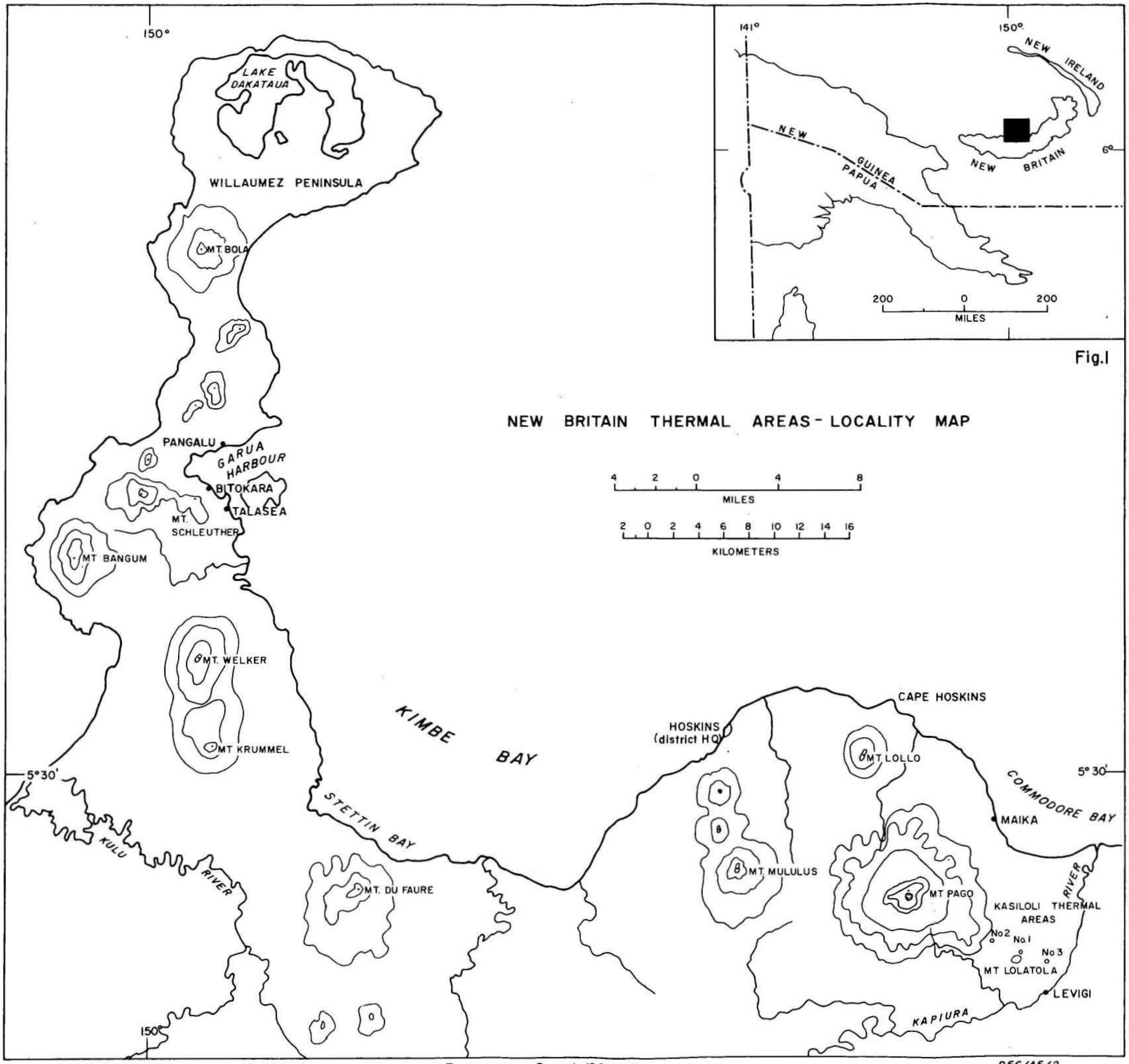

Fig.1

NEW BRITAIN THERMAL AREAS - LOCALITY MAP

To accompany Record 1969/115

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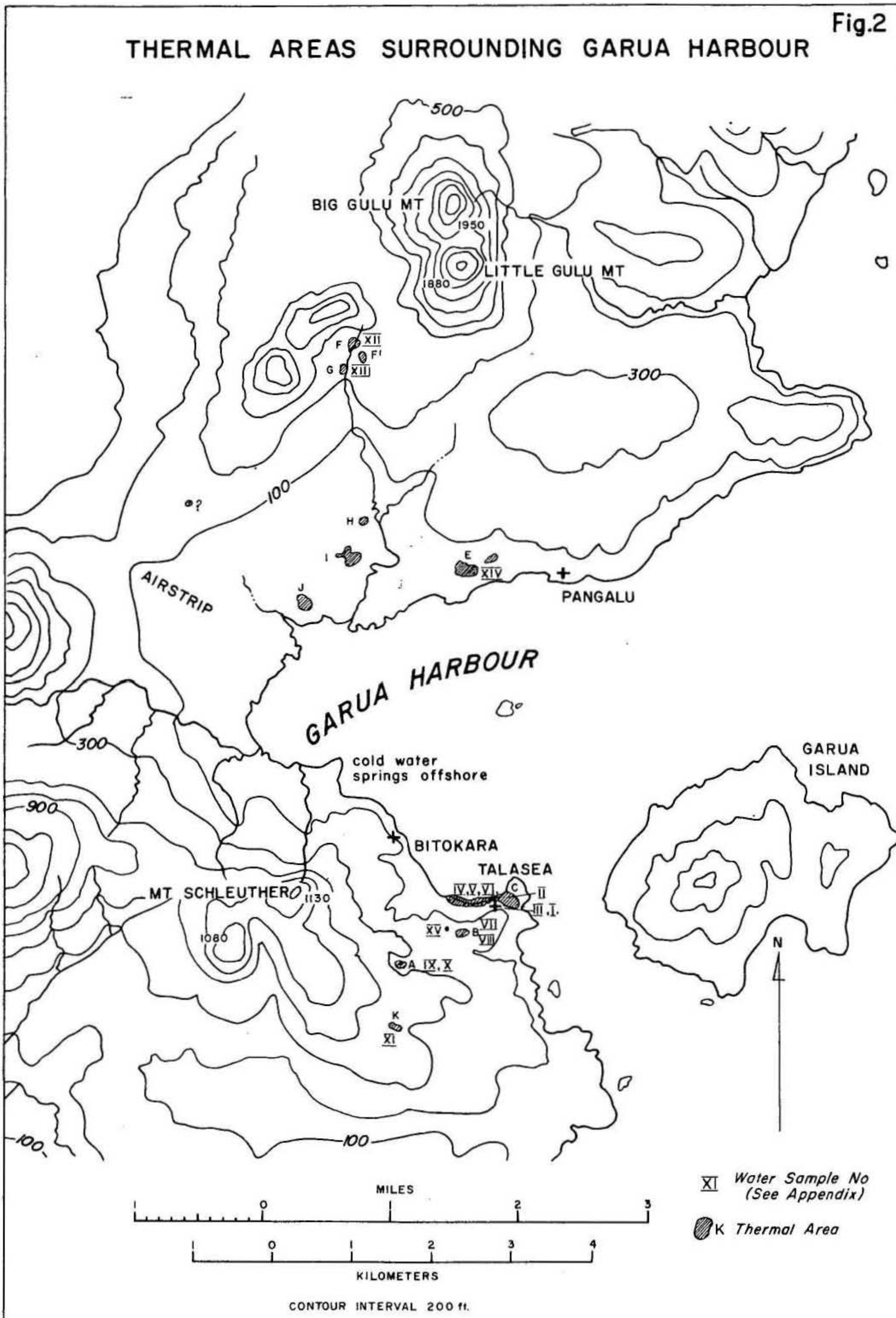

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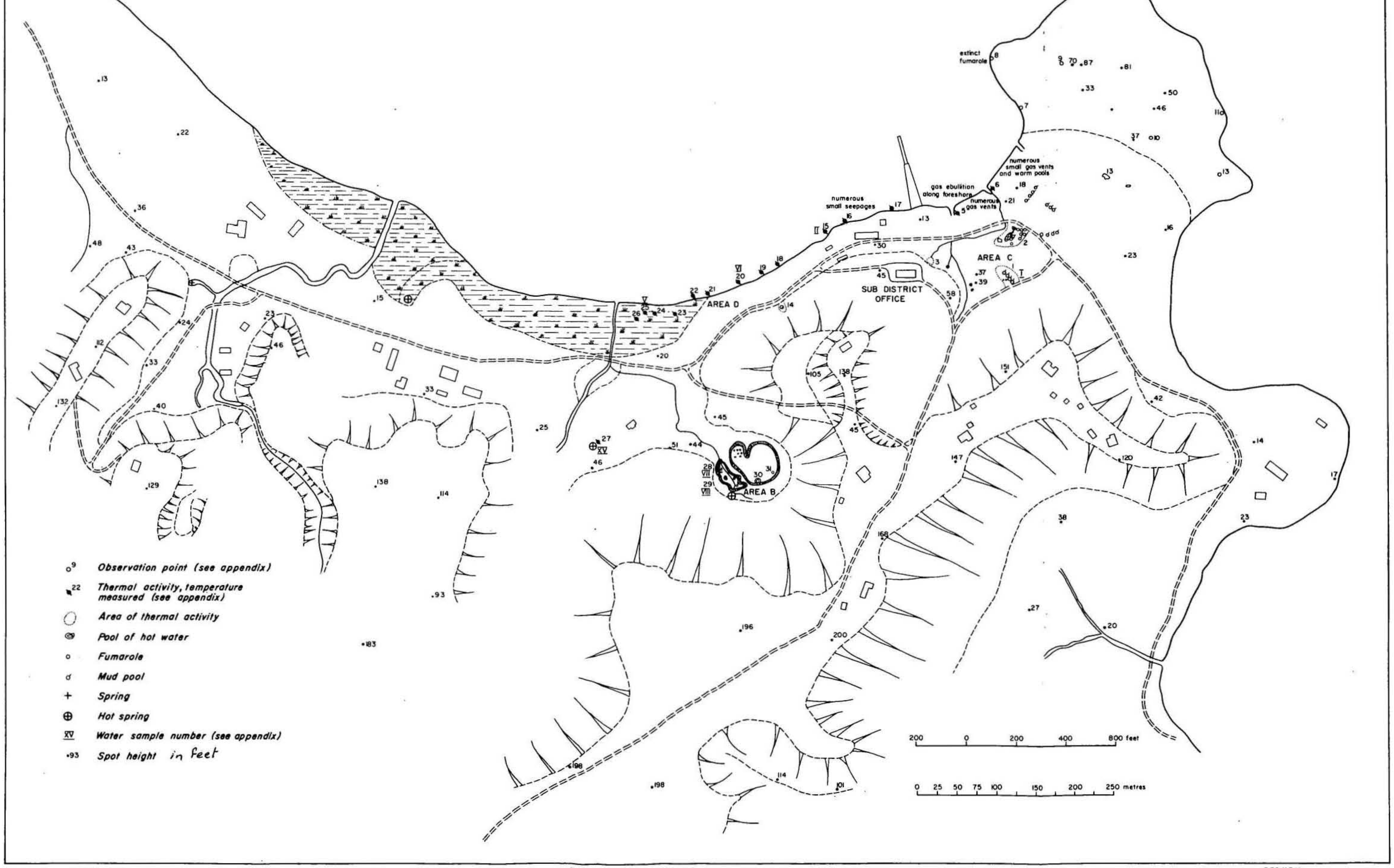
Fig. 3

THERMAL ACTIVITY IN THE TOWNSHIP OF TALASEA



Zone B

The zone is situated in an embayment in a lava flow, and is similar in many respects to Zone A. There are two areas of activity, a small active area along the bed of a stream issuing from the base of the lava flow, and a larger less active one to the east (Fig. 3). Both areas occupy depressions, about 1.3 metres below the surrounding land surface, in a chaotic deposit of hard red clay mixed with sinter.

The western area consists essentially of three embayments along the stream, each one no more than 8 metres wide, floored with boulders of altered basalt set in a chaotic deposit of red clay, sinter, and, rarely, sulphur. Breaking through this surface, which in many places is no more than a treacherously thin crust, are fumaroles, hot springs and pools of hot water whose surface is disturbed by gas ebullition. A warm stream enters the area from a spring, at the base of a lava flow, with a temperature of 43°C, and leaves the area at a temperature of 50°C. The highest recorded temperature in the area was 94°C in a fumarole, temperatures in other fumaroles ranged downward to 69°C.

The eastern area is a large almost circular depression floored with chaotic sinter and red clay. Its activity is confined to a number of hot springs along the southern edge and some small fumaroles in the north-western part of the area. The fumaroles yielded the highest temperature, 99°C, the springs and boiling pools were between 84°C and 95°C.

The smell of hydrogen sulphide is quite strong throughout the zone, and small amounts of sulphur occur around active vents in both areas.

Zones C and D

Thermal activity in this area manifests itself as mud pools and mud pots with gas ebullition (the smell of hydrogen sulphide is strong), fumaroles, and hot springs. Gas ebullition in hot springs occurs along the shoreline, and an area containing pools of fetid mud extends east of the District Office (Fig. 3). The highest temperature of 95°C was found in Area C1 (Fig. 3); in Area C2 they ranged from 75°C to 85°C, whereas Point 3 yielded a temperature of only 40°C.

PANGALU THERMAL FIELD

The Pangalu field is probably more active than the Talasea field. At Pangalu itself (Zone E) there are an active geyser and some springs, on the bed of a small lake producing hot water at a temperature of 104°C. Zones F to J are arranged along a north-south line. A very powerful fumarole is located in Zone F.

No field evidence was found to prove that these zones are arranged along a fault line, although on the aerial photographs a prominent lineament was observed. Zone E is at the base of a conical hill with some thermal activity near the summit; this hill appears to be the remnant of a small volcano.

Zone E

This zone is on the northern side of Garua Harbour west of Pangalu Village (Fig. 2), it is larger than any of the other zones, and contains a vigorous geyser (Plate 1b).

The zone is elongated in a north-westerly direction. At the north-western boundary there are two deep mud pots containing a grey viscous mud; south-east of these there is a fumarolic area floored with chaotic red clay mixed with sulphur and sinter. The fumarolic area ends abruptly against a ridge of decomposed lava on whose south-eastern flanks are two geysers. The smaller one near the crest of the ridge is only mildly active; the other is vigorously active, and throws up a thick column of white gas charged water to a height of 6 metres about every forty-five seconds. Extensive sinter terraces flank the sinter mound around the orifice of the geyser, and descend to a shallow lake which occupies most of the south-eastern part of the area. Gas bubbles ascend continuously from the bed of the lake, and there are also a number of hot springs on the lake bed. The temperature of one of these springs was 104°C, compared with temperatures of 100°C in the mildly active geyser, and 95°C in one of the fumaroles.

The other area in Zone E is situated on top of the small hill which is probably an eroded volcanic cone.

Zone F

Zone F (Plate 1a) is situated two miles to the north-west of Pangalu Village, and consists of two areas displaying dissimilar kinds of activity.

Along a north-west trending ridge fumaroles break through gaps between blocks of a spongy highly decomposed lava. The gas everywhere escapes gently. The maximum temperature in this area was 100°C.

The other area is quite different. Here hot springs and a high-pressure fumarole occur in a small area on the floor of a narrow valley drained by a small stream. The fumarole emits mainly water vapour, at high pressure, with a whining roar. The pitch of the sound is determined by a boulder which is jammed in the vent, splitting the vapour jet. A thin crust of siliceous sinter surrounds the main fumarole; it is undermined in places, and punctured by small hot springs. The temperature of one of these springs was 90°C. A large pool of warm muddy water lies close to the outflow stream and another small warm spring was found a few hundred metres downstream.

Plate 1a: Pangalu thermal field - general view of Zone G.

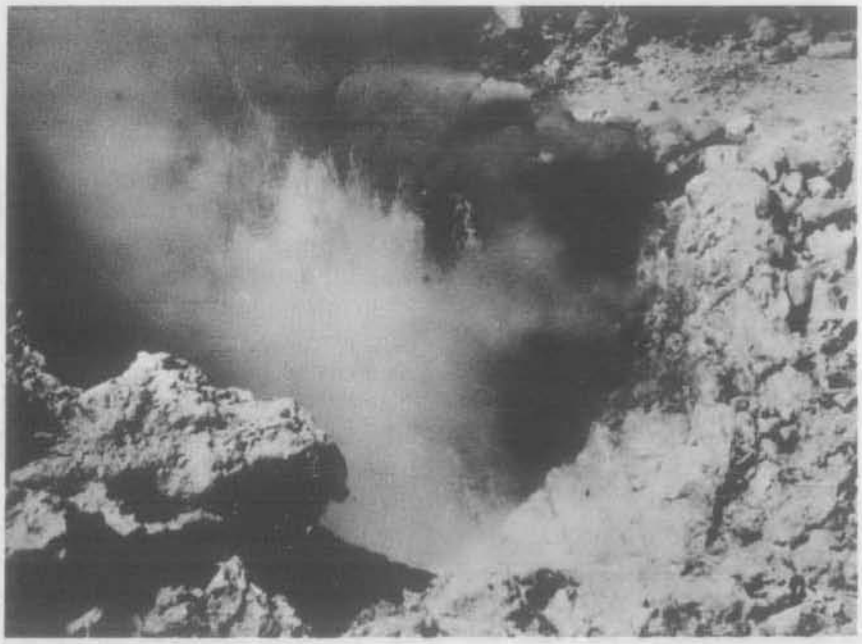


Plate 1b: Pangalu thermal field - Zone E. Pangalu geyser at the beginning of an eruption.

To the south-south-east of this area there is another thermal area which was not visited. It is marked F[1] on Figure 2.

Zone G

This zone consists of one thermal area lying across the stream running from Zone F. It measures about 30 metres by 20 metres.

The major feature of this zone is a large pool of muddy-yellow water surrounded on three sides by banks of highly decomposed lava. On either side of the stream there are gravel flats through which a number of hot springs break out. Spring temperatures ranged up to 100°C. Another spring breaking out near the pool had a temperature of 95°C, and the pool itself, whose surface was broken by ascending gas bubbles, yielded the same temperature.

Sulphur is widespread in the southern part of the zone and a strong odour of hydrogen sulphide was noticed everywhere.

Zones H, I, and J

These zones were located on aerial photographs, and their existence was confirmed later from an aircraft. They were not visited in 1967. An attempt to reach zones J and I was abandoned because of thick mangrove swamp.

Another possible thermal zone is marked on the map (Fig. 2) with a question mark. It has not been visited.

CHANGES IN THE LEVEL OF ACTIVITY

Activity in the areas previously examined by Reynolds (1954) was much lower in 1967. A particular example of this is the solfatara in the thermal area east of the District Office. The temperature in a small seepage just below the now extinct solfatara was 97°C in 1954, compared with 40°C in 1967.

In many other areas there was a notable difference between temperatures taken in 1954 and 1967. This could be partly a seasonal fluctuation. August is a dry month at Talasea, whereas April, the month in which temperatures were taken in 1967, is a wet month. The consequent raising of the water table during the wet season could cause a decrease in temperature. However, in many cases, including the example mentioned previously, the difference is probably too large to be accounted for by seasonal variations alone, and one must conclude that temperatures in the thermal areas around Talasea have, in general, decreased since 1954. It is interesting to note that according to local people zone C was much more active only a few years ago.

KASILOLI THERMAL FIELD

INTRODUCTION

Kasiloli thermal field lies at the base of the Hoskins Peninsula between Mount Pago (synonom Mount Bango) and the Kapiura River (Fig. 1). The local natives use the name for three areas of thermal activity which are about two kilometres apart. For convenience the largest and central area is here referred to as Kasiloli No. 1, the area to the east as Kasiloli No. 2, and the area to the west as Kasiloli No. 3. Kasiloli No's 1 and 2 were visited in August, 1967, to collect data for inclusion in the International Geological Congress report on the thermal waters of T.P.N.G.

Kasiloli No. 1 is accessible by four wheel drive vehicles from Cape Hoskins. The road around the coast as far as Maika is in good condition, but its continuation inland is little more than a wide walking track. The road passes alongside Kasiloli No. 1, and continues on to Levigi village on the Kapiura River. The total road distance from the district headquarters at Hoskins is twenty three kilometres.

Fisher (1957, p. 33), states that the area measures about 100 metres by 60 metres, and contains steaming mounds built up by chemical deposits, as well as several boiling mud pools with temperatures up to 100°C; this description probably refers to Kasiloli No. 1. Fisher calls the field Kasololi or Lotatolo; subsequently the name Levigi was used the the Rabaul Vulcanological Observatory staff. During the present investigation it was found that the local people call the area Kasiloli, and for this reason the name has been adopted in this report.

GEOLOGICAL SETTING

The Kasiloli thermal fields are situated on the lower western slopes of Mount Witori, an extinct volcano of probable late Pleistocene age (D.H. Blake pers. comm.). Mount Pago, nine and a half kilometres west of Kasiloli No. 1, lies within the caldera of Mount Witori; it is dormant, the last recorded eruption being early this century (Fisher, 1957). Mount Lolatolu (synonoms Mount Ulatolu and Pyramid Mountain), two kilometres south of Kasiloli No. 1, is an extinct volcanic cone.

KASILOLI NO. 1

Kasiloli No. 1 (Fig. 4) at present occupies a shallow depressed area about 260 metres by 190 metres, and between 0.5 and 3.5 metres below the level of the surrounding country. The 'floor' of this depression is composed of grey bedded sinter forming a more or less level surface. In the central and western parts of the field there are a number of elevations or 'islands', which stand between

1.5 and 2.5 metres above their surroundings (Plate 2a). Their margins are sharp, and their summits concordant and on a level with the surrounding country; they are interpreted as residuals of the former surface of the thermal area which were left standing when the surrounding ground subsided. They are composed of grey sinter on which a reddish brown soil has developed.

Kasiloli No. 1 is surrounded by thick rain forest but the thermal field itself is free from vegetation. The 'islands' have a patchy cover of low bracken with a few pandanas palms, a similar type of vegetation is found around much of the margin of the thermal area. Dead and dying vegetation along the southern margin suggests a recent change in the pattern of activity.

The thermal manifestations of Kasiloli No. 1 include a geyser, some very active boiling springs, hot and warm springs, mud pools, and gas vents. The hot springs and mud pools are located within sinks of various shapes and sizes. The simplest type of sink is steep-sided with a slightly over hanging lip, usually somewhat circular, and about 2 metres deep and 2 metres in diameter. They apparently form by collapse of the ground surface into an underlying cavity. It is likely that many, if not all, of the sinks in the area initially had this simple form, and that they were subsequently modified by further collapse and, or precipitation of material around the edges.

The most active part of the field is the western half. The eastern end of the field shows signs of having been more active in the past, but when visited in August, 1967, activity was virtually confined to the emission of gas from small vents (Plate 2b). Activity from the field is from all accounts variable; there was more activity at the time of this investigation than there had been fourteen months earlier when a party of Europeans from Hoskins visited the area. The mud pools along the southern margin look very recent, and this, coupled with the presence of dead and dying vegetation, suggests that activity is increasing on this side. It is likely that seasonal variations in rainfall have a marked effect on activity in the field.

Tabe Geyser

Tabe is the name given by local natives to the geyser on the western margin of Kasiloli No. 1 (Fig. 4). Tabe erupts at irregular intervals; it may be quiscent for hours at a time, but eruptions have been observed to follow each other at intervals of as little as fifteen minutes. Eruptions take the forms of bursts of steam and water, initially to a height of ten metres, at intervals of two to three seconds; these gradually decline in height and intensity as the eruption draws to a close. Eruptions usually last about three minutes. The water temperature measured at Tabe immediately after an eruption was 96°C.

Hot Springs

There are two types of hot springs in the area.

(1) Springs which are violently active, either continuously or intermittently, and which throw white gas charged water up to 1 metre into the air. There are a number of these springs, all of them in the north-western part of the field. Temperatures measured ranged from 89°C to 101°C with most in the high nineties.

Two springs which contain dark grey muddy water, and erupt periodically, are best included in this group. One is situated toward the eastern side of Lake Mondi. Their temperatures are 85°C, and 91°C, respectively.

(2) A more 'normal' type of hot spring characterised by continuous upwelling of water containing gas bubbles. These occur in all the hot pools and in Lake Mondi. Their temperatures range between 55°C and 95°C.

Mud Pools

Mud pools occur throughout the thermal field, but are most common around the margins, particularly on the southern and western sides, where many lie within the surrounding rain forest. The sinks containing mud are generally simple collapse features with no secondary deposition. The colour of the mud varies from light grey to dark brown-grey, and the consistency ranges up to that of thick cream. Temperatures measured range from 60°C to 96°C.

Gas Vents

Gas vents are fairly widespread, particularly in the eastern part of the field. The gas issues from small holes in the floor of the area and on the tops of irregular mounds of grey, chaotic, sulphurous sinter up to 1 metre high. Sublimated sulphur occurs around some of the vents. In some cases gas issues quietly from the vent; in others emission of gas is accompanied by a continuous low hiss.

Temperature readings and water analyses

The points at which temperatures were measured at Kasiloli No. 1 are numbered in Figure 4. Details of the temperature points are given in Appendix IV.

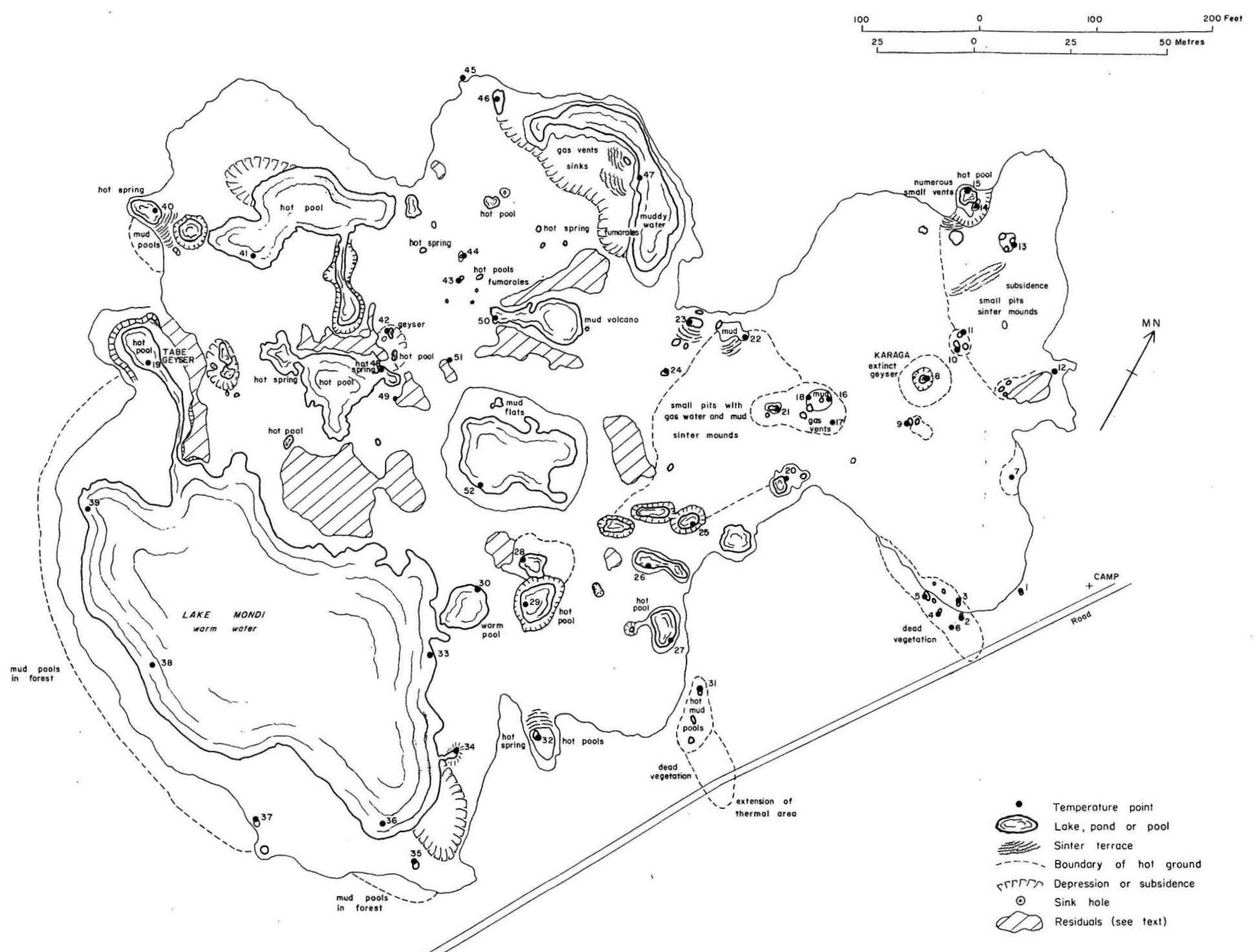
Plate 2a: Kasiloli No.1. western end.

Plate 2b: Kasiloli No.1. Northern corner.

Fig. 4

KASILOLI NO I THERMAL AREA, NEW BRITAIN

Plane Table Survey by I. E. SMITH



Four samples of water collected at Kasiloli No. 1 have been analysed and the results are incorporated with those from the Talasea and Pangalu thermal fields in Appendix I.

KASILOLI NO. 2

Kasiloli No. 2 is about one hours walk (2 kilometres) through rain forest from Kasiloli No. 1. Activity is confined to emission of gas from small vents and, a few pools of bubbling mud. The whole area is composed of humocky grey white sulphurous sinter, much of it covered by low lying bracken. The relief is about 15 metres and the total area is about 100 metres square.

The temperature of a mud pool at Kasiloli No. 2 was measured as 85°C; temperatures of gas vents ranged between 96°C and 100°C. Sublimated sulphur occurs around many of the vents.

A NOTE ON NOMENCLATURE

Since the preparation of this record, Blake (pers. comm.) has disclosed that the head man of nearby Levigi Village uses the name Namagura for the area referred to here as Kasiloli No. 1 and the name Kasololi for the area referred to here as Kasiloli No. 2. In order to prevent confusion the following names are proposed for the thermal field described in this report as Kasiloli Thermal Field.

LIVIGI THERMAL FIELD - including the three areas referred to here as Kasiloli No's 1, 2, and 3 (= Kasiloli Thermal Field)

NAMAGURA - here named Kasiloli No. 1
KASOLOLI - here named Kasiloli No. 2
LIVIGI NO. 3 - here named Kasiloli No. 3

REFERENCES

FISHER, N.H., 1939 - Report on the volcanoes of the Territory of New Guinea. Terr. New Guinea. Geol. Bull. No. 2.

FISHER, N.H., 1957 - Catalogue of the active volcanoes of the world. Part V. Catalogue of the active volcanoes and solfatara fields of Melanesia. Int. Volc. Assoc., 1957.

REYNOLDS, M.A., 1954 - An examination of thermal areas at Garua Harbour, New Britain. August, 1954. Bur. Miner. Resour. Aust. Rec. 1954/63.

APPENDIX I

NOTES ON THE THERMAL WATER COLLECTED FROM THE TALASEA, PANGALU AND KASILOLI THERMAL FIELDS

During the investigation of the thermal areas samples of spring water were collected. Twelve samples were collected from the Talasea area, three from the Pangalu area, and four from Kasiloli No. 1. The samples were collected in 42oz plastic containers; temperature was measured at the sample point using a mercury in glass maximum reading thermometer; in the case of the Kasiloli samples the pH was determined in the field using universal indicator. The sample localities are marked on Figures 2, 3, and 4.

Analysis of the water samples was carried out in the Geological Laboratory, Bureau of Mineral Resources (Bennett and Ferguson, 1968).

Presentation of Data

Full analyses of the water samples are presented in Table 3. In Table 1 the analyses are expressed as a percentage of the total ion plus element content. In Table 2 significant ion and element ratios are given. Figures 5 and 6 are plots of temperature and pH, respectively, versus the major constituents.

Reference

BENNETT, D.W., and FERGUSON, J., 1968 - Analysis of thermal water samples from New Guinea B.M.R. Geol. Lab. Rept No. 9. In Bur. Miner. Resour. Aust. Rec. 1968/145.

TABLE 1. Analyses of Thermal waters from the Talasea, Pangala, and Kasiloli Thermal fields (in percent of the total ion/element content)

Spec. No.	T.N.B. I	T.N.B. II	T.N.B. III	T.N.B. IV	T.N.B. V	T.N.B. VI	T.N.B. VII	T.N.B. VIII	T.N.B. IX	T.N.B. X	T.N.B. XI	T.N.B. XII	T.N.B. XIII	T.N.B. XIV	T.N.B. XV	K-A	K-B	K-C	K-E
Locality	T	T	T	T	T	T	T	T	T	T	T	P	P	P	T	K	K	K	K
Cl^-	< 0.2	55.9	0.6	58.8	44.6	57.6	< 0.3	< 1.5	< 2.8	< 0.9	< 0.2	< 0.1	< 0.1	16.2	< 1.0	57.3	57.4	63.6	57.6
$HCO3^-$	0.7	0.6	-	-	-	-	-	32.4	-	-	-	-	-	-	47.6	-	-	-	-
$SO_4^=$	67.6	5.5	73.0	1.5	11.9	2.4	78.6	7.2	14.0	56.5	64.4	69.7	70.2	53.4	2.6	0.6	0.5	1.1	0.7
SiO_2	11.5	0.6	13.4	0.9	8.4	1.2	12.9	38.1	59.5	30.9	24.8	18.7	17.2	17.8	30.7	1.9	2.0	2.2	2.0
Ca + Sr	17.4	2.2	4.9	3.6	3.3	2.8	1.6	< 11.8	< 11.5	< 3.7	< 0.7	0.8	< 2.1	< 0.7	9.7	2.4	2.4	2.7	2.5
Mg	0.5	2.4	0.5	0.5	1.3	1.1	0.1	1.8	1.0	< 0.1	0.1	< 0.1	0.9	0.1	2.3	0.1	< 0.1	< 0.1	0.1
Total Alkali*	2.0	32.8	1.7	34.6	30.1	35.6	1.2	< 6.2	8.9	2.8	< 1.3	4.6	1.0	11.3	5.3	37.8	37.5	30.2	37.6
Trace Metals**	< 0.2	< 0.2	< 5.1	< 0.1	< 0.2	< 0.1	< 5.2	< 1.2	2.4	< 5.1	< 9.8	< 5.9	< 8.7	< 0.6	< 0.8	0.1	< 0.1	< 0.1	0.1

* . Total Alkali = Na + K + Li

** Trace Metals = Al + Cu + Zn + Fe + Mn + Co + Ni + Pb + Cr

T = Talasea Field; P = Pangalu Field; K = Kasiloli No. 1

TABLE 2

RATIOS OF CONSTITUENTS

	Ca/Na	Mg/Ca	K/Na	Li/Na	HCO_3^-/Cl^-	$SO_4^=/Cl^-$	Fe/Cl^-
TNB I	11.5	.03	.33	.011	4.3	41.1	.1
II	.072	1.1	.08	.00045	.01	.01	.00003
III	4.22	0.1	.43	.027	-	119.0	6.35
IV	.117	.15	.14	.0007	-	.025	.00003
V	.122	.4	.14	.0012	-	.3	.0004
VI	.09	.4	.17	.0007	-	.04	.0001
VII	2.56	.07	.9	.03	-	210	885
VIII	2.4	.15	.24	.015	22.15	4.95	.01
IX	1.74	.09	.35	.02	-	4.95	.1
X	1.8	.09	.4	.02	-	61.0	.8
XI	.92	.09	.9	.013	-	322.0	34
XII	.3	.09	.7	.04	-	646.0	24
XIII	2.8	.43	.3	.074	-	643.5	77.5
XIV	.08	.009	.3	.02	-	3.29	.03
XV	2.3	.24	.25	.01	45.75	2.5	.1
K - A	.08	.01	.22	.002	-	.01	.0001
- B	.08	.007	.21	.002	-	.01	.00005
- C	.08	.008	.23	.002	-	.01	.00006
- E	.08	.008	.23	.002	-	.02	.0002

TABLE 3. Analyses of waters from the Talasea - Pangalu and Kasiloli Thermal fields (from Bennett and Ferguson 1968)

Spec. No.	T.N.B.-1	T.N.B.-11	T.N.B.-111	T.N.B.-IV	T.N.B.-V	T.N.B.-VI	T.N.B-VII	T.N.B.-VIII	T.N.B.-IX	T.N.B.-X	T.N.B.-XI	T.N.B.-XII	T.N.B.-XIII	T.N.B.-XIV	T.N.B.-XV	K-A	K-B	K-C	K-E
Locality*	T	T	T	T	T	T	T	T	T	T	T	P	P	P	T	K	K	K	K
Temp ^{o}C	86	82	62	101	86	100	81	44	94	85	95	95	90	104	62	96	96	89	98
pH**	3.0	6.7	2.7	3.8	4.1	3.2	2.5	6.3	4.3	2.9	2.6	2.2	2.3	2.1	6.8	4.2	3.8 (5.5)	3.9 (4.0)	2.9 (5.0)
Specific Conductivity (mircromho. cm^{-1}	861	19600	1230	29700	1720	21500	1990	125	100	633	1,680	3750	3130	4740	151	29900	29400	28600	28500
Total diss-olved solids	963	13410	166	21340	1097	14620	342	115	112	199	965	1818	1940	1225	174	21440	21120	19920	21710
Cl^- ppm	< 2	7560	< 2	12360	482	8370	2	< 2	< 2	< 2	< 2	< 2	< 2	232	< 2	12200	11970	11370	11670
HCO_3^- "	8.6	76.5	-	-	-	-	-	44.3	-	-	-	-	-	-	91.5	-	-	-	-
$SO_4^=$ "	822	739	238	308	128	350	420	9.9	9.9	122	644	1293	1287	763	< 5	118	124	198	136
SiO_2 "	140	87	43	195	91	177	69	52	42	67	239	347	315	254	59	403	407	389	403
Total Hard-ness ppm	550	2080	76.2	2340	145	1635	89.1	50.2	23	55.5	146	346	442	43	65.7	1305	1270	1205	1255
Ca "	210	295	15.6	750	35	396	8.7	16	8	7.9	7.0	15.0	37.5	10.2	18.6	513	501	475	494
Sr "	0.7	4.4	< 0.1	10.5	0.3	5.3	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	4.1	4.0	3.8	4.0
Mg "	6.0	325	1.5	110	13.9	156	0.65	2.5	0.7	0.74	0.63	1.40	16.0	0.10	4.5	5.2	4.0	4.2	4.1
Na "	18.3	4100	3.7	6400	285	4400	3.4	6.7	4.6	4.4	7.6	50	13.4	125	8.0	6500	6450	6000	6200
K "	6.0	325	1.6	885	40.5	770	3.0	1.6	1.6	1.6	6.0	33	3.8	33.6	2.0	1450	1350	1375	1410
Li "	0.20	1.85	< 0.1	4.45	0.35	3.0	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	2.0	1.0	2.7	< 0.1	16.0	16.0	15.0	15.5
Al "	0.3	< 0.05	1.99	0.17	0.77	0.2	8.8	< 0.05	0.18	8.0	27.9	58.0	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	0.67	< 0.05
Cu "	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.7	0.3	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Zn "	< 0.02	< 0.02	0.06	0.03	< 0.02	< 0.02	0.07	< 0.02	< 0.02	< 0.02	0.08	0.24	0.42	< 0.04	< 0.04	0.08	0.06	0.06	0.06
Fe "	< 0.2	< 0.2	12.7	0.4	0.2	1.0	17.7	< 0.2	< 0.2	1.6	68	48	155	7.0	< 0.2	1.9	0.7	2.3	0.7
Mn "	1.5	0.85	0.5	2.0	0.35	2.15	0.2	< 0.1	0.1	0.1	0.3	0.85	2.5	< 0.1	< 0.1	4.8	4.9	4.7	4.65
Co "	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
Ni "	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.5	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
Pb "	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.2	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
Cr "	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2

* T = Talasea; P = Pangalu; K = Kasiloli No.1.

** lower bracketed figures are pH valuesas determined in the field.

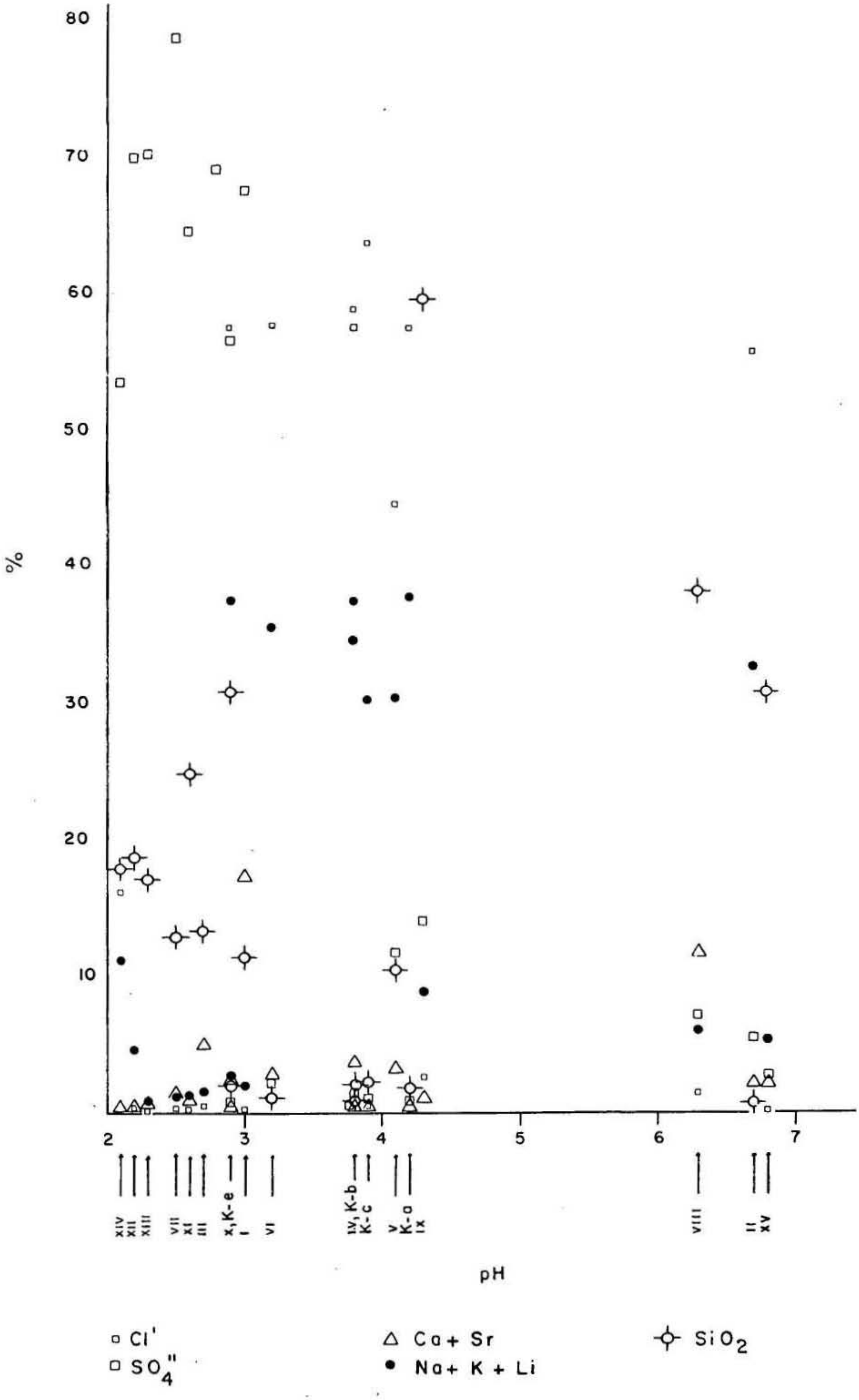


Fig. 6 - pH vs. percent Cl', SO_4'', (Ca + Sr), (Na + K + Li), SiO_2.

APPENDIX II

LOCATION OF WATER SAMPLES COLLECTED FROM THE TALASEA, PANGALU, AND KASILOLI THERMAL FIELDS

Sample Registration Number	Field Number	Locality
67710401	T.N.B. I	Talasea, Zone C, point 2 (Fig. 3)
02	" II	Talasea, Zone C, point 16 (Fig. 3)
01	" III	Talasea, Zone C, point 4 (Fig. 3)
02	" IV	Talasea, Zone C, point 20 (Fig. 3)
02	" V	Talasea, Zone C, point 25 (Fig. 3)
02	" VI	Talasea, Zone C, point 19 (Fig. 3)
03	" VII	Talasea, Zone B, point 28 (Fig. 3)
03	" VIII	Talasea, Zone B, point 29 (Fig. 3)
04	" IX	Talasea, Zone A
04	" X	Talasea, Zone A
05	" XI	Talasea, Zone K
09	" XII	Pangalu, Zone F
06	" XIII	Pangalu, Zone G
07	" XIV	Pangalu, Zone E
08	" XV	Talasea, Zone B, point 27 (Fig. 3)
67710701	K-A	Kasiloli No. 1, point 9 (Fig. 4)
01	K-B	Kasiloli No. 1, point 19 (Fig. 4)
01	K-C	Kasiloli No. 1, point 34 (Fig. 4)
01	K-E	Kasiloli No. 1, point 42 (Fig. 4)

APPENDIX III

TALASEA THERMAL FIELD; DESCRIPTIVE LIST OF NUMBERED POINTS (FIGURE 3)

AREA C1. Muddy pools, varying from a watery to a thick consistency, and small fumaroles. Temperatures range from 61°C to 95°C.

AREA C2. Similar to Area C1 with deep mud pots and small fumaroles. A fetid odour pervades both areas. Water sample T.N.B. I.

POINT 3. Decadent fumarole - temperature, 40°C in a small stream issuing from the area.

4. Mud pool - 7' diameter - muddy water, gas ebullition, temperature 62°C. Water sample T.N.B. III.

5. Gas escape through a blue-grey mud. Hydrogen sulphide present, temperature 86°C. Blocks of altered volcanic glass found in mud.

6. Outcrop of decomposed lava, small stream of warm water flowing from Zone C, temperature 44°C.

7. Altered obsidian in outcrop.

8. Extinct fumaroles in altered obsidian. Two main vents just above sea level, 0.5 metres in diameter, run back into the rock for a considerable distance. The rock around the orifice is soft and crumbly.

9. Banded basalt lava blocks covering hillside.

10. Same as point 9.

11. Vesicular basalt with a well developed banded structure.

12. Recent uplifted reef limestone. Uplift 3 metres. Now being eroded by the sea.

13. Mud pots with a thin watery boiling mud. Pots over 1 metre deep. Three pots and a small mud spatter cone. Temperature 86°C in mud pot.

14. Fumarolic area, temperatures 67°C to 96°C in a series of vents running almost north-south.

15. Small seepage just below high water mark. Clear water, temperature 82°C.

POINT 16. Clear spring just below high water mark, temperature 82°C. Water sample T.N.B. II.

17. Small seepages along foreshore coming up small joint planes which are often filled with hydrothermal minerals.

18. Seepage; temperature 84°C.

19. 6 metres west of point 18; boiling pool temperature 100°C, surrounded by altered obsidian. Water sample T.N.B. VI.

20. 25 metres along shore from point 19; small seepage just below high water mark, boiling vigorously temperature 101°C; steam and hydrogen sulphide. Water sample T.N.B. IV.

21. Same as point 20, temperature 101°C.

22. Seepage through mud; faint smell of hydrogen sulphide; temperature 99°C.

23. Large boiling pool; numerous seepages and small gas vents along shoreline.

24. Vigorously boiling pool, temperature 99°C.

25. Deep pool with gas bubbles, temperature 86°C. Water sample T.N.B. V.

26. Boiling pool of clear water, temperature 99°C. Whole of the foreshore area as far as the creek is covered with hot water springs and seepages and gas vents breaking through a dark odoriferous mud, covered with an iron oxide crust.

27. Warm spring issuing near base of lava flow, temperature 62°C. Water sample T.N.B. XV.

28. Spring, temperature 81°C. Water sample T.N.B. VII.

29. Clear pool with gas bubbles, temperature 44°C. Water sample T.N.B. VIII.

30. Pools with vigorous gas ebullition, temperatures 95°C and 64°C.

31. Spring, temperature 84°C.

APPENDIX IV

KASILOLI NO. 1 DESCRIPTIVE LIST OF NUMBERED POINTS (FIG. 4)

(WC) = watery consistency (TC) = thick consistency

1. Steep-sided collapse sink 1.6 metres deep, bubbling mud (WC), medium grey, temperature 71°C.

2. Collapse sink, 1 metre deep, 1.6 metres diameter, bubbling mud (WC), light grey, temperature 71°C.

3. Vertical sided sink, 1.6 metres deep, 1.6 metres diameter, medium grey, bubbling water, temperature 77°C.

4. Steep sided sink, 2 metres deep, 2 metres diameter, bubbling mud (TC), medium brown grey, temperature 63°C.

5. Trough shaped steep sided sink, 1.6 metres deep, 2.6 x 8 metres, bubbling mud in southern half, medium to light grey (WC), temperature 82°C. Light grey muddy water in northern half (bubbling), temperature 77°C. Close to this there are 2 smaller holes exuding gas, and one with bubbling mud.

6. Recent looking steep sided sink, 0.6 to 1.3 metres deep, 3.3 x 6.6 metres, contains vigorously bubbling light grey mud (WC), temperature 96°C. Area ringed by dotted line around those points on the map (Fig. 4) all looks comparatively recent. The sinks look as though they have collapsed recently, and they lie on the edge of but within, the bush line. The vegetation within a few feet of these points is dead, and toward the road it is dying; the area is apparently extending toward the road.

7. Decadent thermal area, mounds (0.3 metres) of grey sinter with shallow depressions. Sulphur deposits, a little gas given off, temperature of gas 98°C and 84.5°C (second temperature in sulphur deposit not at gas vent).

8. Karaga - a low flat-topped cone 0.6 metres above surrounding ground. Central 'crater' is about 2.6 metres diameter, the outer rim is 3.3 metres diameter, and the total elevated area is 13.5 metres diameter. The cone is composed of greyish white massive sinter. The outer surface has 'spatter'. The 'crater' is 2 metres deep, and contains clear water with gas bubbles. Temperature 66°C. Before 1962 this centre was, from native accounts a geyser, but in 1962 activity ceased.

9. A shallow depression 0.3 metres deep circled by dotted lines on the map (Fig. 4); two deeper sinks within the depression; western one is 2-5 metres deep, 2-2.6 metres diameter, and contains solid grey sulphurous mud; at one side there is a deep hole exuding gas at 63°C. Eastern sink is 1.6-2 metres diameter, 1.6 metres deep, and contains bubbling water, temperature 96°C.

10. Double sink 1.6 metres deep, 3.3 x 2 metres, divided in centre; each contains medium grey bubbling mud (TC), temperature 71°C.

11. Next to 10. Collapse depression 2.6 metres deep, 2 x 4 metres; medium to light grey mud (WC); also mud (TC and WC) light grey, temperature 60°C.

12. Vent in pile of sulphurous sinter; quiet emission of vapour, temperature 93°C.

13. Vapour vent in sinter mound; decadent area sinks filled with solid mud, temperature 52°C (thermometer not properly in ground?).

14. Bubbling, muddy medium-grey water, temperature 85°C.

15. Muddy water bubbling, temperature 38°C.

16. Hole, 2.3 x 1.3 metres, contains 3 sinks 2 - 2.3 metres deep with muddy water; from time to time mud erupts up to 1 metre above ground surface, which is splattered with mud over a radius of 2.3 metres from the hole, temperature 91°C.

17. Recent gas vent, hole in mound of sulphurous sinter, vapour issuing forcefully with a low hiss, temperature 99.4°C.

18. Small mud cone 0.3 metre high, gas issuing with a low hiss from a hole in the top - mud spatter cone, temperature 98°C.

19. Tabe, temperature 96°C, active geyser (see text p. 8).

20. Sink 1.3 metres deep, 6.2 metres diameter, contains medium grey water, gas bubbles, temperature 46°C.

21. Sink 1.6 metres deep, 5.3 metres diameter, slumps around margin, muddy - medium brown grey water, gas bubbles, temperature 71°C.

22. Irregular sink contains dark grey violently bubbling mud (TC), one second pulse, temperature 82°C.

23. Sink - oval shape 20 x 10metres, with marginal slumping, bubbling thin mud, temperature 82°C.

24. Sink 1.3 metres deep, 1.6 metres diameter, sulphur sublimates on walls, contains clean water, hot spring bubbling up on one side, temperature 91°C.

25. Sink 6.6 x 3.3 metres, small spring in centre, temperature 72°C.

26. Large double sink, well formed sides, gas bubbles, springs, temperature 81°C.

27. Large sink, well formed sides, contains water, gas bubbles, springs, temperature 91°C.

28. Violently bubbling hot springs, periodic eruption sending white vapour charged water 0.6 metre into the air; little water is given out between eruptions, temperature 101°C, erupts approximately every minute.

29. Large pool fed from point 28, well formed sides, temperature 71°C.

30. Large pool, greenish water, springs in centre, feeds into L. Mondi, temperature 70°C.

31. Large sink 6.6 x 3.3 metres; two holes 1.6 metres diameter, 2 metres deep, contain light brown grey mud (WC), gas escaping with irregular hiss, one of a number of such pools extending back to the road, remnant elevations very similar to that of nearby islands, temperature 74°C.

32. Hot spring in pool of hot water; one of two pools in a large irregular depression 1-1.3 metres deep, 10 metres diameter, containing sinter hummocks; gas bubbles, temperature 91°C.

33. L. Mondi - marginal, temperature 49°C.

34. New hot spring on mud flats at margin of L. Mondi, pool of water 2 metres diameter, slightly elevated mud cone 6.6 metres diameter, temperature 89°C. Spring flows into lake, gas bubbling up with spring.

35. Irregular sink, some subsidence around margins, 0.6 metres deep, 2.6 x 1.6 metres, contains dark grey muddy water. Periodically erupts sending water 1 metre above the water surface, temperature 85°C.

36. Spring in L. Mondi, bubbling gas, temperature taken at lake margin 1 metre from where gas bubbling up, temperature 53°C.

37. Sink 0.6 metres diameter, constructional sinter around margins, contains boiling water, temperature 92°C.

38. Temperature of lake margin 46°C; there are numerous sinks 1.6 metres deep, 1.6 metres diameter approximately. These are just within the bush; probably explain dead vegetation.

39. Temperature of lake margin 49°C.

40. Temperature in hot pool fed by hot spring 91°C, spring erupts periodically.

41. Temperature 95°C in hot pool at point of emergence of hot spring with gas bubbles.

42. Hot spring - well developed form, periodic eruptions throwing water 1.3 - 1.6 metres in the air; in between bubbles vigorously; the water discharged during eruptions into a pool, temperature 98°C.

43. Small mud cone 0.2 metres high, 1 metre diameter, contains boiling muddy water, temperature 99°C.

44. Vigorously boiling spring, water thrown 0.3 metre in air in circular depression inverted cone 1.3 metres diameter, gas emitted.

45. Shallow sink floored by congealed grey mud, small vent with very thick mud bubbling slowly, temperature 85°C.

46. Depression containing numerous small gas vents, some bubbling mud, temperature at gas vent 79°C.

47. Lake occupying irregular sink, slumping at the margins, grey brown water, scum of bubbles on top, temperature 79°C. Some springs around margin, gas bubbles emerging at several places. Wall behind lake is 3.3 metres high.

48. Vigorously boiling hot spring, white water thrown 0.5 metres into air continuously, temperature 95°C, outflow forms a small lake.