Proceedings World Geothermal Congress 2010
Bali, Indonesia, 25-29 April 2010

Low Enthalpy Geothermal Energy Resources for Rural Māori Communities–Te Puia Springs, East Coast, North Island New Zealand

Pia Pohatu[1], Tui Warmenhoven[1], Andrew Rae[2, *], Diane Bradshaw[2]

[1] He Oranga mo nga Uri Tuku Iho Trust, 20 Barry Avenue, Ruatorea 4032, New Zealand

[2] GNS Science, Wairakei Research Centre, Private Bag 2000, Taupo, 3352, New Zealand

* a.rae@gns.cri.nz

Keywords: Te Puia Springs, low enthalpy geothermal, Ngāti Porou, rural Māori communities, traditional and historical uses

ABSTRACT

Māori have a long association with New Zealand's natural environment. This association is based on knowledge that has built up over time through centuries of interaction with the natural world, and includes use of low enthalpy geothermal resources within iwi/Māori communities. A "low enthalpy" geothermal resource is considered one where heat energy is generally <150°C. We explore the knowledge that existed within Māori communities pertaining to traditional uses, and also what technical capability and capacity these communities have or require to utilise energy from this resource. A review of the scientific data to date is also provided. "Rural Māori Communities" refers to those living in Te Puia Springs (an area containing a low enthalpy geothermal resource) and having a cultural relationship with, or significant interest, in the geothermal resource.

1. INTRODUCTION

1.1 Tangata Whenua

Māori as indigenous people of New Zealand identify as tangata whenua *people of the land.* Societal arrangements are determined by tribal groupings through shared genealogy to a common ancestor. These groupings include waka *migration canoe*, iwi *tribes*, hapū *subtribe* and whanau *family* groups. Iwi and hapū are geographically located through occupation of the land by way of original occupation, intermarriage, gift or conquest.

Ko Waiapu te Awa, Ko Hikurangi te Maunga,
Ko Ngāti Porou te Iwi.
Waiapu is the river, Hikurangi is the mountain,
Ngāti Porou is the tribe.

Figure 1: Mt. Hikurangi (P. Pohatu).

The proverb locates the *Ngāti Porou* tribal grouping to the East Coast, North Island of New Zealand.

The hapū, Te Whānau a Iritekura *the descendents of the chieftainess Iritekura* are amongst fifty or so hapū who associate with the tribe *Ngāti Porou* and is predominantly resident in the geothermal area of Te Puia Springs.

A number of hapū were able to access the abundant foods and natural resources of Te Puia. Statements made by indigenous chiefs taken from minutes books of the Native Land Court in 1885 illustrate the value of the waters and food sources:

> "the mineral enriched waters of Te Puia fed into surrounding lakes, streams, swamps and marshes. This habitat was home to many species of native birds and an abundance of eels" (Nepia, 1995).

Te Ratahi Iti (lake), *Ratahi nui* (swamp) and the Makarika Stream were a part of the surrounding water system and eel fishing was a highly regulated activity. *Aruhe* fernroot was also plentiful around Te Puia as the soil type was best suited to its growth. This was a highly valued natural food (staple). The area was not used by hapū for cultivation of crops such as taro or kūmara *sweet potato.*

While other hapū including Ngāti Rakai, Te Whanau a Rakairoa and Te Whanau a Te Kaipakihi all have traditional associations with the access and use of the natural resources of Te Puia Springs (Nepia, 1995), Te Whanau a Iritekura hold the mana whenua *authority over the land.*

1.2. Treaty of Waitangi Claims and Direct Negotiations

For over 180 years, land grievances brought on by the mechanisms of post-colonial government have alienated the hapū and iwi of Ngāti Porou from management and control over land and resources. Today, hapū and iwi are involved in a Waitangi Tribunal inquiry seeking redress for historical grievances with the Treaty of Waitangi – an agreement signed between the British Crown and Māori in 1840 guaranteeing, hapū their authority over lands, resources and taonga *economic, cultural, environmental and social resources both tangible and intangible*. The tribe is concurrently involved in direct negotiations with the New Zealand Government. A component of these negotiations includes the future legal title, governance and management in regard to the geothermal resources of Te Puia.

1.3. Te Puia Springs, A Low Enthalpy Geothermal Resource

Low enthalpy geothermal springs occur at two locations on the East Coast of North Island, New Zealand. Springs at Morere and Te Puia (Figure 1) discharge warm water at 50–

70°C. This paper focuses on the geothermal springs and surface manifestations at Te Puia, approximately 110 km north of Gisborne (Figure 1). As many as eight thermal springs are located in a ~1.5 km^2 area on land presently administered by the New Zealand Government's Department of Conservation.

Sections 2 and 3 of the paper describes some of the traditional (indigenous knowledge) and historical uses of geothermal resources at Te Puia Springs and Sections 4 – 6 examine scientific findings and collaborative work that is currently taking place in order that the resource may be better understood and managed in the future.

2. TRADITIONAL KNOWLEDGE/USES

Mātauranga *traditional knowledge* refers to indigenous knowledge that was orally transmitted from one generation to the next. The following illustrates knowledge, uses and practices relating to the geothermal resources at Te Puia springs and is by no means a complete description.

2.1 Geothermal Resources

Puia is a Māori term that is associated with geothermal hot pools, hot springs and thermally heated water, muds and clay deposits. Place names such as Waiariki *prestigious waters*, Waiaranga *bobbing waters*, Waitangi *gurgling waters* and Waipiro *putrid water* (Ngata, 1993) are traditional expressions that identify or describe the quality or type of water. Other terms recommend use for particular waters such as Waimirimiria which refers to *massaging waters*. These were used for the purpose of making babies strong and supple from long periods of lying on their backs, and to encourage early walking. Wairata was a pool used for the ritual of child water birth which was commonly used during the winter months (Kupenga, 2009).

While there were numerous ways the pools and springs were used by Māori, each pool had a specific and carefully selected purpose – the pools were not multi-purpose each was managed according to features such as water quality and volume. Restrictions on use were periodically placed and strictly adhered to. The physical properties of the pool including access, size, clarity and temperature determined use. Domestically, larger pools were for bathing and smaller, hotter pools were reserved for cooking.

To Māori, the waterways, pools and springs were highly valued and treated with utmost respect. This is clear from the very personal nature in which the water was used and the superior level of wellbeing and health that was derived from its use.

2.2 Occupation

Te Puia was an ancient pa and kainga, although the pa *Pahuretanenui* was located on an elevated site. Otherwise Te Puia was not a site of permanent habitation (Nepia, 1995) but Te Whanau a Iritekura occasionally occupied a number of temporary whare *dwellings* in order to access and use the natural resources. Dwellings and places were named in relation to their locality, for example Te Rongo o Te Puia *the scent of Te Puia* was the name of a house whereas the area from where drinking water was taken was named Te Waipuna *the spring of drinking water* (Nepia, 1995).

2.3 Healing, Medicinal and Therapeutic Use

Bathing is an ancient practice that was either common or sacred, the latter requiring ritual and karakia *prayer, incantations* (Kupenga, 2009). The mineral properties within the pools and springs afforded a high level of general wellbeing and treatment of aches and pains related to rheumatics, arthritis, respiratory illnesses and skin problems such as eczema.

The pools were also used to prepare warriors for impending battle and assist with their rehabilitation post-battle. Ritual and karakia were used to enhance the mana *powers* gained from the water to not only prepare them physically but also mentally and spiritually for the tasks required. In this context the springs and the associated ritual and karakia were symbolic gateways to the activities or tasks that required a state of tapu *sacredness* – as in entering battle and the need to return to a state of noa *common* during times of peace.

2.4. Domestic Use

Domestically, harakeke *flax* was laid in the hot water to soften and hasten its preparation. This was also used as a secondary treatment associated with establishing a more permanent colouring of the flax prior to working into clothing, baskets, containers, mats and such. Smaller and elongated shaped pools were usually used for this purpose (Kupenga, 2009). Paru *mud clays* were used as pigmentation for weaving materials which were placed into the source for a certain period, removed and dried.

Hot water and steam was used daily for cooking food. *Waituhi* is an extremely hot pool or spring beyond a human's ability to stand the heat and therefore the spring was used for cooking.

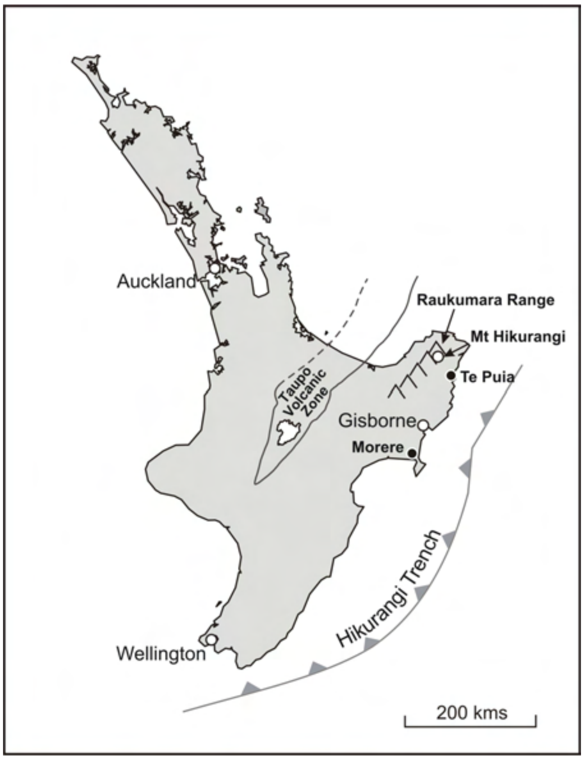

Figure 2: Location map of East Coast thermal springs, North Island, New Zealand.

2.5. Methane Gas

While not a geothermal resource, methane gas seeps are referred to here as they are also found in situ and traditionally associated by Māori with geothermal resources. The names of areas and landblocks for example, Te Ahi A Te Atua *the Fire of the Gods*, indicate to us today where these gas seeps occur, although they were most visible at night when alight and are known to burn continuously. In the main, the heat was used to warm oneself and cook food while travelling.

3. HISTORIC USES

This section gives a brief account of post-colonial developments which took place in the Te Puia area.

3.1 Commercial

The first commercial use of the geothermal resources was by European settlers in the beginning of the 20th Century. Recognition of the potential for scenic tourist attractions, similar to those already established at Rotorua, Hanmer and Te Aroha, was the main impetus for the establishment of a commercial bathing spa ca. 1901. An accommodation house and two bath houses were built on land leased from the Crown's Land and Survey Department (Figure 3). Subsequently, hot water was tapped along metal pipes to local homes and the hotel (Rockel, 1986).

Improved roading along the East Coast by the early 1930's attracted more visitors to the district and made a bathing spa tourist attraction commercially viable. In 1935, the Te Puia Springs Hotel was opened (Figure 4). The establishment had a concrete swimming pool behind the main building (Figures 5 and 6), along with private bathing houses and landscaped gardens. By 1981 however, the swimming pool was closed and filled in, and the hotel pools have not been in use for a number of years.

Figure 3: Accommodation house at Te Puia Springs, ca. 1901. Source: Rockel (1986).

Figure 4: Te Puia Springs Hotel, ca. 1935. Source: Rockel (1986).

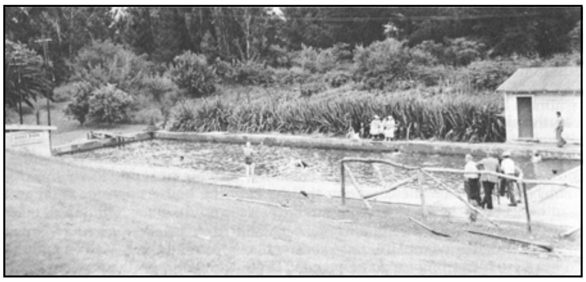

Figure 5: The public pool at Te Puia Springs Hotel, ca. 1940. Source: Rockel (1986).

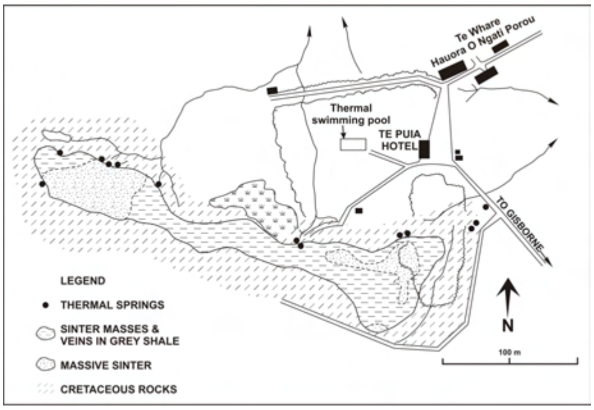

Figure 6: Map showing spring locations at Te Puia, as mapped by Glover (1968), the surface geology proximal to the springs, as well as the hotel and district hospital (Te Whare Hauora O Ngāti Porou). Modified from Macpherson (1945).

3.2 Te Puia Hospital – Te Whare Hauora O Ngāti Porou

A small hospital was first erected in Te Puia in 1907 in response to a severe outbreak of typhoid (Mackay, 1949). This was a state administered hospital up until the late 1990's. Today the hospital land and facilities is owned and managed by Ngāti Porou Hauora, an iwi health provider and Primary Healthcare Organisation (PHO). The hospital facility continues to access and use geothermal waters for hot water and hydrotherapy. Currently, spa development is planned, however negotiations in relation to future access, use and management of the resource are taking place between the hapū and hospital Board.

4. DISTRICT GEOLOGY

The East Coast of the North Island, New Zealand, is an active accretionary prism of uplifted marine sediments formed by westwards subduction of the Pacific Plate beneath the Indian Plate, along the Hikurangi Trench (Figure 2). The marine sedimentary stratigraphic succession consists of Middle Tertiary to Recent strata unconformably overlying Cretaceous meta-sedimentary basement rocks. The meta-sediments include indurated sandstones, siltstones and argillites (greywacke) and coarse, volcanogenic conglomerates (Kingma, 1966). Active volcanism does not occur in the region.

At Te Puia, surface geology consists of lower Cretaceous sandstone and siltstone greywackes of the Taitai series (Figure 6). These are unconformably overlain by Paleocene to Eocene calcareous sandstones, siltstones and bentonitic mudstones, and by Miocene sediments, volcanogenic tuffs and conglomerates (Kingma, 1966).

Te Puia Springs is located on an active landslide where large Late Cretaceous sedimentary blocks are sliding on a slip plane at 55 mm/yr towards the coast (Mazengarb and Speden, 2000).

Calcareous sinter (travertine) deposits occur around active springs (Figure 6) and form a prominent east-west ridge up to 30 m above the present hot springs (Macpherson, 1945; Alacali, 2002). The sinter covers an area 600 m long and 20 m wide and the east-west orientation maybe related to a fissure associated with the active landslide (Mazengarb and Speden, 2000).

The district is transected by north- and north-northeast trending thrust faults and accompanying anticlinal and synclinal folds. The resulting structure is complex, with overturned sequences, low-angle normal and reverse faults and mélange zones (Kingma, 1966; Francis, 1991). At Te Puia, an exposed core of Cretaceous to Oligocene rocks forms a faulted dome that is surrounded by radially dipping Lower to Upper Miocene sediments (Lyon et al., 1992).

5. GEOTHERMAL SURFACE MANIFESTATIONS

5.1 Thermal Springs

Surface thermal manifestations at Te Puia Springs include hot springs and pools, gas vents and both travertine and sulphur deposits. These features are located in a 700 m, east-west trending zone (Figure 6). Thirteen hot springs were mapped by Macpherson (1945) and by Glover (1968), but only eight of these were mapped in 2002 by Alacali (2002), Jonathan (2002) and Kato (2002). Spring discharge waters have temperatures ranging from 54–69°C (Kato, 2002). The waters have a diffuse, milky colour and are typically surrounded by deposits of grey to black muddy clay, sulphur and/or travertine deposits.

Weak to vigorous bubbling of CO_2 and H_2S gases are frequently observed in the spring pools (Kato, 2002). Areas of gas venting also occur away from the springs. These gases are predominantly CH_4, CO_2 and H_2S (Jonathan, 2002; Kato, 2002).

5.2 Spring Chemistry

Chemical analysis of the Te Puia thermal spring waters show them to be highly mineralised, of near neutral pH, with sodium and chloride being the dominant components. The average spring chloride and sodium concentrations are approximately 7500 ppm and 4500 ppm, respectively. All springs have similar chemical characteristics, suggesting derivation from a common source and are classified as neutral sodium chloride waters (Kato, 2002). The Cl/Br ratios of the spring waters are similar to that of sea water, suggesting a sea water derivation.

Application of cation geothermometry (Na-K-Mg) by Kato (2002) and Hunt and Glover (1995) show that likely reservoir temperatures are close to 100°C. There doesn't appear to be any evidence for steam loss in the subsurface, indicating that thermal waters are below boiling point and have cooled conductively during their ascent to surface (Kato, 2002).

The concentration of lithium (13-14 ppm) is much greater than that of sea water and is similar to that of high temperature geothermal waters discharging from springs in the Taupo Volcanic Zone. This suggests that deep in the reservoir these waters may have been at elevated temperatures of 200-330°C. The lack of active volcanism in the area infers that such temperatures can only be attained at great depth. However, the near equilibrium concentrations of Na, K and Mg at temperatures close to 100°C indicates that cooling from such elevated temperatures had to have occurred slow enough for cation equilibrium to be maintained (Hunt and Glover, 1995).

6. GEOPHYSICS

A heat loss assessment of the Te Puia thermal area shows that in 2002, the total flow rates of all active springs was 8.7 l/s. This infers a minimum thermal potential for the Te Puia geothermal system of 1.8 MW (Jonathan, 2002).

Regional geothermal gradient studies indicate a normal thermal gradient of 30°C/km, implying that depths of 6-12 km are required to attain temperatures of 200-300°C (Hunt and Glover, 1995).

Regional magnetic studies show that the East Coast thermal springs at Morere and Te Puia are spatially associated with regional anomalies that are thought to be manifestations of either buried ophiolite bodies that were emplaced into the accretionary prism, or seamounts that have been subducted beneath the prism (Hunt and Glover, 1995). It has been proposed by Hunt and Glover (1995) that these bodies facilitate dewatering of subducted marine sediments from the prism and/or the subducted plate. This deep sourced water has risen to shallow crustal levels and is modified by both interaction with the overlying sedimentary strata, and mixing with near-surface meteoric waters, before discharging at surface springs.

7. SUMMARY AND DISCUSSION

Te Puia is the primary and most significant geothermal resource within the Ngāti Porou tribal district, therefore the area is of immense value to the hapū who hold mana whenua over the land. The matauranga *traditional knowledge* pertaining to Te Puia is integral to the sustainable development of the resources. Collaborative relationships between Crown research agencies and hapū is fundamental to the future ownership and management of the natural resources.

The geothermal manifestations located at Te Puia Springs, East Coast, New Zealand, are part of a low enthalpy geothermal resource (i.e., <150°C, as classified by Thain et al., 2006). The heat source is considered to be non-magmatic and derived from crustal rocks with a natural thermal gradient and enhanced permeability, due to tectonic processes along an active tectonic plate margin. This resource is comparable to the low enthalpy geothermal resources of the South Island, New Zealand (e.g., Hanmer Springs).

The Te Puia thermal spring waters are mineralised and of near neutral pH. The waters are classified as neutral sodium chloride waters with sodium and chloride being the dominant cation and anion components (7500 ppm and 4500 ppm, respectively). Waters have Cl/Br ratios that are similar to that of sea water, suggesting a sea water derivation. Estimates from cation geothermometry imply that the spring waters are sourced from a geothermal reservoir having temperatures close to 100°C. However, lithium contents suggest much higher temperatures (i.e., 200-300°C) occur at significant depths (i.e., 6-12 km). It has been proposed by previous workers (Hunt and Glover, 1995) that deep reservoir waters are sourced from dewatered subducted marine sediments, which rise to shallow levels, interacting with sedimentary strata and mixing with meteoric waters.

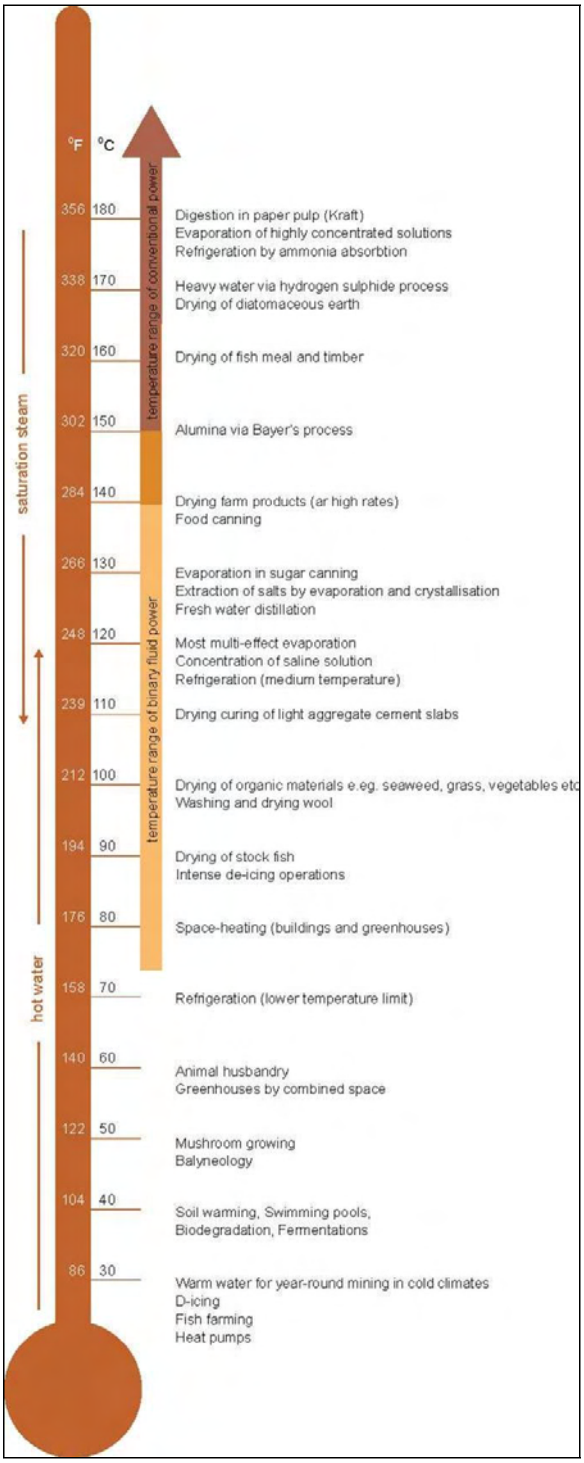

Figure 7: Lindal diagram, showing applications for geothermal resources. Source: Lindal (1973).

Travertine sinter terraces that occur away from areas of active spring discharges form prominent ridges above the thermal area. These are indications that geothermal spring activity has been ongoing in the area for geologically significant periods of time. Utilisation of the thermal springs at Te Puia dates back to pre-colonialisation times when local Iwi and Hapū groups traditionally used the warm water and surrounding mineralised rocks.

Including that already used by the local hospital (Te Whare Hauora O Ngāti Porou), the potential exists at Te Puia for further utilisation of the thermal springs. The total flow rates from springs across the thermal area have been estimated to be 8.7 l/s, with a minimal thermal potential of 1.8 MW. These values are considered to be low, but do not preclude finding an appropriate application of the resource that suits the needs of local- and/or district-wide communities. With resource temperatures below 100°C and the low flow rates, power generation is not likely to be pursued. However, low enthalpy geothermal resources can be used for a wide range of domestic, agricultural and industrial applications that involve direct use of the heat. Various low enthalpy applications for resources with temperatures <100°C are summarised in the Lindal Diagram (Figure 7; Lindal, 1973). These include industrial drying and washing, aquacultural and horticultural, refrigeration and space heating applications.

To completely understand the thermal resource at Te Puia, and provide a basis for decisions regarding further utilisation, it is planned to undertake a MT resistivity geophysical survey of the surrounding the thermal area. Data resulting from his survey will add to the Te Puia scientific database and provide a clearer assessment of the geothermal potential beneath Te Puia. Such a survey may assist the targeting of an exploration borehole.

REFERENCES

Alacali, M.: Geological assessment of the Te Puia thermal area, East Coast. Diploma in Geothermal Energy Technology, unpublished report 2002.01, University of Auckland, 17p, (2002)

Francis, D.A., Webby, D.C., Christie, A.B., Brown, L.J.: Sheet QM303 Raukūmara. Geological Resource Map of New Zealand, 1:250 000. New Zealand Geological Survey Report M 180, (1991)

Glover, R.B.: Chemical analysis of and brief comments on miscellaneous mineral waters. unpublished Chemistry Division Report No. CD118/12-RBG/23. D.S.I.R., New Zealand, (1968)

Hunt, T.M., Glover, R.B.: Origin of mineral springs on the East Coast, North Island, New Zealand. Proceedings of the 17th New Zealand Geothermal Workshop, 71-76, (1995)

Jonathan, N.A.S.: Heat loss assessment of the Te Puia thermal area, East Coast, New Zealand. Diploma in Geothermal Energy Technology, unpublished report 2002.11, University of Auckland, 30p, (2002)

Kato, V.: Te Puia springs and their chemical composition. Diploma in Geothermal Energy Technology, unpublished report 2002.12, University of Auckland, 30p, (2002)

Kingma, J.T.: Sheet 6 – East Cape. Geological map of New Zealand 1:250 000. Wellington, New Zealand. D.S.I.R, (1966)

Kupenga. A.T.: He Korero e pa ana ki Nga Puia, (Unpublished Manuscripts), (2009)

Lindal, N.: Industrial and other applications of geothermal energy. In: H.C.H. Armstead (ed.) Geothermal Energy, UNESCO, Paris. 135-148, (1973)

Lyon, G.J., Giggenbach, W.F., Francis, D.: The stable isotopic composition of some East Coast natural gases. Proceedings 1991 NZ Oil Exploration Conference, 310-319, (1992)

Mackay, J. A.: Historic Poverty Bay and the East Coast, N.I., N.Z. J.A. Mackay, Gisborne, (1949) Macpherson, E.O.: Te Puia hot springs. New Zealand Journal of Science and technology 26B, 244-254, (1945)

Mazengarb, C., Speden, I.G. (compilers): Geology of the Raukumara area. Institute of Geological & Nuclear Sciences, 1:250 000 geological map 6. 1 sheet + 60 p. Lower Hutt, New Zealand. Institute of Geological & Nuclear Sciences, (2000)

Ngata, H.M.: English – Māori Dictionary, Learning Media Ltd, New Zealand, (1993)

Nepia, M.: Report for Te Runanga o Ngāti Porou on the Alienation of the Waipiro No.6 (Te Puia) Block, (1995)

Rockel, I.: Taking the waters, early spas in New Zealand. Government Printing Office, Wellington, New Zealand. 195 p, (1986)

Thain, I., Reyes, A.G., Hunt, T.: A practical guide to exploiting low temperature geothermal resources. GNS Science Report 2006/09. 76 p, (2006)