

THE GEOTHERMAL FEATURES SHOWN ON HOCHSTETTER'S GEOLOGICAL
MAP OF THE AUCKLAND PROVINCE

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ABSTRACT

Ferdinand von Hochstetter (1829-1884), who visited New Zealand in 1859 with the Novara expedition, made four geological maps of portions of the country; two of these show geothermal fields, in addition to regional geology. Hochstetter's map of the Geology of the Auckland Province is at a scale of 1:700,000 and shows the locations of 22 geothermal fields, 18 in the Taupo Volcanic Zone. Several of these have changed in their activity since 1859 or even been destroyed; others appear to have changed only slightly. Hochstetter's maps thus provide a valuable record of earlier geothermal activity in this important geothermal region and reveal how it has changed since 1859.

INTRODUCTION

Ferdinand von Hochstetter (1829-1884) was the most outstanding member of the Novara expedition which took its name from the Austrian frigate that arrived in Auckland on 22nd December, 1858, as part of a world circumnavigation. Hochstetter obtained leave from the expedition to remain in New Zealand to make surveys of its natural history, geology and geomorphology (Carle, 1988). He was the first to describe and interpret many features of the geology of New Zealand and to recognize that the Taupo Volcanic Zone (TVZ) is a graben.

Hochstetter also made the first regional geological survey of any area in New Zealand and produced the first geological maps of the colony (Hochstetter and Petermann, 1863, 1864a,b). 'The Bibliography of New Zealand Geology to 1950' (Adkins and Collins, 1967) cites 24 books, papers and reports by Hochstetter, some co-authored. The most notable of these are his books entitled 'Geologie von Neu-Seeland' (1864), which formed part of the results of the Novara expedition, and 'Neu-Seeland' (1863); both of these have been translated into English by Fleming (Hochstetter, 1959) and Sauter (Hochstetter, 1867) respectively. The English version of 'Neu-Seeland' is not the same as the German edition, with the former containing more about the geology and geography but less about the Maori and the colonisation history.

Hochstetter was greatly impressed by geothermal activity in New Zealand and devotes about 60 pages to it in both books (33 in the Fleming translation), almost entirely describing thermal features in the Taupo Volcanic Zone ("this marvellous region").

These accounts include sketches and paintings of individual thermal features, and wider views of thermal areas such as those at Orakeikorako and Rotorua.

Especially valuable are the four geological maps made by Hochstetter (Hochstetter and Petermann, 1863, 1864) published in both German (1863) and English (1864) and drafted in Vienna by A. Petermann. The map he made of thermal activity at Rotomahana on a scale of 1:12,000 is superb, and provides a record of a beautiful thermal area largely destroyed by the Tarawera volcanic eruption of 10 June, 1886. This paper, however, describes the distribution and depiction of thermal features on his maps, at a scale of 1:700,000, of the southern part of the Auckland Province (Hochstetter and Petermann 1863, 1864).

THERMAL FEATURES ON HOCHSTETTER'S MAPS OF THE AUCKLAND PROVINCE

The maps

Three maps produced by Hochstetter on a scale of 1:700,000 show the distribution of thermal features. There are the two geological maps, identical in every respect except that one is in English (Hochstetter and Petermann, 1864) and the other in German (Hochstetter and Petermann, 1863). Thermal features are also shown on the route map that accompanies his book 'Neu-Seeland' (Hochstetter, 1867), but many symbols here are absent or difficult to see.

Hochstetter's Route

Hochstetter and his party entered the Taupo Volcanic Zone (Figure 1) on 13 April 1859 in the Waihi-Tokaanu area after travelling overland from the northwest. He spent 5 days near Tokaanu, surveying this area and its thermal activity, before walking along the eastern shore of Lake Taupo. He viewed thermal activity between Mount Tauhara and the Waikato River, which he crossed close to its outflow from the lake. He travelled (April 22) via Karapiti (Craters of the Moon) on the mail route before going northeast to Orakeikorako, where he spent several days. After crossing the Waikato River again here, he continued in a northeast direction along the western side of the Paeroa Fault scarp, passing Te Kopia and Waikite. He left the Waikite Valley (April 26) and went to Rotomahana (April 28). At Rotomahana, he mapped and described the extensive thermal activity there before going to Rotorua for five days (May 3). He and his party (rejoined by their photographer on April 26) travelled northwards along the eastern shore of Lake Rotorua to Tikitere where they made a short detour to the northeast (May 6), viewing the thermal activity as far as Ruahine. They then travelled northward to Maketu and back to Auckland (May 21) via Tauranga (May 9), Matamata and Taupiri, passing en route the Okaura

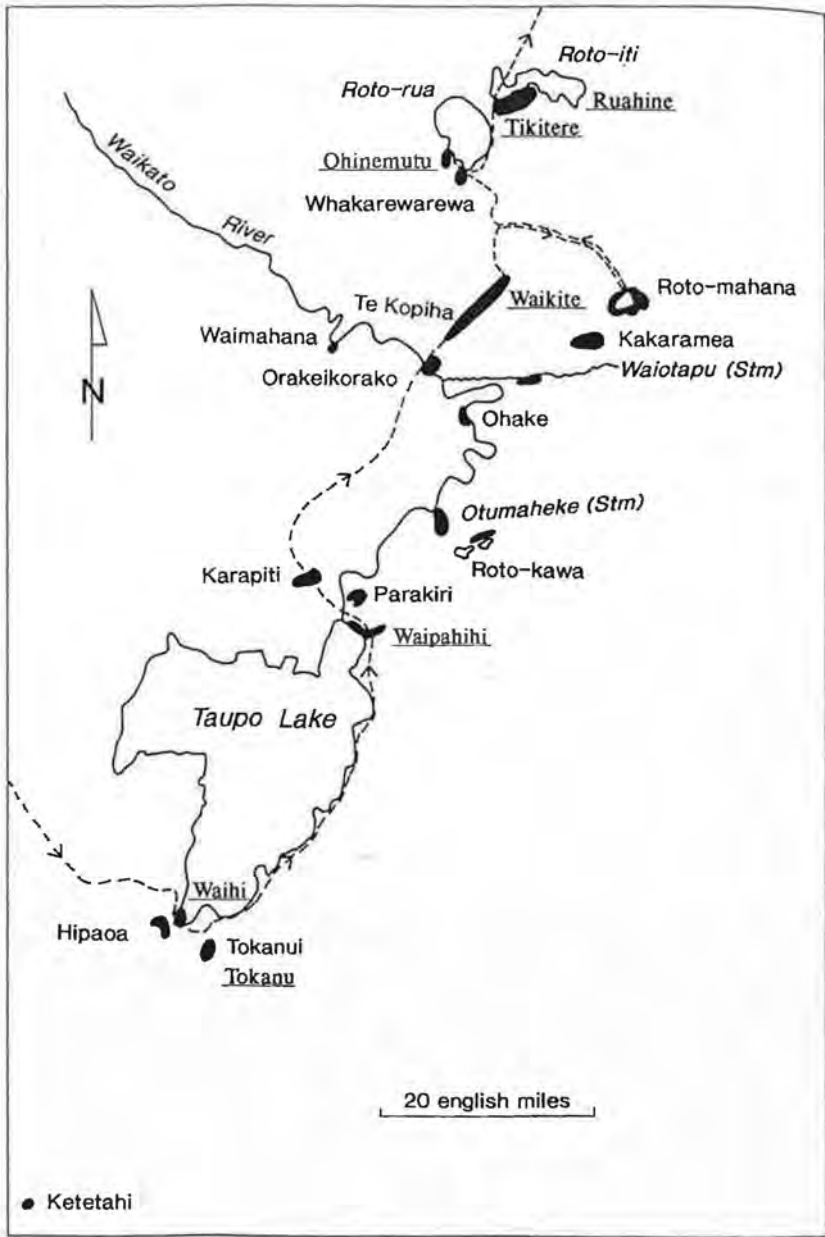


Figure 1: Locations of hot springs, fumaroles and solfatara in the Taupo Volcanic Zone shown on the Hochstetter and Petermann maps (1863, 1864). Their positions and Hochstetter's spelling are shown. Places mentioned in the Hochstetter (1867; 1959) volumes but not shown on the map are underlined.

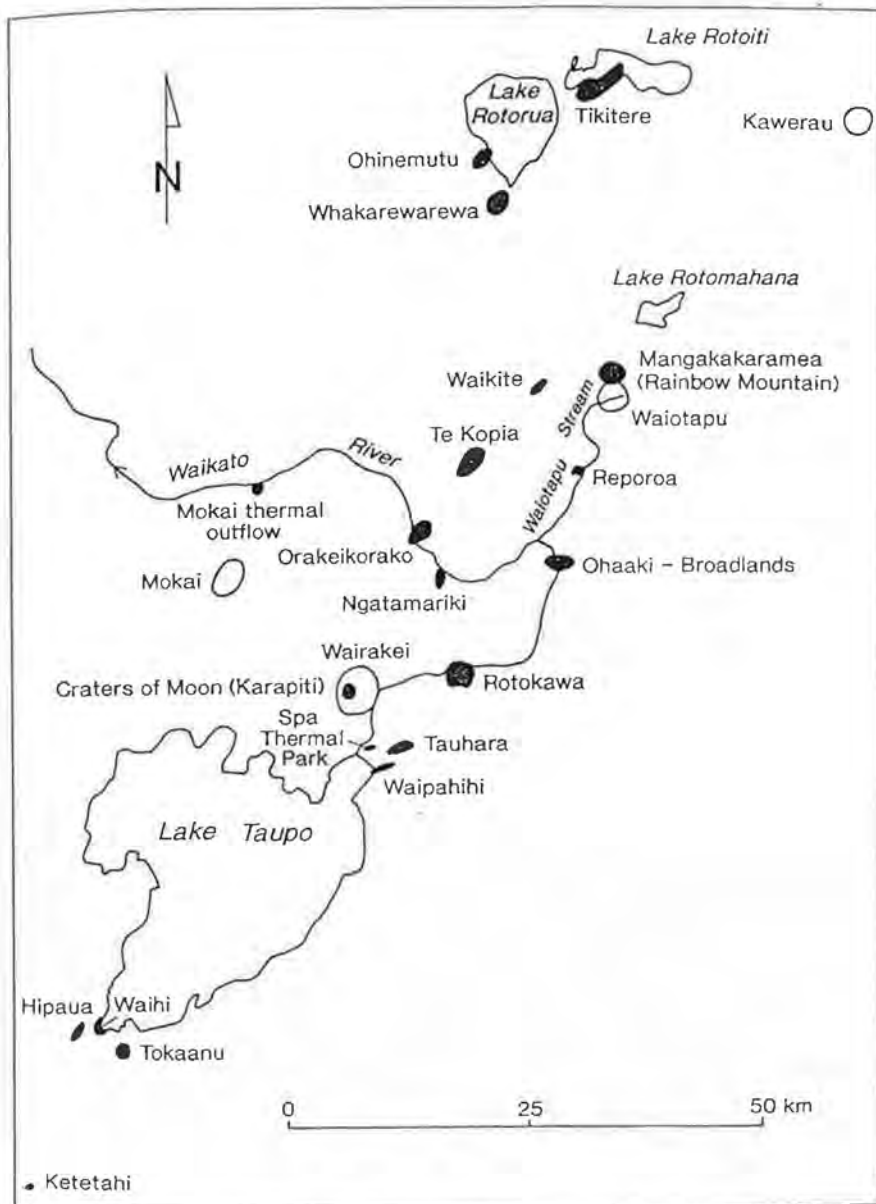


Figure 2: The main geothermal areas in the Taupo Volcanic Zone mentioned by Hochstetter (1867: 1959) and Hochstetter and Petermann (1863; 1864a and b) with modern spellings and positions. Also shown are locations of Wairakei, Waiotapu, Mokai and Kawareau geothermal fields not mentioned by Hochstetter.

Springs on the Waiho River in the Hauraki Rift. Hochstetter and his party were therefore in the TVZ for only a little over three weeks.

Hochstetter's depiction of thermal features

The thermal features are shown on Hochstetter's geological maps at 1:700,000 by a series of orange and yellow dots, all less than 1 mm diameter. These are intended to occupy previously printed black semicircles but some in my copy of the map are offset slightly, as are the yellow and orange colours. The number of dots is clearly meant to indicate the distribution of the thermal manifestations and not the intensity of thermal activity. The key describes symbols as representing "Hot springs, fumaroles and solfataras" ("Heisse Quellen, Fumarolen u. Solfataren"). The key thus makes no distinction between the different types of discharge features present in a thermal area, but alongside some there are labels such as 'hot water' or 'mineral spring'. The text of his books makes clear, however, that Hochstetter distinguished between the different types of features. The thermal activity at Ketetahi and nearby is not shown by a symbol but by the label 'Solfatare'. Some thermal areas are named on his maps, e.g. Hipaoa (Hipaua) and Ohake (Ohaaki), others are not. In several instances, the maps show only the names of the most prominent single discharge feature in a thermal area, e.g. fumaroles at Karapiti, Parakiri and Te Kopiha (Te Kopia).

Distribution of thermal areas on Hochstetter's map

Hochstetter shows 22 separate thermal areas on his maps (Figure 1), 18 of them in the Taupo Volcanic Zone. The maps treat Tikitere-Ruahine, Rotomahana and Te Kopia-Waikite as areas of contiguous activity. The areas are listed in Table 1, and the distribution of those he mentions are also shown on a recent map (Figure 2). Hochstetter visited 13 of the thermal areas shown on his map, 12 in the Taupo Volcanic Zone. He mentions all of these in his books and/or map texts (Hochstetter, 1863, 1864; Hochstetter and Petermann, 1863, 1864a, 1864b). Many are described in considerable detail with the names of many individual discharge features mentioned. There are 4 thermal areas in the TVZ shown on his map which he did not visit: Rotokawa, "Otumaheke Stream" (?part of Rotokawa), Ohake (Ohaaki), Waimahana (Mokai outflow), and one which he shows on the south bank of Waiotapu Stream (near Reporoa).

Comments on individual fields

Thermal activity on the southern shore of Lake Taupo.

Hochstetter's map shows three distinct thermal areas here: Hipaoa (Hipaua), Terapa (Waihi) and Tokanu (Tokaanu), and these

TABLE 1: Thermal areas shown on Hochstetter and Petermann's maps (1863, 1864)
of the southern part of the Auckland Province.

Manifestation name or nearest place name on map	Name in Hochstetter (1867 or 1959)	Modern Name	Seen by Hochstetter?	Apparent size (No. of dots)	Comments
Te puia	Not mentioned	Te Puia	No	2	On north side of Kawhia Harbour.
Hikurangi	Springs not named	-	Yes	2	Described as "powerful and probably chalybeate" by Hochstetter (1867).
Hipaoa	Hipaoa	Hipaoa	Yes	6	Hochstetter comments on alteration.
No name given	Waihi area	Waihi	Yes	4	" " "
Tokanui	Tokanu	Tokaanu	Yes	11	
No name given	Waipahihi	Waipahihi	Yes	10	Steam for "a whole mile along the lake shore".
Parakiri	Parakiri (fumarole)	Spa Thermal Park	Yes	6	More active in 1859 than nowadays.
Karapiti	Karapiti (fumarole)	Craters of the Moon or Karapiti	Yes	10	Part of Wairakei system.
Roto-kawa	Roto-kawa	Rotokawa	No	4	Visited by Dieffenbach (1843)
Orumaheke	Otumaheke Valley	None	No	11	Confusing (see text) but possibly part of Rotokawa system.
Ohake	Ohake	Ohaaki-Broadlands	No	8	
On Waiotapu Stream	Not mentioned	?Reporoa	No	9	
Orakei Korako	Orakei Korako	Orakeikorako	Yes	7	Detailed descriptions in Hochstetter (1863, 1864, 1867, 1959).
Rotoreka Valley Te Kōpiha, Waikite	Pairoa Range Te Kōpiha	Te Kōpia-Waikite	Yes	18	Manifestations extend in north-east direction for about 10 km. Active now only at Te Kōpia, Waikite and Puakohurea.
Kakaramea	(Mt) Kakaramea	Maungakakaramea or Rainbow Mountain	No	8	Northern part of Waiotapu system. Much more active in 1859 than now.
Rotomahana	Rotomahana	Rotomahana	Yes	13	Mapped by Hochstetter on a scale of 1:12,000. Features mostly destroyed by volcanic eruption on 10 June 1886.

are described in both books. Their locations match those of present-day activity although there have obviously been changes in the intensity of activity. Indeed, Hochstetter himself draws attention to the changes which occurred there that followed the debris flow which engulfed the Maori village at Waihi in 1846: this flow derived from the Hipaua thermal area where steam had altered andesite rocks to soft clays.

Thermal activity on the northern shore of Lake Taupo

The thermal features here comprise hot water discharges along the Waipahihi Stream and on the lake shore nearby. Hochstetter shows discharges extending from the mouth of the Waipahihi Stream almost to the Waikato River, and he said (1867) that the lake steams for 'a whole mile along the shore'. He also noted in his books the lakeside siliceous deposits there and mentions that the Waipahihi Stream discharges warm water into Lake Taupo. Part of this area is still thermally active and the Waipahihi Stream water is still warm, but the thermal activity does not now extend as far to the west along the lake shore as he shows on his map. The level of Lake Taupo is now higher than it was in 1859 so some of the thermal discharges he shows are now likely to have been submerged or extinguished. There are silicified deposits a meter or so below the present lake level near the outlet of the Waipahihi Stream and this shows that thermal waters once discharged here.

The nearby thermal area, which Hochstetter labels Parakiri, is now commonly referred to as the Spa Thermal Park. It is much less vigorously active than it was in 1859, with most decline occurring in the past 50 years following the raising of the level of the Waikato River. He describes a vigorously discharging fumarole, Parakiri itself, but this must have died shortly after his visit since no other visitors are known to mention it. Hochstetter does not show the altered and steaming ground which occurs between Parakiri and Mt Tauhara (the Tauhara thermal area), 5 km to the east, although he mentions it in his books, as indeed did Dieffenbach (1843) in his book.

Karapiti

Hochstetter's map shows the Karapiti thermal area, which takes its name from the most prominent fumarole there. Hochstetter describes and illustrates this fumarole in his two books. Nowadays this area is more commonly known as Craters of the Moon, and the Karapiti fumarole itself ceased discharging about 1981. Hochstetter's map, however, does not show the thermal activity in the Wairakei Valley, formerly known as Geysir Valley, and about 4 km north-east of the Karapiti area. This is a little surprising because of the vigorous geyser eruptions that were probably taking place there then, some of which Dieffenbach evidently saw, but Hochstetter's route was a few kilometres west of this valley. He does, however, mention some thermal activity in a small valley 'one mile' northwest of

Karapiti. This is most likely to be an area of steaming and altered ground where activity still occurs today, and not the thermal manifestations in Wairakei Valley which Hochstetter knew Dieffenbach had visited in May 1841. Dieffenbach did not report a name for this area or springs, and he described its location poorly, hence Hochstetter's omission. Even so, it is surprising that he was unaware of a major thermal area so close to his route and yet had heard about the more feeble manifestations further away at Ohaaki and Rotokawa.

Rotokawa and Otumaheke Stream

Hochstetter did not visit Rotokawa, as Dieffenbach did; however, the maps show two small lakes at Rotokawa with thermal activity on the northern shore of the eastern one. There is extensive steaming ground in this area today but only a single lake. This lake is drained to the northeast by the Parariki Stream which flows into the Waikato River. This stream is not shown on Hochstetter's maps nor is the thermal activity prominent in its upper reaches. The thermal activity which Hochstetter does show occurs along the Otumaheke Stream, so labelled, on his maps. This is a problem. Fleming pointed out (Hochstetter, 1959) that this name is now given to a stream much closer to Taupo, located in the area where Hochstetter shows the Parakiri thermal area. There is no sizeable stream flowing north from Tauhara towards the Waikato River, and certainly not in the position Hochstetter depicts his Otumaheke Stream to be. However, there is a small creek of very local catchment entering the Waikato River at about the location Hochstetter shows his Otumaheke Stream. Furthermore, there is feeble steam discharge and weakly steam-altered ground nearby, and the conglomerates and tuffs at the river edge are silicified here. A few springs now discharge chloride-bicarbonate waters on both banks of the Waikato River 500m east of the stream mouth. This thermal area forms part of the Rotokawa geothermal field. The confusion is compounded by Hochstetter's mention (1867) of an Otumaheke Valley occupied by a "rivulet of warm water" on the north side of the Waikato River. This valley is very close to Karapiti, and reads as though it is the Waipouwerawera Stream or a short warm water stream draining Totara Gut (L. Klyen, pers. comm.). The possibilities are: (a) that Hochstetter made a mistake in his map and mislocated some of the thermal activity of the Spa area by 10 km, which seems unlikely; (b) that in 1859 the thermal activity near the small creek (whose position is thus shown correctly) may have been very much more extensive and intense than it is today, but Hochstetter coincidentally shows the creek to be more substantial than in fact it is; or (c) that he confused the thermal activity east of Karapiti, which he believed to be near the present Otumaheke Valley, with some feeble discharges he heard about at the place he believed to be Otumaheke Stream near Rotokawa. Option (b) is preferred since the alteration near, and at, the mouth of the small stream testifies to former geothermal activity here.

Ohake

Hochstetter shows the Ohake (Ohaaki) thermal area on his map as occurring on both banks of the Waikato River. He mentions in his books solfatara here, and the spring Te Kohaki which is clearly the Ohaaki Pool. He most likely obtained this information from the local Maori as he did not visit this thermal area.

Thermal activity on Waiootapu Stream (? near Reporoa)

Hochstetter's map shows a small, unnamed thermal area on the south bank of the Waiootapu Stream, about 8 km east of its junction with the Waikato River. He makes no mention of this area in either of his books or map descriptions, and he did not travel on the east side of the Paeroa Range. He thus heard about this area from others, presumably some of his Maori guides. Fleming (Hochstetter, 1959) identified this thermal area as Golden Springs. This is an area of fairly minor thermal activity only 2.5 km distant from the mouth of the Waiootapu Stream and on its north bank. More likely, however, the thermal activity Hochstetter depicts is either the more impressive and vigorously active Reporoa thermal area, 8.4 km from the stream mouth, but on the north bank, or the now feeble discharges known today as the Loop Road Springs; these are 10.0 km from the mouth of Waiootapu Stream but on its south bank.

Orakeikorako

Hochstetter's map shows thermal activity at Orakeikorako and he gives careful and valuable descriptions of the thermal activity in both his books. Thermal activity in this area has changed greatly since 1859 and these changes have been described in detail by Lloyd (1972).

Thermal activity along the Paeroa Fault

The maps show a northeast-striking band of thermal activity extending uninterrupted for about 10 km on the western foot of the 'Paeroa Range' (Paeroa). There are brief descriptions in his books of thermal activity at Te Kopihia (Te Kopia) and Waikite, about 10.5 km apart, but no mention of the thermal activity between them which his maps show. As pointed out by Fleming (Hochstetter, 1959), however, and by Bignall (1994), the occurrence of hydrothermally altered ground along the scarp suggests that thermal activity may have been more widespread in 1859 than it is now.

Maungakakaramea

Hochstetter's maps show thermal activity here, and he makes a very brief mention of it in his books. Thermal activity at Maungakakaramea, now more usually known as Rainbow Mountain, has been declining over the past century and it was clearly much more vigorous in 1859. Thermal activity here is now known to

comprise the northern surface expression of the Waiotapu geothermal field. Most manifestations at this field today occur about 3 km south of Maungakakamea but these are neither mentioned in Hochstetter's books nor shown on his maps.

Rotomahana

The thermal features here are described in detail in Hochstetter's books and shown on his map of the thermal area made on a scale of 1:12,000. The thermal manifestations were destroyed on 10th June, 1886 during the volcanic eruption from Mount Tarawera (Keam, 1988).

Waimahana (Mokai outflow)

Hochstetter's maps show a small thermal area on the south bank of the Waikato River near a place that he labels 'Waimahana', but he makes no mention of it in either of his books. This area seems to match most closely with the very minor thermal features at Hot Water Beach, 8 km downstream from where the Waipapa Stream flows into the Waikato River; it is likely that other features that discharged in 1859 were submerged or extinguished when Lake Whakamaru filled in about 1961. The warm and feeble discharges here are now known to be outflows from the Mokai geothermal field which is expressed by mud pools and fumaroles 12 km south of the river. Hochstetter's maps do not show these features, but the maps suggest thermal activity near the Waikato River was greater in 1859 than it has been in recent years.

Rotorua

Hochstetter's maps show two thermal areas present on the south-west shore of Rotorua. The southernmost is Whakarewarewa and so labelled; the northern one is Ohinemutu, which is mentioned in his book but also includes the Kuirau (Park) thermal area west of the present hospital. Thermal activity in the Rotorua area is well described and there have been many changes to it since 1859 (eg. Allis and Lumb, 1992).

Rotoiti

Hochstetter's maps show thermal activity extending in a northeast oriented band from Tikitere to Ruahine, as described in the books, but his maps suggest that the activity extends even further east, to include Ngarehu Point on the Tawhitinui Peninsula where Hochstetter and his party had a survey station. This area is still thermally active in a manner which matches Hochstetter's descriptions. He does not mention the small area of thermal activity at Taheke on the northern shore of Rotoiti although his route was within 1 km of it.

Hochstetter's depiction of thermal features outside the TVZ

Hochstetter's maps show thermal areas outside the TVZ. only one

of which (Okauia) he visited. These are the Te Puia springs on the north shore of Kawhia Harbour, Okauwia (Okauia) on the west bank of the Waiho River, 6 km east of Matamata, those at Te Aroha and at Makomako (Miranda). He mentions these four only very briefly in his books but regards them as quite insignificant in comparison to the thermal areas of the TVZ. The thermal springs in these areas are still active.

His map also shows thermal features on the south-east flank of a 'Hikurangi Mountain', west of Lake Taupo. He labels these as being two mineral springs, the only features thus designated on his map. He describes them as "powerful" but makes no mention of their temperatures. This perhaps implies that they were cool, and there are no warm or hot springs known here now.

DISCUSSION

Hochstetter also knew about thermal activity at Ngawha, Northland, at Moutohora (Whale Island), and at Whakaari (White Island). These areas, however, lie outside that covered by his maps. However, he mentions being told (correctly) about thermal activity at Rotoehu but he did not show this on his maps, perhaps because he was unsure as to its exact location.

The main thermal areas in the TVZ which Hochstetter did not show on his maps or mention are Ngatamariki and Kawerau. Nor does his map show the extent of thermal manifestations at Wairakei, Mokai or Waiotapu. Several thermal areas with minor activity were also apparently unknown to him. His maps are, however, very sound and important documents in the history of New Zealand geology. Hochstetter thoroughly deserves the praise he has received over the past 135 years for his grasp of the geology of the TVZ and his maps. This praise can rightly be extended also to include Hochstetter's mapping and the descriptions he gives its thermal manifestations. Much of the country he covered, particularly west of Taupo, was difficult to traverse, and he avoided using the easier Waikato River route or following Dieffenbach's path. That such a high quality map could be produced after only 7 months field work testifies to Hochstetter's outstanding ability and the help he received from those members of his party who assisted him with the surveying and scientific observations. They spent 23 days in the TVZ, and Hochstetter's depiction of the distribution of its thermal features is essentially correct.

Several of the thermal areas he shows and describes have changed little since 1859 but others have undergone spectacular changes or even been totally destroyed (Rotomahana). The occurrence of thermal features at places no longer superficially active, or else feebly so, is important to help add the time dimension that is needed to assess individual geothermal reservoirs and to appreciate the dynamic but changing nature of active geothermal systems.

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REFERENCES

- Allis, R.G. and T.Lumb (1992): editors. Rotorua Geothermal Field, New Zealand. *Geothermics*, 21(1-2), 317p.
- Adkin, G.L. and B.W.Collins (1967): A bibliography of New Zealand Geology to 1950. N.Z.Geological Survey Bulletin 65. Wellington, 244p.
- Bignall, G. (1994): Thermal evolution and fluid-rock interactions in the Orakeikorako-Te Kopia geothermal systems Taupo Volcanic Zone, New Zealand. Ph.D.thesis. University of Auckland (unpublished).
- Carle, W. (1988): Carle's biography of Ferdinand von Hochstetter Geological Society of New Zealand. Miscellaneous Publication 40, 24p. Translated by C.A.Fleming and L.O.Kermode.
- Dieffenbach, E. (1843): Travels in New Zealand with contributions to the geography, geology, botany and natural history of that country. John Murray, London. Volume 1 431p.
- Hochstetter, F. von (1863): Neu-Seeland. Cotta, Stuttgart. 555p.
- Hochstetter, F. von (1864): Geologie von Neu-Seeland. Beitrage zur Geologie der Provinzen Auckland und Nelson. Novara-Exped.. Geol. Theil 1 (1), 274p.
- Hochstetter, F. von (1867): New Zealand: its Physical Geography, Geology and Natural History. Cotta, Stuttgart, 515p. Translated by E. Sauter.
- Hochstetter, F. von (1959): Geology of New Zealand. Contributions to the geology of the provinces of Auckland and Nelson. Wellington, 320p. Translated and edited by C.A.Fleming.
- Hochstetter, F. von and A. Petermann (1863): Geologisch-topographischer Atlas von Neu-Seeland. Sechs Karten, hauptsächlich gebiete der Provinzen Auckland und Nelson umfassend; mit Kurzen erlauterungen. Perthes, Gotha, 10pp.
- Hochstetter, F. von and A. Petermann (1864a): The geological and topographical atlas of New Zealand. Six maps of the Provinces of Auckland and Nelson. Delattre, Auckland.
- Hochstetter, F. von and A. Petermann (1864b). The Geology of New Zealand: in explanation of the geographical and topographical atlas of New Zealand. Translated by C. F. Fischer. Also lectures by Dr. F. Hochstetter. Delattre, Auckland, 109pp.
- Keam, R.F. (1988): Tarawera: The Volcanic Eruption of 10 June 1886. Auckland, 472 pp.
- Lloyd, E.F. (1972): Geology and Hot Springs of Orakeikorako. N.Z.Geological Survey Bulletin 85. Wellington, 164pp.