A PRELIMINARY GEOCHEMICAL RECONNAISSANCE MAPPING OF DEIDEI AND IAMALELE GEOTHERMAL RESOURCES, FERGUSSON ISLAND, ESA'ALA DISTRICT, MILNE BAY PROVINCE, PAPUA NEW GUINEA

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Keywords: *Woodlark Basin, D'Entrecasteaux Islands, Deidei, Iamalele, thermal area, hot spring, neutral chloride waters, acid sulphate waters, silica geothermometers, cation geothermometers, water isotope, reservoir temperatures.*

ABSTRACT

A geochemical analysis of samples (water, gas and rock) from Deidei and Iamalele thermal areas of the Milne Bay Province of Papua New Guinea (PNG) revealed that the Yaiyaiboalana and Seuseulina hot springs in Deidei thermal area contain high levels of Cl at neutral pH with low bicarbonate. This was obtained following a chemical reconnaissance survey carried out by Mineral Resources Authority (MRA) in April 2013. The samples were analyzed at the New Zealand Geothermal Analytical Laboratory (NZGAL), GNS Science, Warakei, New Zealand.

Samples collected from Munamelala in the Iamalele thermal grounds were analyzed to be steam heated acid sulphate fluids (pH~1.7, SO_4 ~2500 mg/L, and very little Cl~1mg/L) which could not be used to infer geothermal reservoir conditions.

Based on silica (TQZ) geothermometry and cation geothermometry, Yaiyaiboalana and Seuseulina hot springs may well be fed from high temperature geothermal reservoir conditions suitable for electrical power generation. The calculated reservoir temperature (TNa/K) inferred for Yaiyaiboalana and Seuseulina springs were 270°C and 280°C respectively.

Possible contamination by seawater is likely as the springs are situated approximately one kilometer inland from the sea at an elevation of 9-23m above sea level. However, there is insufficient data to conclude whether sea water is an end-member component as high temperature water – rock interaction has modified the composition and the water isotopic data is inconclusive.

1.0 INTRODUCTION

As part of MRA's ongoing investigations on geothermal resources throughout the country, staff of Geological Survey Division carried out a chemical reconnaissance survey in April 2013 on Deidei and Iamalele thermal areas of Fergusson Island, Esa'ala District, Milne Bay Province (Figure 1).

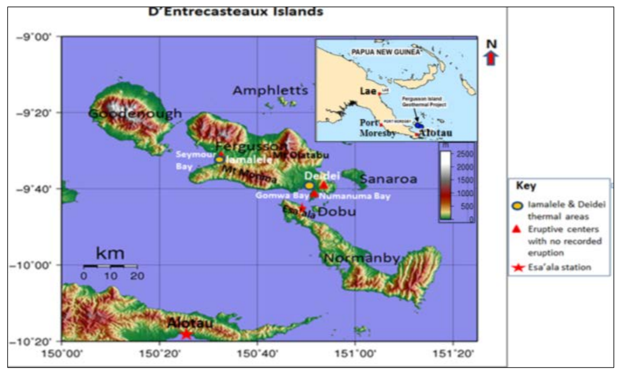

Figure 1: Digital elevation model image of the D'Entrecasteaux Islands showing location of Deidei and Iamalele thermal areas of Papua New Guinea

The chemical reconnaissance survey involved the collection of geothermal samples (water, gas and rock) from Deidei and Iamalele thermal areas for analysis at the New Zealand Geothermal Analytical Laboratory (NZGAL), GNS Science, Warakei. A follow up ground magnetics survey was carried out in December 2013 on Deidei thermal area following the recommendations of the findings of the chemical reconnaissance survey. The results of these surveys are discussed in this paper.

1.1 General features

The Deidei and Iamalele thermal areas are located on Fergusson Island (Figure 1), the largest island of the D'Entrecasteaux Islands. The D'Entrecasteaux Islands are located off the south – east coast of New Guinea and are described as a group of volcanic islands in the Pacific.

Fergusson Island has an area of over 1,437 km^2 and consists of mountainous regions with peaks ranging from 1680 – 2070 m covered with rain forests (Davies, 1973).

In the center of the island are lower hills rising to about 600 m. Areas of plain and low hills (60 – 100 m in elevation) exist in the SE at Deidei and Salamo areas. The Island has a population of over 11000 people (Census 2000).

Deidei and Iamalele are accessible by ships and boats from Alotau, the provincial capital of Milne Bay Province. The old Esa'ala airstrip at Awarai Bay on neighboring Normanby Island is closed and no longer operational.

2.0 REGIONAL GEOLOGY

During the Mesozoic Era, Papua New Guinea has been the buffer zone between the northerly moving Indo-Australian Plate and the westerly moving Pacific plate (Rogerson et al, 1987, Figure 2). This resulted in a mid-tertiary continent island – arc collision between the northeast margin of the Australian continent (Fly platform) and a southerly facing Cainozoic island arc system (Melanesian Arc, Figure 2). The net result has been an intensely folded and faulted geologically complex zone, called the New Guinea Orogen (Rogerson et al, 1987).

Rogerson et al (1987) described the D'Entrecasteaux Islands as located within the Central Orogenic Belt and comprise variably deformed sedimentary, metamorphic and igneous rocks; a foreland thrust belt, island arcs, and intervening small ocean basins. Grindley and Nairn (1974) described the D'Entrecasteaux Group as representing the continuation of the Owen Stanley metamorphic belt and ranges, offset sinistrally to the north by 100 km, and continuing eastward as the Louisiade Archipelago.

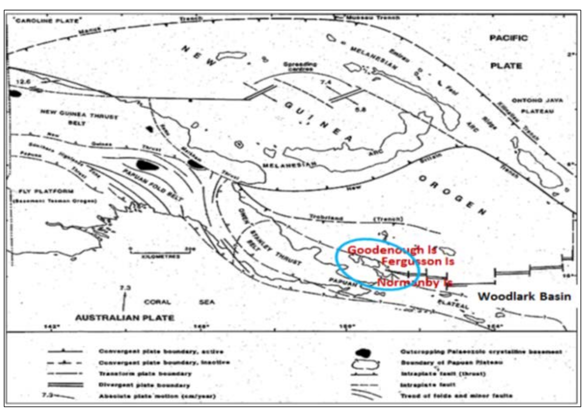

Figure 2: Basic tectonostructural subdivisions of PNG (after Rogerson et al., 1987)

The D'Entrecasteaux Islands are at the western end of the Woodlark Basin rift system, an active crustal extensional feature that developed around 5 Ma ago in response to subduction and plate rotation along an irregular boundary between the Pacific and Indo-Australian plates (Benes et al., 1994, Baldwin et al., 2004 and Taylor et al., 1999).

Crustal expansion has created domal structures in high-grade metamorphic basement rocks (Davies, 1973). The metamorphic rock domes, called core complexes, formed within ophiolitic assemblages in the Cretaceous Papuan Fold Belt with each rock dome probably having a core of granodiorite (Davies, 1973).

According to Binns and Scott (1987) the Woodlark Basin is opening at 7 cm/yr and propagating westerly at 12 cm/yr. The westerly trending Woodlark Basin seafloor spreading center propagated into the D'Entrecasteaux between Fergusson and Normanby islands during the Pliocene (Taylor et al., 1999). Late Pliocene to Holocene NNE trending normal transverse faults associated with the Woodlark seafloor spreading system are interpreted by many authors as having formed grabens, within which Pliocene to Holocene calc-alkaline volcanism has been actively associated (Taylor et al., 1999).

K-Ar and Rb-Sr dating suggests that this volcanism youngs westward from 3.2 my on Normanby to 0.4 to 1.2 my on the Kukuia Peninsular of south-western Fergusson Island (Davies and Ives, 1965). Recent peralkaline volcanism developed at the point of intersection between the Woodlark spreading system and the D'Entrecasteaux domes between Fergusson and Normanby islands which are indicated by hot spring activity within active extensional structural zones in the D'Entrecasteaux Islands (Smith, 1976).

2.1 Geology

Fergusson Island consists of domes of metamorphic rocks with granodiorite cores, and ultramafic and volcanic rocks on the margins (Davies et al. 1965).

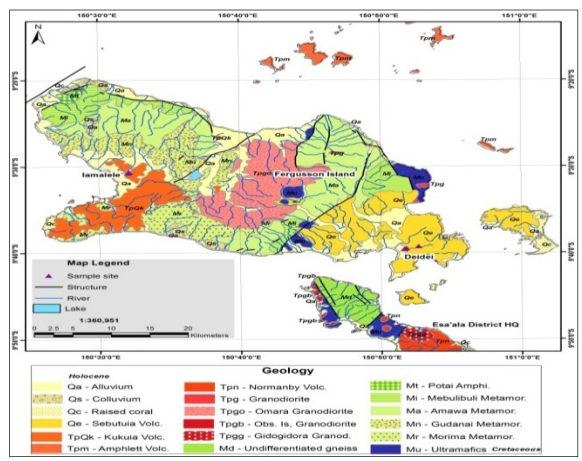

Figure 3: Geology map of Fergusson Island (map after Davies, 1973)

The margins of the domes and anticlines are faulted and Quaternary volcanism is associated with these faults (Davies, 1973). Ultramafic and associated gabbroic rocks are in fault contact with the metamorphics on Goodenough, Fergusson and Normanby islands. Fault movements have been predominantly vertical, but there is some evidence for northeast trending left-lateral strike-slip displacement (Davies, 1973).

According to Davies and Ives (1965), domed and broadly folded basements of Cretaceous metamorphic rocks (core complexes) consist mainly of amphibolite facies, with lesser greenschist facies rocks. The dome axis trends NNE and is paralleled by a number of fault controlled drainages. Ultramafic and associated gabbroic rocks of Cretaceous or older age are in fault contact with the metamorphic rocks in several areas and are thought to represent over thrust sheets of sea-floor volcanic rocks (Davies and Ives 1961).

The dome margins are marked by large, often curvilinear faults that locally form decollement structures. Quaternary volcanism has occurred adjacent to the faulted dome margins and hot spring activity is associated with some of the rift structures (Davies and Ives, 1961).

Epithermal mineralization in the islands is structurally controlled and can be related to either shallowly dipping dome bounding faults or younger steeply dipping rift zones. Mineralization often occurs near the intersection of two types of faults (Davies, 1973).

The Deidei and Iamalele thermal areas are situated on the Quaternary Sebutuia Volcanics (Qe) and the Pliocene to Pleistocene Kukuia Volcanics (TpQk) respectively (Figure 3). The Sebutuia Volcanics comprises rhyolite pumice and obsidian, ash flow tuff; trachyte, dacite, and minor dolerite (Davies, 1973). The Kukuia Volcanics comprises rhyolite, rhyolitic obsidian, andesite ashflow tuff and some basalt (Davies, 1973).

The Sebutuia and Kukuia Volcanics are overlain at low land areas by the Quaternary Alluvium deposits (Qa, Figure 3). These are in turn underlain by the Cretaceous D'Entrecausteaux Complex. Intruding the D'Entracasteaux Complex and exposed in the middle of the Fergusson Island geology map is the Tertiary Omara Granodiorite (Tpgo) as depicted in Figure 3.

The oldest rock units exposed at places throughout the Fergusson Island geology map is the Gabbro (Mb, Figure 3) of the Cretaceous to Older origin (Davies, 1973).

2.2 Geothermal occurrence

A field survey focused on two areas, Deidei and Iamalele that are located in the eastern and western parts of the Ferguson Island respectively (Figures 1 and 3).

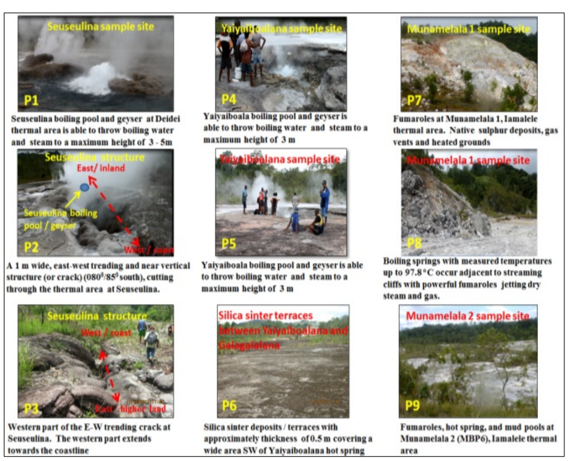

Figure 4: Photographs of sample sites

Deidei thermal area is further divided into two parts (western and eastern) and described accordingly:

- The western part – includes Galagalalana, Seuseulina and Yaiyaiboalna sample sites where geothermal surface manifestation consists of boiling pools, geysers, hot springs and steams, steam vents and mud pools (Figure 4). The western part is situated at the south western edge of the higher land mountains in the NE (Figure 1) and occupies an approximate area of over 250, 000 m^2 at the base of Bwaia Peninsula, one and a half kilometers inland of Kedidia Bay (Figure 1 and 3). The area is generally flat with elevations ranging from 9 – 15 m (height above sea level). The thermal area here is predominantly of volcanic rocks, mostly greyish extremely altered rhyolitic and andesitic ash flow. The andesitic ash flow has been altered due to the geothermal activity thus developed a milky white silica rich mud ripples (or sinter) throughout the site (see notes and photographs in Figure 4). The rhyolitic tuffs have been further altered and overlain by the recent alluvial reworking which mostly comprises of gravel, sandy silt and beach sand from the nearby salt water intrusion. No sulphur is being deposited and thus no H_2S odor was detected.

- The eastern part – including the Bolousunamo sample site where geothermal surface manifestation comprises fumarole (or steam and steam heated ground, gas vents and elevated sulphur deposits). This part is situated on the higher land area in the NE, occupies an approximate area of over 40, 000 m^2 and is about one and a half to two kilometers east or inland from Seuseulina (Figure 1 and 3). The site is located on a gentle slope at an elevation of 115 m. Deidei and other eruptive centers and mountains further east and south of Bolousunamo rise to over 300 m in elevation. The ground surface at Bolousunamo has been extremely altered to red clay and ash and loamy soil throughout. In places, black rhyolitic pumice occurred completely altered and decomposed to reddish brown clay. There is elevated concentration of native sulphur and sulphur dioxide gas at this location

The Galagalalana, Yaiyaiboalana and Seuseulina hot springs (boiling pool and geysers) in the western part and the Bolousunamo fumarole in the eastern part of the Deidei thermal area occur in close proximity and adjacent to a stream which flows down west from the higher land mountains in the east (Figure 3).

Observed also in the field at Seuseulina sample site is a major east – west trending, near vertical spreading center or crack (with approximate strike and dip angle of 080^o / 85^o south, Photographs P1, P2 and P3 of Figure 4). The hot springs, boiling pools and geysers are aligned almost parallel to the crack at this site. Chilled vents along this crack indicated extreme boiling temperatures on site.

It was also observed that the intensity of geothermal activity increases from Galagalalana (hot springs only) in the west (or SW) to Yaiyaiboalana (hot spring, boiling pool and geyser able to throw boiling water to a maximum height of 3 m) and Seuseulina (hot spring, boiling pool and geyser able to throw boiling water to a maximum height of 5 m) toward the east.

Iamalele thermal area is located toward the western part of the Fergusson Island and at the head of Seymour Bay (Figures 1 & 3). The area is flat with undulating hills ranging from 15 – 23 m above sea level. According to Edwards (1950) and Davies et al. (1965), the thermal area consists of six or more solfataric in a belt of 7.5 km long and 1.5 km wide running NNW. The main areas of activity are between 0.5 and 2 km SSE of Iamalele village with less intense activity to the NNW (Grindley and Nairn, 1974).

Two locations (Munamelala 1 and 2, Photographs P7, P8 and P9 of Figure 4) with more intense thermal activity were identified in the SSE section of the Iamalele thermal area and samples were collected from these locations (Figure 11).

The most active site (Munamelala 1, Photograph P7 & P8 of Figure 4) as described also by Grindley and Nairn (1974) is a sandy flat between a small lake of stagnant water to the south and altered lava flows to the north. Boiling springs with measured temperatures up to 97.8 ^{o}C occur adjacent to streaming cliffs with powerful fumaroles jetting dry steam and gas. Mud pools and small vents surrounded by sinter and sulphur deposits are common at this site. Water and gas samples were collected at this location (see table 1).

Thermal site 2 (Munamelala 2, Photograph P9 of Figure 4) is about 200 m to the west of Munamelala 1 sample site. It consists of mainly collapsed, altered flow rhyolites with fumaroles and solfataras. A small bubbling pool by the track had a measured temperature of 93.3 ^{o}C. Water and gas samples were collected from this location (see table 1).

3.0 GEOCHEMICAL DATA

A list of samples (water, gas and rock) collected from Deidei and Iamalele thermal areas for analysis is presented in Table 1 while the analyzed laboratory results of the hot springs and their compositions are presented in Table 2.

Gas samples were contaminated by air therefore the results were ignored. The results of the rock sample analysis were not sent to MRA but are discussed in GNS Science Consultancy Report 2013/253 by Mroczek and Rae (2013).

Feature Description							Measured Parameters						Water	Gas	Rock
Province/ Region	Geothermal Field	Feature_Local Name	Feature No.	Feature Type	Easting	Northing	Elevation (m)	Conductivity (mS)	Salinity (ppt)	TDS (g/l)	Temp (°C)	Measured pH	Sample Collected	Sample Collected	Sample Collected
MBP_Ferg. Island	Deidei	Yaiyaiboalana	MBP2	hot spring	265597	8931186	15	35.6	18.6	0.65	103	7	√	√	
		Seuseulina	MBP3	hot spring	265297	8930970	9	15.21	-	0.65	101	3	√	√	√
		Bolousunamo	MBP4	gas vent	267150	8931600	115	-	-	-	75.9	4		√	
	Iamalele	Munamelala	MBP5	hot spring	229294	8947103	13	10.72	-	0.65	97.8	1	√	√	√
			MBP6	hot spring	229508	8947224	23	13.14	-	0.65	93.3	1	√		

Table 1: List of geothermal features sampled for water, gas and rock analysis. (NB: measured pH for Seuseulina (pH 3) in Table 1 is considered a field error. Laboratory analysis (Table 2) of the water confirms it's near neutral pH).

Date	14/04/13	14/04/13	15/04/13	15/05/13	
Lab. No.	2013002620	2013002621	2013002622	2013002623	
Sample Name	**F2 Yaiyaiboalana**	**F3 Seuseulina**	**F5 Munamelana**	**F6 Munamelana**	**Seawater**
Temp °C	22	21	21	22	
pH	8.63	8.21	1.69	1.65	8
Na	3273	3107	22	36	10450
K	502	556	16.2	29	354
Ca	54	46	6.5	7	405
Mg	0.05	0.04	3.3	3.1	1235
SiO_2	394	421	326	331	0.428
B	7.4	6.8	2.7	<0.3	4.1
Cl	4825	4668	0.81	1.3	19520
SO_4	96	87	2499	2488	2748
HCO_3	<20	29	<20	<20	154
H_2St	0.12	0.15	6.2	4.1	
NH_3d	0.31	0.34	4.9	3	
As	1.7	1.5	0.04	<0.015	3.7
Fe	<0.08	<0.08	14.6	11.1	15
Al	<0.15	<0.15	82	125	1.6
Mn	0.02	0.02	0.4	0.17	
Cond. µS/cm	14385	14025	9361	11305	
$d^{18}O$ ‰	-1.51	-1.2	4.49	-1.15	
dD ‰	-16.3	-14.4	-1.1	-18	

Table 2: The laboratory results of the hot spring compositions, in mg/L, except where noted.

3.1 Fluid chemistry

The water samples from Yaiyaiboalana and Seuseulina hot springs in Deidei thermal area were collected from near-neutral chloride waters as shown in the photo graphs (Fig. 3). The pH of Yaiyaiboalana and Seuseulina hot springs are near neutral, high in chloride with temperatures > 100 ^{o}C.

The Yaiyaiboalana and Seuseulina springs contain high Cl (~4825 and 4668 mg/L) compared to SO_4 (~96 and ~87 mg/L) and HCO3 (~<20 and 29 mg/L) anions (Table 2) thus plot in the Cl-rich corner of the Cl-SO_4-HCO_3 ternary diagram (Figure 5). The springs are classified as matured geothermal waters likely to be flowing out from the deep-seated aquifer reservoir. Geothermometry analysis from these springs is suitable for inferring aquifer reservoir temperatures of the geothermal system in the area.

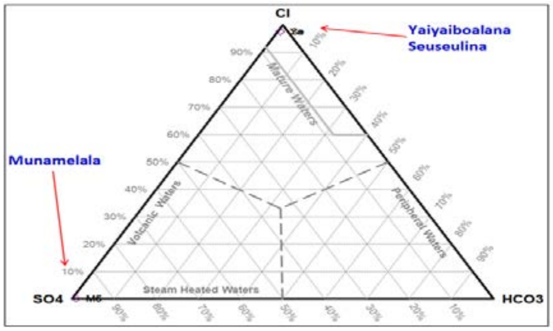

Figure 5: Ternary diagram showing relative concentrations of Chloride (Cl), Sulfate (SO4) and bicarbonate (HCO3) anions classifying the geothermal waters. Plot generated using Powell and Cumming (2010).

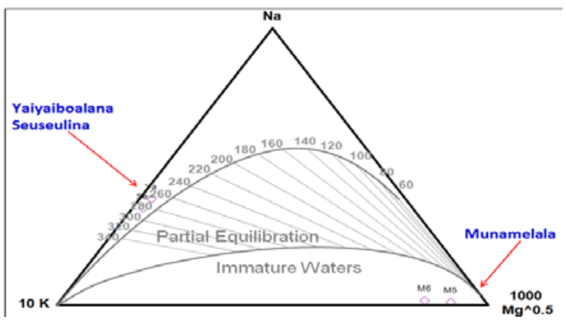

Figure 6: Ternary diagram showing relative concentrations of cations Na, K and Mg and the Na-K and K-Mg geothermometers (Giggenbach, 1988). Plot generated using Powell and Cumming (2010).

Mroczek and Rae (2013) inferred enrichments in K and SiO_2 and depletions in Ca, SO_4 and Mg with respect to seawater signifying water-rock interaction at elevated temperatures. They further noted that low HCO_3 implies the fluids are discharging from hot deep aquifers and not from a reservoir that has equilibrated at lower temperatures (Mroczek and Rae, 2013).

The Na-K-Mg ternary diagram (Figure 6) further confirms these matured geothermal waters have reached full water-rock equilibrium. The calculated reservoir temperatures (T_{NaK}) of the fully equilibrated waters from Yaiyaiboalana and Seuseulina springs as shown in Figure 6 are 270 ˚C and 280 ˚C respectively.

Although the chloride contents (~4800 mg/L) of the Deidei thermal fluids are a quarter that of seawater (Cl ~19 520 mg/L), the possibility of sea water contamination is not ruled out as the springs are situated approximately one kilometer inland from the sea and at an elevation of 9-15m above sea level, thus subject to further investigations and confirmation.

In contrast, two samples from Munamelala 1 (MBP5) and Munamelala 2 (MBP6) hot springs in Iamalele thermal area (Table 1) were collected from steam-heated acid sulphate waters (Figure 3). These fluids are very acidic: pH~1.7, SO4 ~ 2500 mg/L, Cl ~ 1 mg/l (Table 2) and plot in the SO_4-rich corner of the Cl-SO_4-HCO_3 ternary diagram (Figure 5). Steam-heated acid sulphate waters are formed by the interaction of shallow water with magmatic gases and atmospheric oxidation of hydrogen sulphide at the surface (Marini, 2000) and therefore do not reveal characteristics of a geothermal reservoir. Geothermometry analyses are not suitable for these waters.

3.2 Geothermometry

The calculated geothermometer temperatures of the Yaiyaiboalana and Seuseulina springs generated using Powell and Cummings (2010) are presented in Table 3. Iamalele springs are omitted as they are classified as immature waters unsuitable for geothermometry analysis.

Sample Name	Meas. T °C	T_{AmS} cond.	T_{Ch} cond.	T_{QZ} cond.	$T_{Na\text{-}K\text{-}Ca}$	$T_{Na\text{-}K\text{-}Ca}$ Mg corr	T_{NaK} Fournier 1979	T_{NaK} Giggenback 1988	T_{KMg} Giggenback 1986
Feature 2 Yaiyaiboalana	103	107	220	234	260	260	257	269	335
Feature 3 Seuseulina	101	112	226	240	273	273	273	283	351

Table 3: Water geothermometer temperatures (°C) for Deidei springs.

The calculated reservoir temperatures inferred from the silica geothermometers (T_{Ch} and T_{QZ}) are >200 °C (Table 3). Silica (quartz and chalcedony) geothermometers equilibrate faster than the other cation geothermometers hence, reflect temperatures of the nearby aquifer. In contrast, the cation geothermometry typically reflects temperatures of a more distant or deeper source fluid (Powell and Cumming, 2010). Assuming saturation with respect to amorphous silica, the inferred temperatures are 107 and 112 which are similar to the measured temperatures 103 °C and 101 °C (Table 1).

The cation geothermometer temperatures however are much greater than the silica geothermometers; T_{NaKCa} are 260 °C and 273°C while the T_{NaK} are about 10 °C higher at 269 °C and 283 °C (Giggenbach, 1988) respectively. T_{KMg} geothermometer temperatures (335 °C and 351°C) are much greater compared to the T_{NaK} and silica geothemometers as they re-equilibrate rapidly in the up flow zones of geothermal systems where cooling occurs shortly before surface discharge thus reflect temperatures lower than T_{NaK} . Mroczek and Rae explained that the high T_{KMg} temperatures are a result of low Mg concentration and is consistent with the fluids flowing relatively quickly to the surface with minimal equilibration of K and Mg to lower temperatures.

The calculated reservoir temperatures ($T_{Na/K}$) for Yaiyaibuloana and Seuseulina springs inferred from Figure 2 (270°C and 280 °C) and Table 3 (269 and 283 °C) are 270°C and 280 °C respectively.

3.3 Water Isotope

Figure 7 is a plot of δD and $\delta^{18}O$ of the four water samples from Deidei and Iamalele thermal areas. The PNG groundwater composition was deduced by Mroczek and Rae (2013) from two springs in WNB that plotted on the Local Meteoric Water Line (LMWL). It is represented by grey circle on the LMWL while seawater composition and the composition of andesitic water (Giggenbach, 1991) are represented well on the plot.

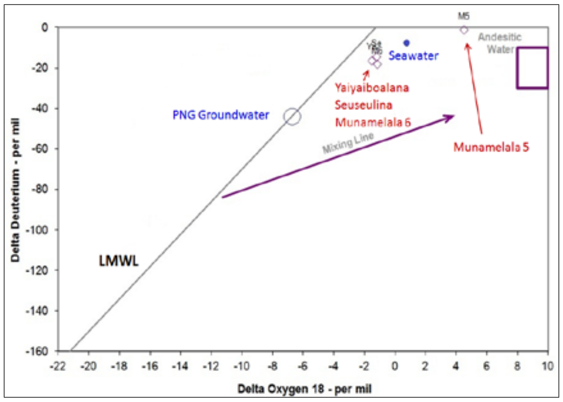

Figure 7: Stable isotopes for the Fergusson Island water samples.

The Deidei samples plot between the LMWL and seawater well away from the mixing line. These two samples have more positive isotopic values with respect to the local groundwater composition which is indicative of water-rock interaction at high temperatures. It is noted that steam-heated acidic waters typically show higher enrichments (more positive values) due to evaporation, hence the Munamelala 1 (plotted as Munamelala 5, Figure 7) plot is expected however, Munamelala 2 (plotted as Munamelala 6, Figure 7) composition is unexpected (Mroczek and Rae, 2013).

It is noted that more samples from a variety of sources (rivers, streams, groundwater wells, thermal fluids) are required to test any conclusions that may be drawn as well as deduce the local (PNG) groundwater composition.

4.0 GEOPHYSICAL DATA

A preliminary follow up ground magnetic survey (Figure 8) was carried out at Deidei thermal area following the recommendation of the findings of the chemical reconnaissance survey.

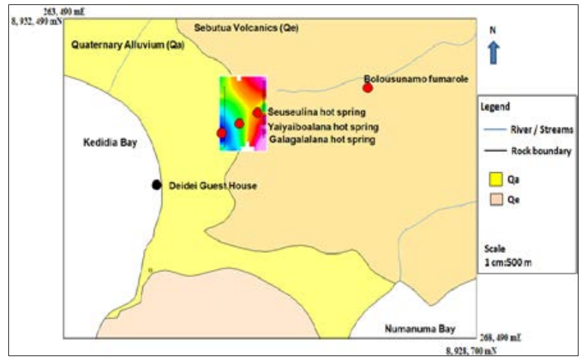

Figure 8: Ground magnetic data for Deidei thermal area overlaid on geology map

A total of four north–south orientated traverse lines of length approximately 600 m long and at 500 m spacing were planned and conducted (Figure 8). The survey was planned so that:

- the survey lines extend beyond surface thermal manifestation areas consequently determining the lateral extent of the Deidei thermal area
- the survey lines cut across the east-west trending near vertical structure (with strike and dip angle of $080^0/85^0$ south) observed at Seuseulina hot spring site subsequently establishing the extent of the structure and the relation between the structure and the surface geothermal manifestation areas (Bolousunamo fumarole site and the Deidei hot springs). This was because the structure was seen to be cutting through the thermal area from Seuseulina toward Bolousunamo.

The ground magnetic survey was terminated after two lines were surveyed due to power failure with the main surveying magnetometer (G-859 MINING MAG Cesium Vapor). Diurnal corrected total magnetic intensity map (TMI) gridded for the two surveyed lines is overlaid on a geology map depicting locations of surface geothermal manifestations in the Deidei thermal area (Figure 8).

The blue colored area in the TMI image indicates low magnetic intensity (42, 199 – 42, 389 nT), intermediate / moderate intensity (42, 3889 – 42, 5867 nT) is depicted by green to yellow colored region while red to purple colored areas indicate high magnetic intensity (42, 587 – 42, 769 nT).

The ground magnetic data for Deidei thermal area correlates well with the known geology of the area (Figure 8). The low magnetic intensity anomaly toward the west occur over mapped Quaternary Alluvium deposits (Qa, Figure 8) while the high magnetic intensity anomaly toward the east occur over Sebutua Volcanics (Qe, Figure 8). Surface thermal manifestations (Galagalalana, Yaiyaiboalana and Seuseulina hot springs) occur in the low to moderate magnetic intensity areas. Surface thermal manifestation toward the east around the high magnetic intensity area was little or uncommon.

The rhyolite pumice, obsidian and ash flow tuff of Sebutua Volcanics in the thermal area has been extremely altered by the thermal activity to clay and silica sinter deposits / terraces, thus the low magnetic signature.

A linear magnetic low anomaly trending almost east – west in the direction of surface geothermal manifestations coincide with the east-west trending near vertical structure ($080^0/85^0$ south) observed at Seuseulina hot spring site. The feature (structure) extends toward the east (ENE) in the direction of Bolousunamo thermal site.

4.1 Proposed model of Deidei Geothermal system

Figure 9 is a pictorial representation proposed for the Deidei geothermal system.

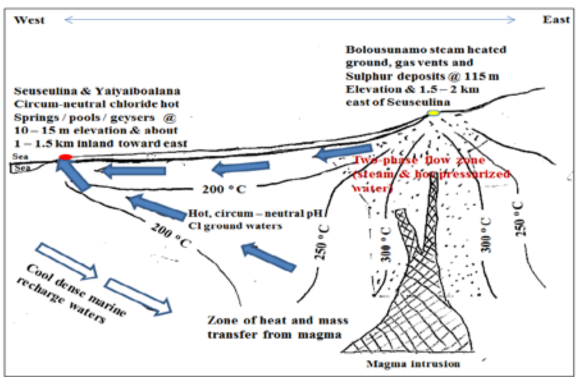

Figure 9: Pictorial representation proposed for Deidei thermal system. Note that the diagram is not to scale.

The temperatures (or reservoir temperatures) used in the representation were estimated from calculated geothermometer temperatures. The pictorial representation suggests circum – neutral chloride outflow at Seuseulina and Yaiyaiboalana hot spring area and steam and hot pressurized water up flow at Bolousunamo steam and steam heated ground area.

5.0 CONCLUSION

Geochemical analyses of samples collected from Munamelala in the Iamalele thermal grounds were analyzed to be steam heated acid sulphate fluids (pH~1.7, SO_4~2500 mg/L, and very little Cl~1mg/L) which could not be used to infer geothermal reservoir conditions.

The samples from Deidei thermal area revealed that Yaiyaiboalana and Seuseulina hot springs contain high levels of Cl at neutral pH with low bicarbonate.

Based on silica (TQZ) geothermometry and cation geothermometry, Yaiyaiboalana and Seuseulina hot springs may well be fed from high temperature geothermal reservoir conditions suitable for electrical power generation. The calculated reservoir temperature (TNa/K) inferred for Yaiyaiboalana and Seuseulina springs were 270°C and 280°C respectively.

Possible contamination by seawater is likely as the springs are situated approximately one kilometer inland from the sea at an elevation of 9-23m above sea level. However, there is insufficient data to conclude whether sea water is an end-member component as high temperature water – rock interaction has modified the composition and the water isotopic data is inconclusive.

It is noted that there is lack of gas and isotopic data analysis on the thermal resources investigated. It is therefore recommended that fumarole sampling methodology is reviewed and gas sampling conducted again to further analyze and correlate these data with the available geochemistry data.

Further detailed investigations are required in surface geological mapping, hydrological investigations, and geophysics surveys on Deidei thermal area to assess and provide information on the dimensions (extent, thickness, depth, upflow, out flow) and structures of the reservoir and identify likely locations for production zone.

Chemical surveys of hot springs not sampled yet in the Fergusson and the other D'Entrecasteaux Islands must be conducted in order to delineate the prospectivity of these geothermal resources for development of geothermal energy.

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