GEOTHERMAL ASSESSMENT OF THE FIJI ISLANDS : AN OVERVIEW

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ABSTRACT

This report attempts to summarise geothermal investigations in Fiji and come to some conclusions in regard to the utilisation potential of geothermal resources in that country. The work carried out, institutions involved and survey results are summarised. Some dffferences in philosophy of approach and in methods of interpretation are apparent, but all studies have introduced some aspects worth considering. Use of a silica mixing model geothermometer for dilute waters provided excessively high temperature estimates. The conclusions reached in this report are that the Savusavu area of Vanua Levu has the greatest potential for utilisation, with reservoir temperature of ~ 160°C, which could produce ~ 1 MWe by a binary system. Alternatively, substantial direct heat utilisation potential exists such as for drying or freezing plants. The next greatest potential lies in small scale direct utilisation of a ~ 125°C, fairly extensive reservoir in the Labasa area. Geothermal systems on Viti Levu and other localities within the Fiji group are indicated to be of low throughput with subsurface temperatures of 90-115°C. Utilisation of such systems is limited to very small scale use in this environment.

INTRODUCTION

The islands of Fiji are located in the S.W. Pacific between 16" and 19°S and consist of two major volcanic islands and numerous smaller islands and atolls. They are situated within the southern part of the belt of volcanism and seismicity which borders the western Pacific and which is related to major crustal structures and subduction. Fiji, however, is within a tectonically complex, low seismicity section of this belt (Fig. 1) and has a volcanic history from Eocene to Recent times, with most activity during the Miocene-P1iocene period (Rodda, 1967). About 60 locations of thermal springs are distributed throughout the two main islands and on five of the smaller islands of the Fiji group (Fig. 2). These springs are the only surface features of geothermal activity and most have temperatures in the 40°-60°C range. Boiling springs do occur, however, in two areas on the island of Vanua Levu. This report attempts to summarise geothermal investigations carried out in Fiji and come to some conclusion regarding the potential for development of the geothermal resources.

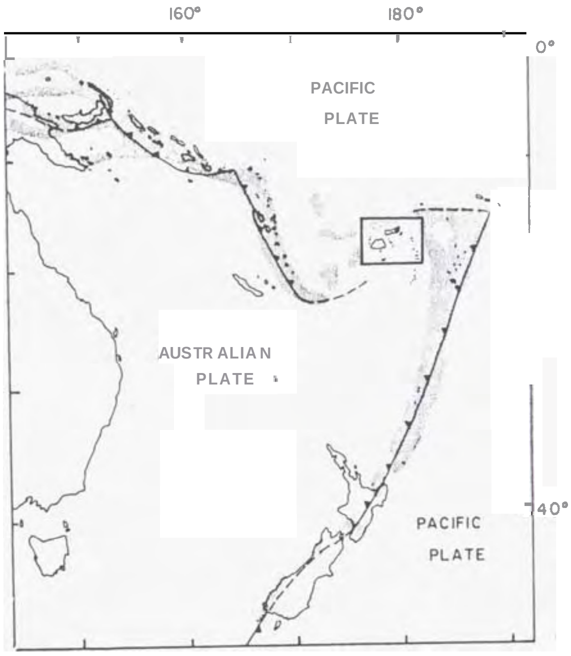

FIG. 1: Location of Fiji Islands in S.W. Pacific. Tectonic features are shown, and zones of shallow (< 70 km) seismicity (after Johnson and Molnar, 1972).

As a comparison, other geothermal occurrences of the S.W. Pacific area can be found summarised in another report (Cox, 1980a).

RECORDED HISTORY AND UTILISATION

The first recorded description of thermal springs in Fiji was of those at Savusavu on the southern coast of Vanua Levu in about 1840 (Wilkes. 1845). During the next 50 years most of the other springs were located and described. Traditionally, many of the springs had been used for bathing, and the boiling springs are still used for the cooking of root crops. During the 1940's small thermal baths were constructed at the Savusavu springs.

In 1951 the colonial government conducted pilot experiments into the feasibility of producing salt from seawater by evaporation using geothermal heat (Munro, 1961; Kennedy, 1961). These experiments were also at Savusavu, and used a 1800 litre main supply tank and various combinations of settling pans (2.2 and 4.8 m^2) set into the ground. The final pilot plant produced a crude evaporite of 95.8% NaCl at about 13.6 kg per day. The experiments were disbanded largely due to problems with temperature variations. (A sample of the salt was, however, used in the Suva gaol to bake a successful batch of bread). The local timber yard at Savusavu attempted some crude experiments of drying timber in an open-ended drum set into hot ground; other, similar experiments were made for drying copra, but none were developed further.

OUTLINE OF GEOTHERMAL INVESTIGATIONS

Scientific assessment of Fiji's geothermal potential began in 1956 when J. Healy (NZ Geological Survey) visited many of the thermal springs on Viti Levu and Vanua Levu. Healy (1960) described and sampled the occurrences, measured flow rates and temperatures, related the systems to local geology and sumnarised the literature to that time. He concluded that the geothermal systems in the Labasa and Savusavu areas of Vanua Levu warranted further work and noted that the characteristics of the Savusavu springs suggested an intrusive neat source.

During the 1960/70's many of the spring groups were further described by Fiji Mineral Resources Department (MRD) geologists in geological mapping surveys. Before the Savusavu salt experiments, Ibbotson (1960) carried out a shallow soil temperature survey around these springs to determine the distribution of near-surface heat. Some additional thermal spring sampling was done during the early 1970's by H. Colley (MRD) with a bias to mineralisation associated with hydrothermal systems.

In 1972 black and white thermal infra-red imagery surveys were flown over the main geothermal areas of Vanua Levu (Savusavu and Labasa) and the small area of Wainunu in S.W. Vanua Levu. The surveys were flown by Canadian Aero Service under contract to MRD, and used a Bendix linescan unit (sensitivity 11.5 - 12.5 μm and resolution of 2.5 mrad.) at flight elevations of 610 and 1220 m. The surveys were initially interpreted by the contractor (Moreton, 1973) with subsequent ground checking by MRD geologists (Colley, 1975). Results of the surveys were later reinterpreted in respect to measurements of surface temperatures (Cox, 1980b; 1981a). The I.R. surveys provided little additional information about the geothermal areas, although several minor, previously unrecorded seepages were located.

From 1974/77 MRD personnel began detailed studies of Fiji's geothermal resources, initially in the more active areas of Savusavu and Labasa-Tabia.

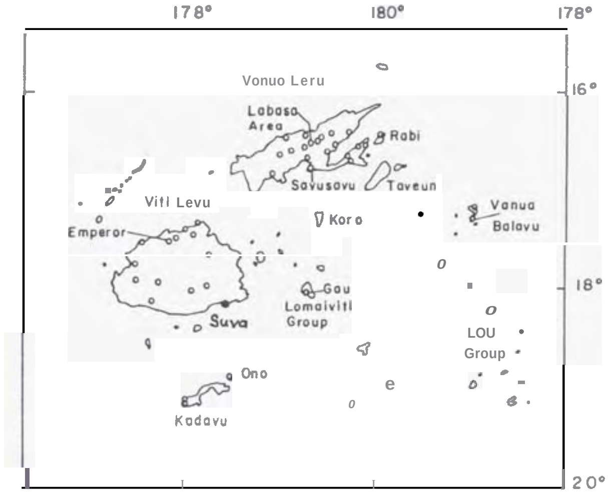

FIG. 2: Locations of thermal springs in the Fiji Islands.

1974-75: Detailed descriptions of thermal features.
Spring sampling and measurements.
Geological mapping/air photo interpretation.
Ground temperature surveys (1 m depth).
Rechecking I.R. anomalies.
Shallow resistivity soundings and traverses (Savusavu only; in conjunction with UNDP geophysicist, S. Gunson).

1976: Spring and groundwater well sampling.
Geophysical surveys at Labasa-Tabia: resistivity soundings and bipole-dipole mapping (equipment on loan from Hawaii Institute of Geophysics and initially set up by HIG geophysicist, J. Kauahikaua); ground magnetics; S.P. traversing.

1977: Stable isotope study of Vanua Levu and Viti Levu springs (in conjunction with J.R. Hulston, Institute of Nuclear Sciences, DSIR, N.Z.).
Reinterpretation of existing airborne magnetic surveys.
Sampling of springs in other parts of Fiji.
Preliminary resistivity survey of Sabeto area, N.W. Viti Levu (incomplete due to equipment failure).

Subsequent to the above studies, in 1978-79, regional reconnaissance surveys were conducted by Pacific Energy and Minerals Ltd (PEM), as part of a work commitment to the Fiji Government for options on a petroleum exploration licence off the north coast of Viti Levu. These included:

Interpretation of magnetic surveys for depths to Curie Point temperatures.
Sampling of many spring groups and interpretation of chemistry.
Reconnaissance soil mercury surveys on Viti Levu and Vanua Levu.

In 1979, K.H. Williamson (IGS, UK) visited Fiji to carry out an appraisal of geothermal prospects and surveys done to that time. This was at the request of H. Plummer (Director, MRD) to Overseas Development Administration, UK. Williamson visited thermal spring localities in northern Viti Levu, Labasa and Savusavu on Vanua Levu and collected samples for chemical and stable isotope analyses.

Following recommendations by PEM, temperature gradient studies were conducted during 1980 and 1981 in northern Viti Levu, and at Savusavu. Measurements were made by N. Skinner (University of the South Pacific, Suva) in holes drilled by MRD as well as existing holes. Thermal gradients had been previously measured in 1972 by J. Sass (U.S. Geological Survey) in 4 shallow mineral exploration holes in northern Viti Levu, 2 at Emperor Gold Mine and 2 MRD holes.

RESULTS OF GEOTHERMAL SURVEYS

Viti Levu - Healy (1960) concluded that the geothermal systems on Viti Levu were of non-volcanic origin with low temperature surface discharges (35°-60°C) and probably had limited subsurface temperatures. From bottom temperatures in drill-holes (to 600 m) at Emperor Gold Mine (EGM) he estimated geothermal gradients of 30" - 55°C/km, but noted that the higher values probably resulted from circulating thermal water (which discharges at several levels in the mine workings).

Temperature profiles measured in drillholes at EGM by Sass (writ.comm.1972) were 32° - 50°C/km, confirming Healy's results, and were considered to indicate near normal crustal gradients, because of thermal water circulation. Gradients in the two MRD holes (100 and 220 m) at Rakiraki and Balenabelo in N and NW Viti Levu were 11.8 and 15.9°C/km, respectively. Preliminary data from recent gradient measurements by Skinner and MRD show values of ~ 47°C/km for Ba and 37.5°C/km for Rabulu (N. Skinner, A. Green, writ.comm.1981). Assessment of chemical analyses of thermal spring waters (Cox, 1980c) shows them to be essentially dilute alkali chloride water with a slightly alkaline pH; SiO_2 values are 45-80 ppm. The dissolved solids content depends on location, being greater in coastal localities largely due to saline groundwater mixing. The springs have low flow rates (< 2 ℓ/sec) and subsurface temperatures estimated from SiO_2 and Na/K/Ca geothermometres are usually in the range of 90°-115°C. The distribution of springs throughout the island shows that many of them are isolated systems, and probably derived their heat from fairly deep circulation ((?) 1 to 2 km). Chemical deposition at some of the springs reflects the chemical character of the rocks through which the waters migrate and the low order temperatures: gypsum is being deposited by the Waibasaqa springs in central Viti Levu, and at Rabulu on the central N. coast, deposition of calcite indicates subsurface water temperatures of < 100°C. Further confirmation of the low magnitude of temperatures of these systems comes from stable isotope studies (Cox and Hulston, 1980), which show the thermal waters to be isotopically similar to local surface water and to have nil $\delta^{18}O$ enrichment.

Regional assessment techniques were employed by PEM (Anderson and Austin, 1979). Using aeromagnetic data (apparently largely offshore northern Viti Levu with some onshore overlap) their contractors (Eureka Resource Associates) deduced depths to the Curie Point and constructed heat flow maps. (The Curie Point is that where the crust has lost its magnetisation due to elevated temperatures). They deduced an average thermal gradient for N. Viti Levu of 73°C/km and for the Ba thermal springs 85°C/km. From these results they selected the Ba area of NW Viti Levu as a primary target for geothermal exploration. Some question, however, apparently exists in regard to the method of interpreting the depth to Curie Point (Williamson, 1980). From reconnaissance soil Hg surveys over major roads (sample spacing 2-5 km with closer spacings over anomalous areas) Anderson and Austin (1979) considered the Ba area as being anomalous in respect to heat flow. They reported values of 35-1105 ppb with backgrounds of 20-70 ppb. It does not appear, however, that regional backgrounds due to lithological changes and metalliferous mineralisation have been fully considered (Williamson, 1980). Consideration of such background conditions are extremely important in Hg surveys for geothermal exploration (Klusman and Landress, 1979; Cox, 1981b) in addition to which most surface geothermal Hg anomalies are of limited extent (e.g. several km). Calcite deposited from the Rabulu springs contained 580 ppb Hg (Cox, 1980c) which is believed to indicate a high background of Hg in that area.

Anderson and Austin (1979) also used airphoto interpretation to locate curvilinear features, which they consider reflect the presence of batholiths resulting from mantle upwelling, and which they consider are features of all major geothermal areas. There is some question as to the existence of such structures in Fiji and especially their relation to geothermal systems in that environment (Williamson, 1980). In this author's experience virtually all Fiji geothermal occurrences are associated with systems of linear, normal faults. PEM also collected samples of most springs on Viti Levu, with chemical analyses of all major constituents (except Na, K, F) being made in the field. Limited analytical results are reported but silica (mixing model) and alkali geothermometer calculations were made. Subsurface water temperatures of 161° to 300°C were estimated by SiO_2 methods for geothermal systems at Ba, Tavua and Rabulu in N. Viti Levu, with lower temperatures for the alkali geothermometers. A basic conclusion of this writer is that the silica mixing model geothermometer used by PEM produces increasingly unreasonable temperature estimates with increasingly diluted waters. Temperature estimates from the alkali geothermometers are more reasonable.

Williamson (1980) collected thermal water samples for chemical and isotopic analysis in the UK. He considered the thermal waters of N. Viti Levu show little evidence of high temperatures at depth, being low in Cl (except where seawater is mixing) and SiO_2 and showing no enrichment of Li, Rb or F. Using alkali geothermometers he calculated temperatures of < 105°C at depth. He concluded from stable isotope data that the subsurface temperatures may not be high enough to allow isopotic exchange tb occur within the period of circulation of the groundwater.

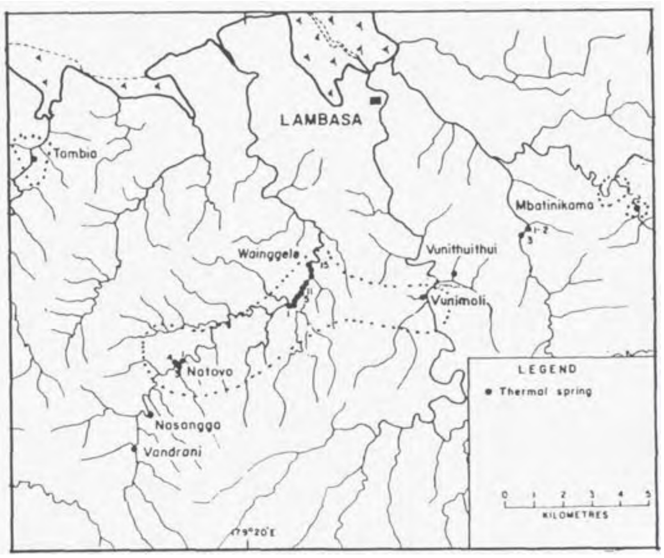

FIG. 3: Thermal springs of the Labasa area. Boiling springs occur at Waiqele (Wainggele); Tabia (Tambia) springs are 80°C. Approximate boundaries of low resistivity zones are outlined.

Labasa Area - Thermal springs in this area occur over a 19 km long NE-trending belt, 8 km south of the town of Labasa (population ∿ 3000). In addition, there is a smaller group of hot (80°C) springs at Tabia, 12 km to the west of the town. The springs in the centre of the Labasa group are boiling (Fig. 3).

Healy (1960) visited the main springs and estimated a heat loss from them of ∿ 4.4 MWt. He considered they may be associated with a single large reservoir, which is of relatively low temperature. He concluded that the waters were probably of local meteoric origin. Cox (1980d) located and described all the occurrences, carried out preliminary sampling, heat loss calculations and soil temeprature surveys. The soil temperature surveys (1m depth), in which > 30°C was considered anomalous, showed that heat flow is essentially convective and that shallow ground temperatures rapidly dropped to ambient away from the discharges. Estimates of heat loss were greater than those of Healy, but included additional springs and were estimated at 14.3 MWt for the Labasa zone and 3 MWt for Tabia. (These values were incorrectly calculated in Cox, 1980d; 1980f). Geological mapping and airphoto interpretation confirmed that all the spring localities are associated with faults (with a dominant NE trend) a point noted by Healy. Total discharge from the Labasa zone was 60 ℓ/sec and from Tabia 12 ℓ/sec.

Site specific geophysical surveys were conducted in the Labasa-Tabia zones (Cox, 1978; 1981a). Electrical resistivity techniques involved 12 vertical soundings (AB/2 = 915 m) and bipole-dipole mapping from 5 sources with 180 measurements of potential, The resistivity mapping was difficult to interpret but basically outlined a shallow, elongate layer of low apparent resistivity (< 20 ohm-m) of ∿ 20 km^2 and limited deep conductive zones, Soundings indicate the conductive zone is at 7 to58 m and is ∿ 150 m thick, with some continuation to depths of > 800 m within several narrow zones some associated with faults. Ground magnetic surveys delineated zones of low magnetisation partly coincident with the low resistivity areas, which are interpreted as being due to hydrothermal alteration. Reinterpretation of existing aeromagnetic data over the area suggests that the Labasa geothermal area could occur within a large collapsed caldera structure, within which faulting is well-developed. S.P. traversing within the Labasa zone showed dipolar anomalies, some wibh peak-to-peak amplitudes of up to 100 mV, near hot springs and associated faults, but overall the results were non-conclusive (Lienert and Cox, 1981). The geophysical surveys are believed to have outlined the approximate extent of a shallow aquifer of thermal water and indicate some vertical extent of thermal features (? hot water upflow) largely associated with faults. On the basis of these data and geochemistry, 3 exploratory drill sites were located.

Geochemical studies of the Labasa area (Cox, 1980e), show the thermal waters are near neutral with Na and Ca as major cations and SO_4 and Cl as major anions, with total dissolved constitutents of ∿ 1100 ppm. The boiling springs at the centre of the belt are depositing $CaSO_4$ (gypsum) and minor SiO_2. Chemical geothermometry indicates a maximum subsurface temperature in the system of 120° - 125°C. The Tabia system is similar chemically but appears to be a small, unique system. Subsurface temperatures there are estimated at ∿ 110°C. Stable isotopes of oxygen and hydrogen indicate the spring waters are of meteoric origin and have the characteristics of fairly low temperature, hot water systems, with recharge occurring locally (Cox and Hulston, 1980). Waters from the different springs are indicated to be of a common origin, but to have experienced varying degrees of mixing with shallow groundwater, and possibly different residence times in a shallow aquifer. Many of these conclusions were initially suggested by Healy (1960).

Anderson and Austin (1979) structurally interpreted airphotos of the area in respect to spring locations associated with curvilinear features and suggested doming caused by igneous intrusions. Igneous intrusions do-occur in the area (Ibbotson, 1969) and are reflected in aeromagnetic data, but a different structural surface expression was interpreted by Cox (1981a) which is believed to indicate subsidence. From their water chemistry Anderson and Austin (1979) determined a possible reservoir temperature of 125° - 143°C ("best" estimate of 128°C) which they consider to be related to a regional, high heat flow. Their soil Hg survey produced a "moderate mercury anomaly" which was excluded from exploration target selection on the basis of the water chemistry suggesting subsurface temperatures *too* low for electric-power generation.

From his geochemical studies, Williamson (1980) determined a total dissolved solids content of ∿ 1200 mg/ℓ and from SiO_2 content calculated a reservoir temperature of 125°C. Results of his isotopic studies confirmed the results obtained by Cox and Hulston (1980).

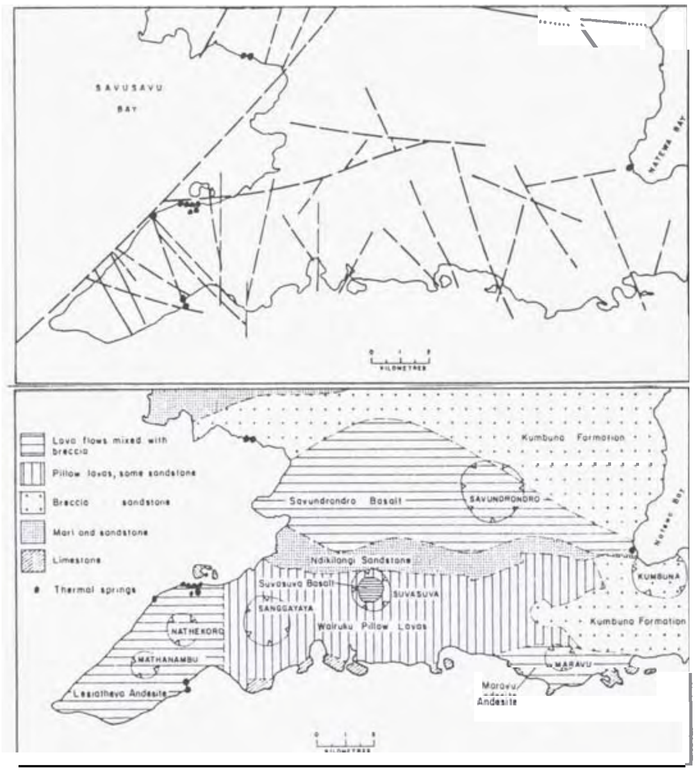

FIG. 4: Savusavu area: (a)Faults inferred from field mapping (Woodrow,1976) and airphoto interpretation. (b)Rock types, formations and volcanic centres (after Woodrow, 1976).

Savusavu Area - The thermal springs at Savusavu occur at 3 main localities around the coast of a block-faulted peninsula ∿ 7 x 3 km (Fig.4). The peninsula is formed of Late Miocene-Pliocene andesitic lavas and breccias (Woodrow,1976). The main springs occur within the town of Savusavu (population ∿2200).

This area was considered by Healy (1960) to have the greatest potential for geothermal utilisation in Fiji; he concluded that the characteristics of the system suggested a hot intrusive body below the peninsula. Calculations of heat loss from the springs (Cox,1980,f) provide a figure of ∿16.8 MWt, in agreement with Healy's conclusions and recalculated heat loss measurements. Soil temperature measurements show an area of about 0.06 km^2 of >40°C around the main springs at Nakama and on the adjacent beach, which is attributed to lateral movement of shallow hot water. However, anomalous ground temperatures were limited to the immediate vicinity of the other spring localities. Limited geophysical surveys were made around the spring locations (Cox, 1980,f). Ground magnetics outlinned areas of low magnetisation, coincident with soil temperature anomalies, and interpreted as being due to shallow hydrothermal alteration. S.P. traverses showed higher potentials near some thermal discharges, but low potentials over the main springs; the results of the surveys are not, however, considered reliable. Shallow vertical electrical soundings AB/2 = 350 m) defined the saline water table and suqqest shallow thin lenses of thermal water near the-main springs, and an indication of deeper zones of thermal water some possibly within faults.

Chemistry of thermal and other waters (Cox, 1980,c; 1980,e) indicate the deep thermal water to be a near neutral Ca-Na-Cl type with an estimated temperature of 160°C. Mixing of 15-25% seawater occurs in many of the springs. The thermal waters are saturated with quartz and boiling springs deposit a quartz sinter, an indication of higher level temperatures. All springs discharge from a system of faults, which are indicated to be hydrologically connected, and to control subsurface fluid migration. On the south coast of the peninsula a coastal coral reef may tend to restrict thermal water discharge. Stable isotope data (Cox and Hulston, 1980) show the thermal waters to be essentially of meteoric origin, with some positive oxygen shift, the slope of which overall indicates seawater mixina. Some minor $\delta^{18}O$ enrichment from thermal conditions may however occur. Three locations for exploratory drilling (one 500 m and two 300 m holes) have been suggested (Cox,1980,b)

At least six volcanic centres occur along the peninsula and further inland (Woodrow,1976) indicating an easterly trend, which coincides with an elongate E-W dipolar magnetic anomaly, suggesting the existence of an intrusive mass at depths of around 200-400 m. Lavas of one of the volcanic centres (Suvasuva) 7 km east of the springs, may be appreciably younger than the surrounding volcanic rocks.

Anderson and Austin (1979) interpreted the Savusavu hot springs to be on the western side of a prominent curvilinear feature, centred over this (?) younger intrusion. They consider this as the "apparent intrusive centre" and to be the centre of the area of interest, showing radial faulting representing shallow doming. Their chemical geothermometry provides a "best reservoir temperature" of 190°C. Soil Hg traverses in this region had a background value of 20-70 ppb, with anomalous values of ∿ 300 ppb at the Savusavu springs, Sinters from these springs contain 150 ppb Hg (Cox,1980,c).

Williamson (1980) showed from chemical analysis that the Savusavu springs have a high Cl content and the highest SiO_2 in Fiji, indicating quartz equilibrium temperatures of 140°C. He concluded that the high surface heat loss and relatively high SiO_2 suggest the area has some promise of a high enthalpy system.

Thermal gradient measurements in the MRD hole drilled in 1981 approximately 3.5 km SE of the main springs are not yet available.

Other Geothermal Areas - Healy (1960) compiled data from previous studies of other thermal areas on Vanua Levu and the smaller islands. Rodda (1979) described and sampled the springs on Vanua Balavu, and Woodrow (1976) described the springs on Rabi Island. These and other previous reports show that these occurrences overall have low flow rates and temperatures of < 60°C. Heat loss calculations for these groups of springs range from 0.05 to 0.8 MWt. Most of the thermal springs on the smaller islands have appreciable seawater mixing, Assessment of available water chemistry (Cox,1980,c) indicated, subsurface water temperatures in the range of 90 - 115°C.

Anderson and Austin (1979) extended their reconnaissance surveys to include the springs of Cakaudrove Peninsula (eastern Vanua Levu) and Rabi Island. From airphotos they interpreted the existence of a 30 km diameter NE-SW elliptical structure centred on Rabi Island, and which intersects the tip of Cakaudrove Peninsula. They report "best" temperatures for subsurface thermal waters of 153°, and 145°C for the Rabi springs. They also report a minor Hg anomaly for these areas.

CONCLUSIONS FROM INVESTIGATIONS

Viti Levu - The thermal spring systems on Viti Levu are expressions of low temperature water systems, some with fairly deep circulation. No significantly elevated geothermal gradients are indicated, and the higher gradients measured do not produce any major heat input to the geothermal systems. The systems are of low throughput of locally derived meteoric water, with subsurface migration largely controlled by faults. Subsurface water temperatures are on the order of 90°-115°C. As a consequence, any possible utilisation would, under current conditions in Fiji, consist of low investment, very small scale direct use.

Labasa, Vanua Levu - The Labasa system is indicated to be a relatively extensive fault controlled system with subsurface temperatures on the order of 125°C. Several exploratory drill sites were recommended near the centre of the zone. Although there exists the potential of significant recharge to this system, any utilisation is limited by the low temperatures. On this basis the area is unsuited for consideration for electric power generation, but some smaller scale direct heat applications may be feasible. The dissolved solids in the waters are ∿ 1200 ppm and the waters contain very low amounts of trace metals; their saturation with $CaSO_4$ and the likelihood of gypsum deposition in the pipes could, however, be troublesome.

Savusavu, Vanua Levu - The Savusavu system has the greatest potential for exploitation of the Fiji geothermal areas. Subsurface temperatures of ∿ 160°C appear reasonable, within a fault controlled reservoir below the peninsula. The subsurface permeability of the lavas, however, is an important factor. An extension of the reservoir inland is a possibility but there is currently no direct evidence for this. Further confirmation of the higher temperatures in this system are quartz deposition from the spring waters and the higher heat loss. Both the thermal waters and sinters are low in trace metals.

Some limitations, however, are evident. Important for exploitation is the need for adequate recharge; the hydrological conditions of the peninsula are not known, especially in regard to whether recharge of groundwater is entirely local or some is derived from further inland. This also introduces a potential problem of drawing in a significant component of saline groundwater after prolonged production. This could be especially important if the Ghyben-Herzberg basal groundwater model applies to the peninsula. In respect to the above, a substantial increase in salinity could produce corrosion problems; silica deposition should also be expected (maximum measured spring SiO_2 = 179 ppm).

Some rough approximations can be made about the geothermal potential of the system. Assuming a reservoir temperature of 160°C and a potential total discharge from the system of ∿ 196 tonne/hr (equivalent of the natural discharge of 60 l/sec) gives an output of ∿ 36.5 MWt. Accounting for permeability variations etc. in wells, would give an optimum of about 10% of this available for utilisation (i.e. ∿ 3.65 MWt) from several ideally sited geothermal wells. As the conversion of thermal to electrical energy is about 30% efficient, this gives a conservative approximate potential of 1.1 MWe; using ∿ 10% of this to run plant and auxilliary equipment leaves ∿ 0.99 MWe.

The indicated temperatures of this system suggest that it would be marginal for exploitation by conventional geothermal power plants and that a binary-type system may be more suitable, Such a set-up may require a system with at least three wells, and a skid-mounted plant (dimensions around 3 x 8 m). Another consideration is the reinjection of discharge water from the binary heat exchanger, if recharge problems are anticipated.

A possibly more economic alternative for Savusavu would be direct heat applications of the thermal waters. These would require shallower wells, and lower production. Some form of drying or refrigeration plant are worthy of consideration in this rurally based area, especially considering the potential for port facilities and road access to Labasa.

Current Power Usage -

In terms of usage of electrical energy, the main requirements in Fiji are on the island of

Viti Levu, on which is the capital ,Suva, the international airport at Nadi, and on which the majority of the population of ~ 500,000 live.

The present installed capacity (diesel generators) of Viti Levu is ~ 68MW (from Williamson, 1980), with another 20 MW generated by other facilities (eg. Emperor Gold Mine). Hydroelectric installations are being constructed, and a 40 MW plant was due for commission in late 1981. The installed capacity of hydroelectric stations should be increased to 60 MW by 1984 and 80 MW by 1987. On Vanua Levu, the installed capacity at Labasa is 2.6 MW (maximum demand 1.6 MW) and at Savusavu 0.6 MW (maximum demand 0.2 MW).

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