Ferdinand von Hochstetter's November 1860 Folio of New Zealand survey data and the location of the Pink and White Terraces

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Alfred Rex Bunn[1] & Sascha Nolden[2]

Abstract

This research utilises Ferdinand von Hochstetter's unpublished November 1860 Folio of survey data from the first major terrestrial topographical and geological survey in New Zealand. The Folio data enable the reconstruction of the survey across the North Island to Lake Rotomahana, with unique bearings to the lost Pink and White Terraces. Originally prepared for the purposes of cartographic production in Gotha, Germany, the Folio features marginalia by cartographer August Petermann and his assistant Arnim Welcker. It also validates Hochstetter's 1859 field diaries and Rotomahana Basin topography navigating to the Terraces. The Folio survey coordinates suggest the Pink and White Terrace springs lie buried beneath the shores of Lake Rotomahana. The Folio locations are consistent with earlier survey Diary iterations. They triangulate with the Basin topography and align with Mātauranga Māori records. Complementary with other recently published research, the Folio data provides historical primary source evidence in support of the search for the lost Terraces at Lake Rotomahana.

Keywords: archival primary sources, cartography, documentary heritage material, Ferdinand von Hochstetter, historical survey data, Lake Rotomahana, New Zealand, Pink and White Terraces, Tarawera eruption, terrestrial surveying.

1.0 Introduction

This paper completes research the authors began in 2016 (Bunn & Nolden, 2016, 2018) based on the New Zealand field diaries and maps of Ferdinand von Hochstetter (1829−1884), held in the Hochstetter Collection Basel and digitally repatriated to New Zealand in 2010 (Nolden, 2014). The diaries contained the only terrestrial survey of the lost *Eighth Wonder of the World*, the Pink and White Terraces at Lake Rotomahana. These terraces were large siliceous sinter formations of five and eight acres, unlike the calcareous terraces in other countries. The White Terrace covered the area of a city block and the height of an eight-storey building. Its terrace basins overflowed with transparent turquoise water, coloured from Rayleigh scattering of sunlight by colloidal silica particles (Ohsawa et al, 2000). The White Terrace had a cream hue and the Pink Terrace was multihued, with transparent, azure water. The Terraces were located on the

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shores of a small lake outside Rotorua, New Zealand. The locations of the Pink and White Terraces are shown in Figures 1 and 13.

Hochstetter was a surveying geologist and explorer, remembered as the *Father of New Zealand Geology*. Bunn and Nolden earlier published research based on the unpublished 1859 field Diary, manuscript maps, sketches, photographs and expense accounts of Hochstetter's survey (Bunn & Nolden, 2016, 2018). This material lacked the most important document – the November 1860 Folio of summary survey data provided by Hochstetter to the cartographer August Petermann (1822−1878). This dataset comprises the complete set of bearings that formed the basis for the iconic published maps resulting from Hochstetter's survey – the earliest New Zealand geological maps to be printed in colour.

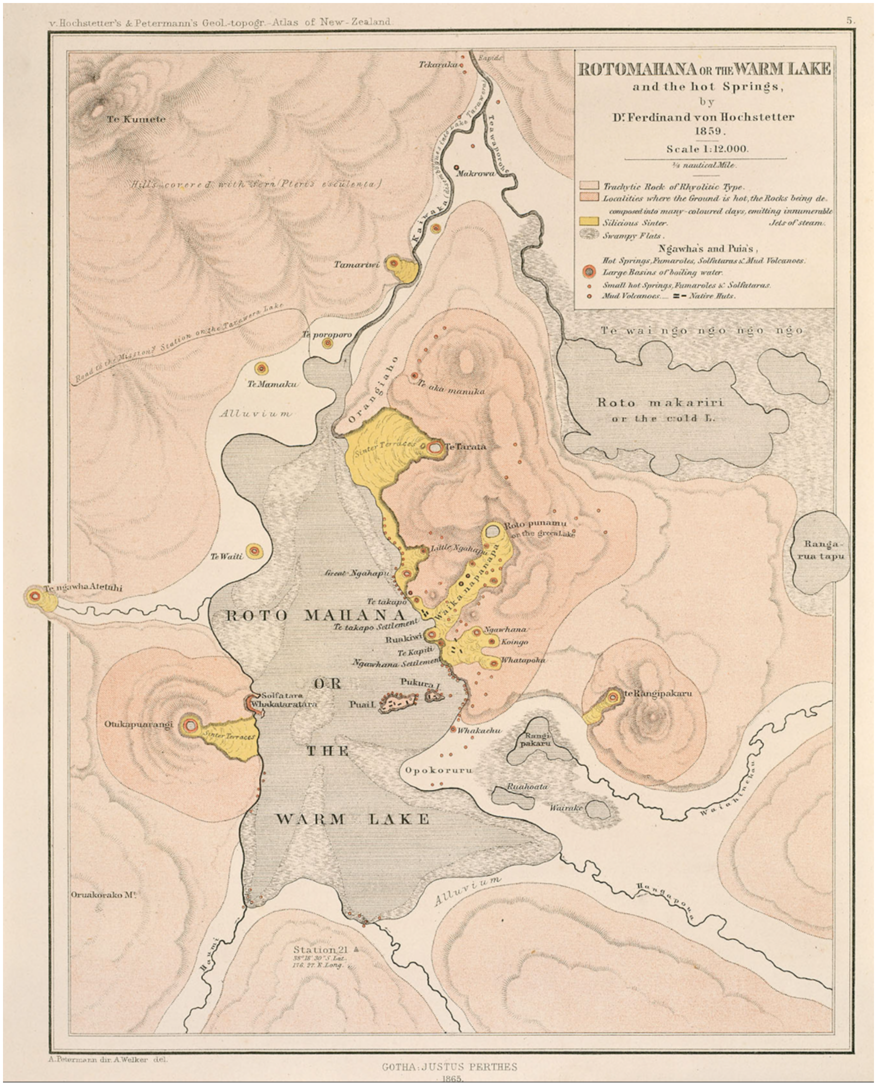

Figure 1. Map of Lake Rotomahana from the English edition of Hochstetter & Petermann's *Geological and Topographical Atlas of New Zealand* – the first atlas to be published in New Zealand (Hochstetter & Petermann, 1864).

Figure 2. Hochstetter in the Bohemian Forest in 1853 equipped for his field survey work (Johnston & Nolden, 2011).

This paper also conflates the series of spatial papers begun by Bunn with surveyors Nick Davies and David Stewart in 2018, working on the technical validation of Hochstetter's survey Diary data, landmarks and bearings. At the time it was noted with regret that the Diary did not contain sufficient bearings for the resection of the Pink and White Terraces. Reverse engineering of the survey observation stations was undertaken, beginning with surviving, distal landmarks having Diary bearings. The reciprocal Diary bearings resected Hochstetter's observation Stations 21 and Puai Station, today within the crater Lake Rotomahana. Next, after correcting declination, Hochstetter's proximal bearings were projected on Google Earth™. The research developed through six iterations between 2016 and 2019 (Bunn, 2019b). Once the stations were resected, the survey baseline was established on Google Earth, *inter alia* confirming map scale and orientation. Hochstetter's bearings to the Pink and White Terraces, along with the lesser-known Black Terrace, were transferred to Google Earth. Finally, Hochstetter's Lake Rotomahana mapping was georeferenced over Google Earth using his stations as control points. It was noted that the georeferenced Terrace locations each lay along the Terrace bearings, validating the stations, bearings, georeferencing and map scale. The approach disclosed the pre-1886 lake lies within the post-1886 Tarawera eruption crater lake; save for the northwestern shore between the Pink and White Terraces, where the old and new shorelines and the crater overlap. The Pink and White Terrace springs lie along this shoreline.

In 2020, Hochstetter's unpublished November 1860 Folio of survey data was passed to Bunn by Nolden. The original Folio is held in the collection of Dr Albert Schedl in Vienna and was brought to New Zealand by Nolden on loan for the Hochstetter Exhibition he curated in Auckland in 2008 (Nolden, 2008). Nolden proposed we collaborate to validate Hochstetter's survey Diary methodology via the Folio dataset. Following careful transcription and translation of the archival source document based on digital surrogates, the results of the research formed the basis for this paper.

2.0 Methods

Hochstetter's survey technique was a marine surveying method similar to that used by Byron Drury (1815−1888) on the *HMS Pandora* 1848−1856 coastal survey of New Zealand:

> To plot an unknown coastline, navigators used magnetic bearings from the ship at several different locations, to the same visible landmarks on the shore (headlands, river mouths or mountain peaks). The ship's position was known from previous observations (ICSM, 2020).

Marine survey baselines were also determined on land. The marine method is described in detail by Charles H Brown, and summarised here as:

> The first part […] laying off of a suitable base line on the land […] two ends marked […] the distance between them being very accurately measured […] the true direction of this base line […] found with great accuracy […] exact latitude

and longitude […] at each end […] carefully calculated […] The next thing […] carefully ascertain the position of all these objects […] by a process called "triangulation". Each end of the base line is made a Station for observations […] angles are measured (Brown, 1953: 191-192).

2.1 Survey background

Hochstetter's survey of the central North Island was unplanned when the Austrian frigate *SMS Novara* sailed from Trieste on 30 April 1857. He prepared for marine and geological survey work by studying the science of magnetism with Edward Sabine (1788−1883). Sabine was developing a chain of magnetic observatories for the Royal Society and the Admiralty global magnetic survey. Hochstetter visited the Admiralty and trained in marine navigation. While Sabine did not publish the first report on magnetic declination and inclination until 1868, the coastal survey data gathered by Stokes and Drury would have been shared with Hochstetter who understood declination and inclination (compass dip) in the southern hemisphere (Muller, 1865).

Hochstetter was recruited by the Auckland provincial government to map the blank area between the west and east coasts and mark out geological formations, coal and mineral deposits. There was little prior mapping of the interior. He was given an outline map of the central North Island and sketch maps by missionaries. He had access to John Stokes (1812−1885) and Drury's coastal survey mapping. In Auckland, Hochstetter was given tracings of the Admiralty charts with sparse details of the inland topography:

> Hochstetter was […] provided with traced outline maps based on British Admiralty Charts on which to record the results of his survey and field observations, although as he noted these were mostly only coastal outlines with some major waterways marked in, with much of the inland areas completely blank. [...] he was obliged to create his own topographical base maps on which to superimpose the geological information, as [Hochstetter] writes: [In order] to make geological surveys, I was obliged to work at the same time topographically; for the few existing maps of the interior were merely outlines traced on the evidence of the reports of missionaries and tourists. The sketch of a map I had brought with me from Auckland presented nothing but standard-

points for the coast; and at a distance of a few miles from Auckland it was but little better than a blank sheet of paper (Nolden, 2015).

2.2 Survey Equipment

Hochstetter made careful preparation for his research. His equipment lists survive and these include a Lamont magnetic travel theodolite loaned by Stuttgart physicist Johann Gottlieb Nörrenberg (1787−1861) and a barometer manufactured by the Viennese company Kapeller; loaned by the Austrian Imperial Geological Survey (Holzer, 2010). Interestingly, he does not appear to have used this theodolite on his survey. His main survey instruments were azimuth compasses.

The National Maritime Museum in Sydney has an 1800s Troughton azimuth compass similar to the type Hochstetter may have used. This has a lens and outer ring, making it a circumferentor in Figure 3.

Figure 3. Troughton azimuth compass of the design Hochstetter may have used (00040567 National Maritime Museum).

Hochstetter refers to multiple compasses and there is evidence of two in his Folio: calibrated to two-minute and ten-minute increments. Hochstetter was myopic and used a telescope on his Pochade-style artist's easel when sighting peaks. This may have relieved eye strain and assisted his data gathering. In Figure 4 Hochstetter is depicted with his telescope on Mount Ngariha, examining Mount Ruapehu. His field easel serves as a four-legged tripod. There is a second instrument on it, most likely an alidade enabling faster recording of multiple bearings. His brush roll is open on the ground.

Figure 4. Tongariro and Ruapehu from Mount Ngariha (Hochstetter, 1867).

2.3 Survey Direction

Hochstetter conducted a compass survey across the North Island, starting with Drury's west coast harbours map (see Figures 5 and 6) and baseline coordinates from mounts Karioi and Pirongia. He led a party across the island, guided by George William Drummond Hay (1827−1881), visiting mission stations, European settlers and Māori. His route followed Māori paths and nascent settlements. He followed rivers and sought high ground for triangulation.

The survey was not purely a marine survey triangulation on high points. He and the Gotha cartographer Petermann with draughtsman Arnim Welcker (1840−1888), filled in the topography. Both Hochstetter and Welcker started with a good coastal chart and coordinates for coastal peaks. They had major rivers and a few settlements and Māori villages marked.

Hochstetter had local guides along the way who provided the place names he recorded. He made copies of ephemeral local maps, including Lakes Rotokakahi, Rotorua and Rotoiti by Pini Te Korekore, (Nolden & Nolden, 2013: 73, 75). This helps explain why smaller rivers on the Figure 10 map correlate with topographic mapping and Google Earth.

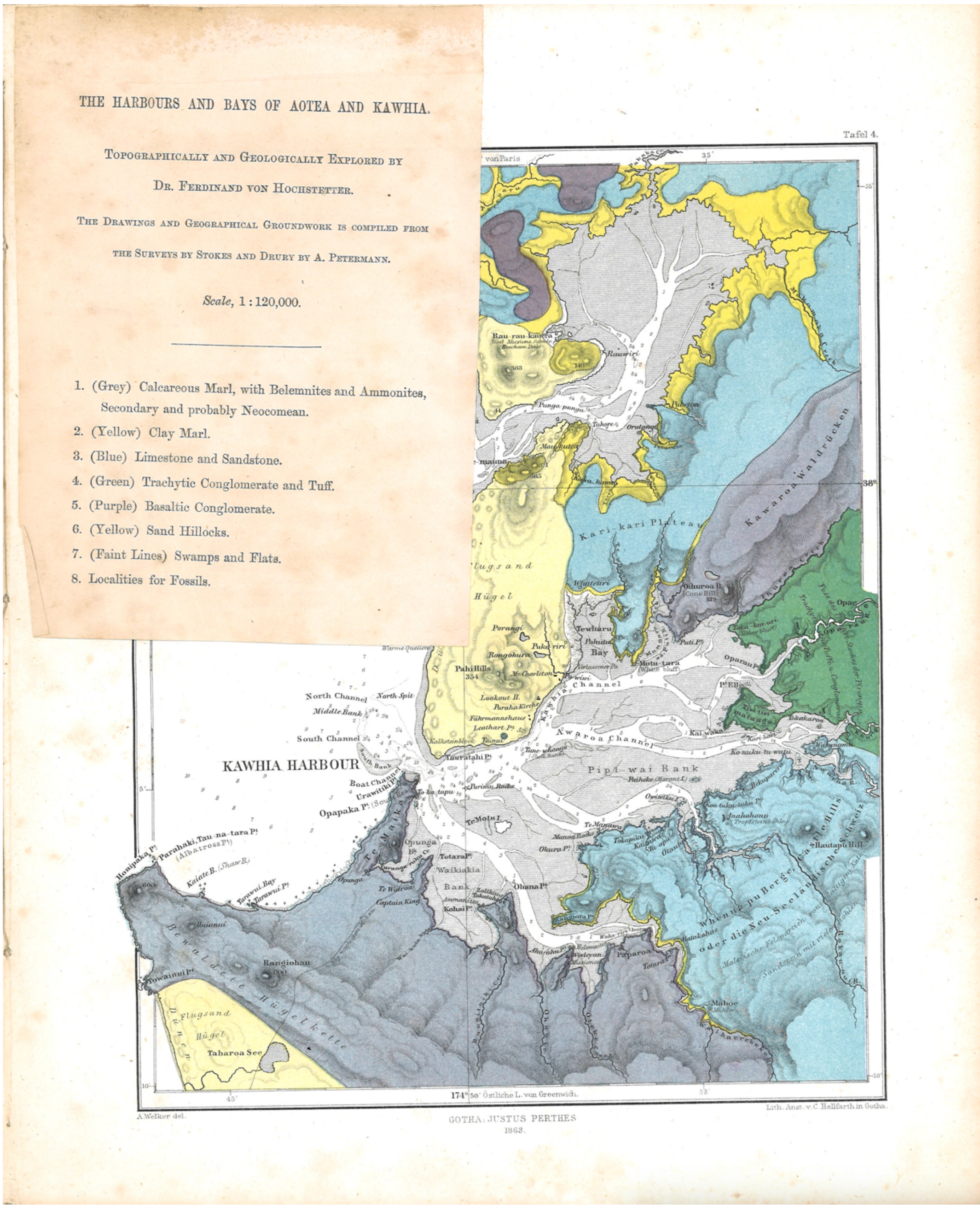

Figure 5. German edition of Hochstetter's topographical and geological map of Aotea and Kawhia harbours. Plate 4 from a copy prepared for the New Zealand market with mounted English translation. (Hochstetter & Petermann 1863).

The hill behind Rangiriri provided an ideal place to establish a survey point, and a fine view over the area, including a first glimpse of two reference points: mounts Taupiri and Pirongia, both of which they would soon become better acquainted with […] This was to me quite a welcome point for planting my azimuth-compass and commencing magnetic bearings which […] yielded me a triangulation, forming the basis for the construction of the topographical map of the southern portion of the Province of Auckland'. (Nolden, 2015).

3.0 Results

3.1 Ground progress

Travelling south from Auckland, Hochstetter reached Rangiriri on 10 March 1859 and viewed the peaks to the south. He marked Pirongia and Taupiri as baseline candidates, for the Mount Pirongia coordinates lay in Drury's coastal survey.

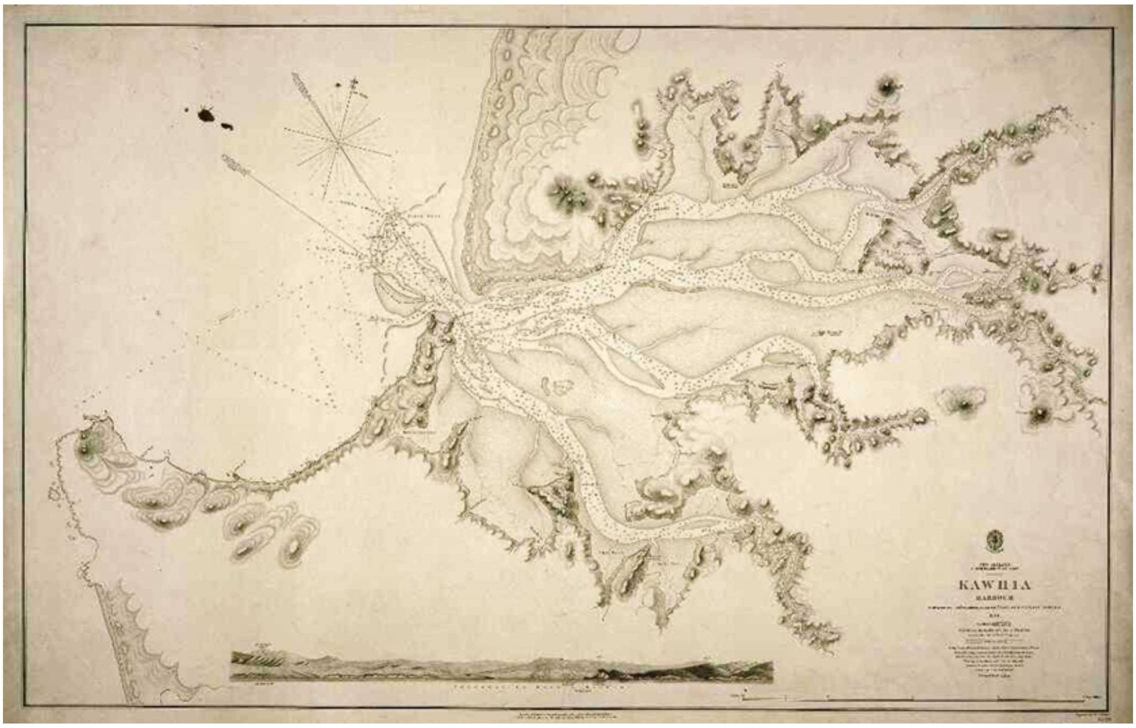

Figure 6. Drury's nautical chart of Kawhia Harbour (London: Admiralty, 1857).

Hochstetter set his survey baseline on *HMS Pandora*'s west coast survey baseline – the Kawhia-Aotea harbour line from Karioi to Pirongia in Figure 6. From here he commenced triangulation across to Lake Rotomahana and the east coast at Maketu, where a second baseline was established. Drury had noted inland landmarks from his vessel: Mt Edgecumbe (Putauaki) was one; seen from Mount Tarawera in Figure 7.

Hochstetter's primary western station lay at Mount Taupiri, with a secondary station on Mount Kakepuku. A second primary station was later set up on Ngongotahā. He appears to have traversed and dead-reckoned along river valleys e.g. Waipa-Mangapu when high points were unachievable. He constructed braced quadrilaterals e.g. from Taupiri and Kakepuku.

Figure 7. Mount Edgecumbe taken from Mount Tarawera: with Whale Island and the coast where Drury anchored *HMS Pandora* (Photograph by Bunn, 2015).

The large party surveyed *en masse*, save for the temporary separation of expedition photographer Bruno Lancel Hamel (1837−?) and a group of porters for logistical reasons. Fifty-five reciprocal bearings were made by Hochstetter and 59 by Welcker. Those by Hochstetter likely served as check bearings, with 20 on major stations. Of these, four are on Ngongotahā. The first is from Kakepuku on Taupiri, as is the last from Whanake. From Whanake also there are reciprocals on Stations 1, 2 and 3. Welcker's reciprocals vary from zero to nine per Folio page. His were probably for resection and distance checking by Sine Rule. Welcker's reciprocals were also likely to validate the bearings and check for magnetic deviation.

In 1856, Drury had measured his baseline distances using a beach baseline and/or by triangulating multiple bearings from offshore. The Folio states the coordinates were "nautically determined", i.e. by Drury, as was for example the position of Motutere / Castle Rock: "On the Coromandel peninsula on the Hauraki Gulf. Position nautically determined. Falls outside the area of my large map" (see Figure 8).

Page one (Figure 8) of the Folio contains the briefing for Petermann and his team at Justus Perthes, one of the leading cartographic publishing houses of the period, as they prepared his commissioned cartography. Hochstetter states the bearings are magnetic and provides the cardinal points. There is no mention of declination or inclination. Neither Hochstetter's manuscript or published maps of Lake Rotomahana feature north arrows. The bearings are divided into major and minor sections with major entries on the basis they were frequently occurring, visible from a distance, or otherwise significant points.

Hochstetter chose to make his first observation station on Mount Taupiri on 12 March 1859. His reconnaissance on 10 March from Rangiriri Hill had noted Taupiri and Pirongia as landmarks. The choice of Taupiri forms an isosceles triangle with Drury's two landmarks i.e. Mount Karioi and Mount Pirongia. This triangle provided for an accurate survey with base angles of 70º, keeping the vertex >30º and delivering an accurate base for the second survey triangle i.e. Taupiri-Pirongia-Kakepuku.

Hochstetter took two check bearings on his Karioi-Pirongia baseline. Firstly, a Station Two−Station One reciprocal from Mount Kakepuku on Mount Taupiri is accurate with an error of 1.367º and a mean bearing of 159.0165º (see Figures 9 and 10). Secondly, he detoured from his *line of advance* to make Station Four on Aotea Harbour. This enabled him to replicate Drury's Pirongia observation and validate Drury's baseline by a second, southerly triangulation Aotea-Karioi-Pirongia from Station Four. He also scaled Mount Pirongia, doubtless to validate the Drury baseline. Once he was satisfied, he returned to his line of advance along the Waipa and Mangapu rivers. See Figures 9, 10 and 11 for the locations of the above peaks.

In his notes, Hochstetter remarks that as a foreigner he enjoyed the confidence of Māori chiefs whose lands he passed through. As they knew he would be leaving their country, they saw no risk in briefing him on place names throughout their tribal lands, pointing these out from hilltop observation stations. They may not have done this for local surveyors, for they had learned to associate these visits with the subsequent sequestration of their homelands, and cooperation was withheld (Hochstetter & Petermann, 1864). Hochstetter's Folio thus comprises an invaluable resource of lost place names. Some of his observation stations do not appear in the *New Zealand Gazetteer* or on topographic mapping. One is observation Station 26 *Omatuku*, now identified only as Hill 252m beside the highpoint on Highway 33.

3.2 Folio Pagination

Hochstetter was meticulous in recording observations in his field diaries, along with geological and scientific data; later published in his book *New Zealand* (Hochstetter, 1867). With the addition of the Folio, nearly all the field survey material and data he delivered to Petermann at Gotha in 1860 has now been documented and published. In Gotha the draughting of Hochstetter's Folio data into large and small-scale New Zealand maps was undertaken by Welcker and others working under Petermann's direction, the latter acknowledging Stokes and Drury's coastal surveys were combined with Hochstetter's terrestrial survey (Bunn, 2019b).

The Folio contains annotations and rough workings, apparently by Welcker and Petermann as they undertook the cartography. These notes provide insight into the survey and the generation of maps, particularly the maps of Lake Rotomahana and the Pink and White Terraces. Page one is reproduced as an example in Figure 8.

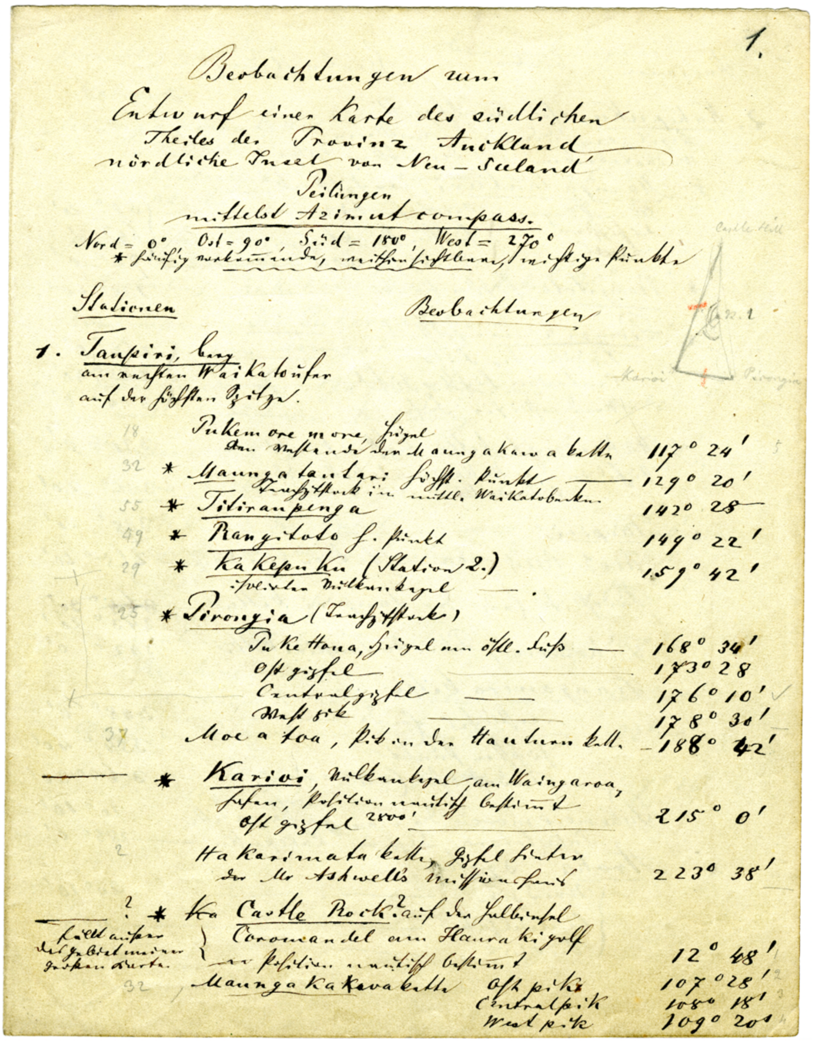

Figure 8. Folio page one (Dr Albert Schedl Collection, Vienna).

Translation (in italics) of the transcription of page 1:

"Observations for the design of a map of the southern part of Auckland Province, North Island of New Zealand

Bearings using Azimuth Compass

North = 0°, *East* = 90°, *South* = 180°, *West* = 270°

*[asterisk] *frequently occurring, visible from a distance, important points*

Stations Observations

1. *Station 1 Taupiri Mountain on the right bank of the Waikato River, at the highest point*

Pukemoremore, hill, on the west end of the Maungakawa Range 117° 24′

* *Maungatautari highest point. Trachyte stock in the central Waikato basin* 129° 20'

* Titiraupenga 142° 28′

* *Rangitoto highest point* 149° 22′

* Kakepuku (Station 2.) *isolated volcanic cone* 159° 42′

* *Pirongia (Trachyte stock)*

    Puke Hona, hill at the eastern foot [of range] 168° 34′

    Eastern peak 173° 28′

    Central peak

    Western peak

Moe a toa, peak in the Hauturu Range 186° 42′

Karioi, volcanic cone at Waingaroa harbour, position nautically determined

    Eastern peak 2800′ 215° 0′

Hakarimata Range, peak behind Mr Ashwell's mission house 223° 38′

* *Castle Rock? On the Coromandel peninsula on the Hauraki Gulf. Position nautically determined. Falls outside the area of my large map* 12° 48′

Maungakakawa Range, Eastern peak 107° 28′

    Central peak 108° 18′

    Western peak 109° 20′ "

In Figure 8, the first Folio page includes Welcker's baseline diagram in the upper right section. This pencil sketch is of three landmarks, i.e. Karioi, Pirongia and Castle Hill (also known as Motutere / Castle Rock). He had coordinates for these from Drury's survey. With Hochstetter's bearings, he measured the Pirongia−Karioi baseline.

The unit is nautical miles. Welcker's distances are noted down the left side against most landmarks. Major and repeatedly used landmarks are denoted by an asterisk.

Note the last four peaks are labelled 1−4. These are not distances. They are sequential numbering associating them with a Hamel photograph. This was first reported in (Bunn & Nolden, 2018), where Hamel's photograph looking south from Lake Rotomahana, bore similarly numbered peaks.

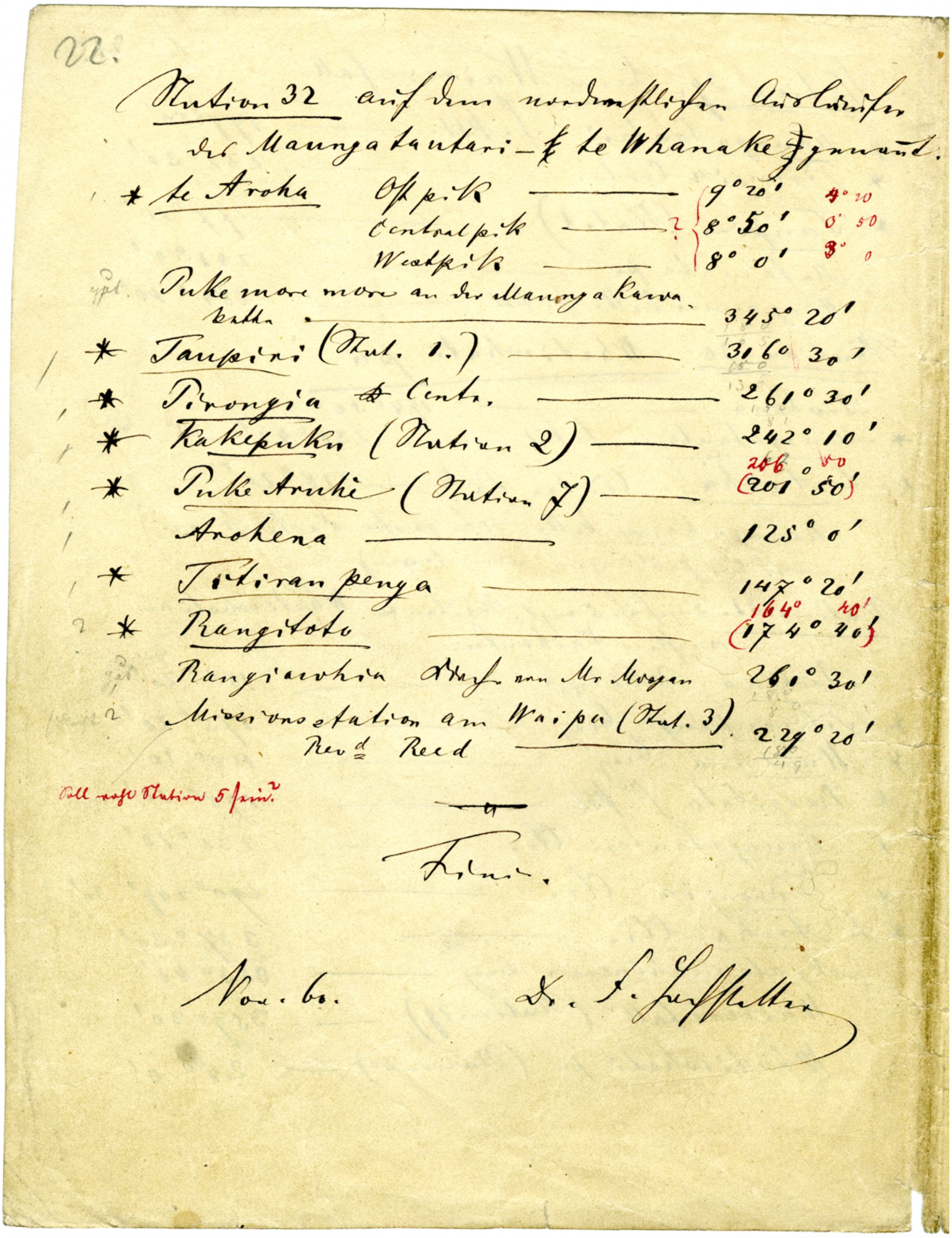

Figure 9. Folio page 22, final entries, date (November 1860), annotations, corrections and signature (Dr Albert Schedl Collection, Vienna).

In Figure 9, Folio page 22 is the final page and shows six reciprocal calculations. It instances the flagging of an erroneous bearing. There are five corrections in red ink. Also a note to check a landmark and correct two compass reading errors.

Translation (in italics) of the transcription of page 22:

Station 32 on the north-western extension of Maungatautari – named Te Whanake

Te Aroha

Eastern peak 9° 20′

Central peak 8° 50′

Western peak 8° 0′

Pukemoremore at the Maungakawa range 345° 20′

Taupiri (Station 1) 316° 30′

Pirongia centre 261° 30′

Kakepuku (Station 2) 242° 10′

Puke Aruhe (Station 7) (201° 50′) {206° 50′ }

Arohena 125° 0′

Titiraupenga 147° 20′

Rangitoto (174° 40′) {164° 40′ }

Rangiawhia church of Mr Morgan 261° 30′

Mission station on the Waipa (Station 3) Reverend Reed 229° 20′

[Annotation:] *Is likely intended to be Station 5*?

End

Nov. 60. Dr. F. Hochstetter.

In Figure 10, the Southern Part of the Auckland Province map charts the survey progress and Stations. The scale units are shown as German and English miles, but sampling the data shows Welcker followed Drury and used nautical miles. German miles were 7,420 m and on some pages of the Folio, it appears a second hand converted some distances into this unit. This probably reflects Petermann's oversight or other procedures at Gotha.

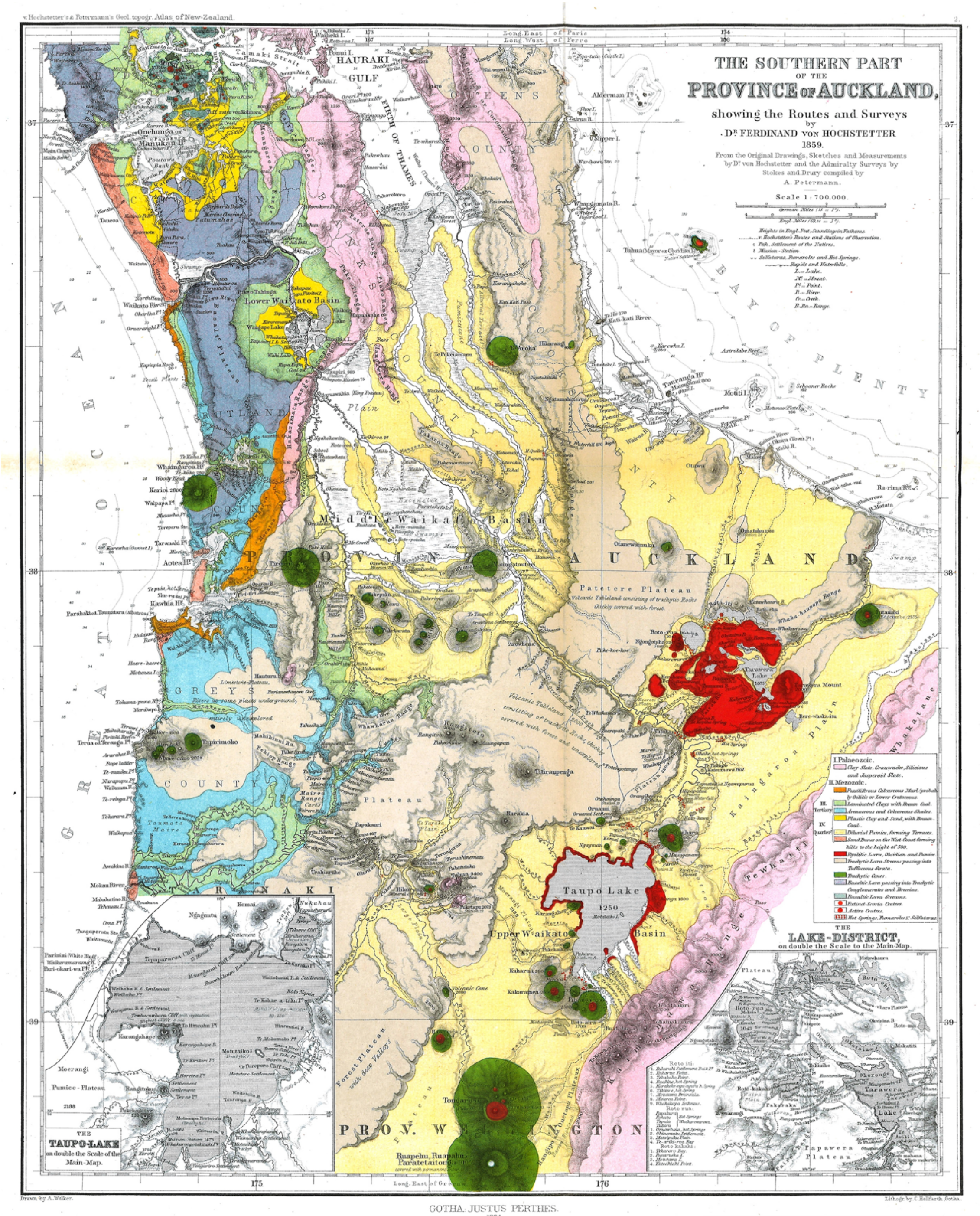

Figure 10. English edition of the map of the southern part of Auckland Province, with two inset lake maps (Hochstetter & Petermann, 1864).

3.3 Survey summation

In his public lecture presented in Auckland on 24 June 1859, Hochstetter stated:

> My observations have, with the able assistance of Mr. Drummond Hay, extended from the East to the West Coast, and the numerous peaks and ranges have afforded facilities for fixing with satisfactory accuracy, by means of magnetic bearings, on the basis of points previously fixed by the nautical survey

of Capt. Drury on the coast-line, all the great natural features of this portion of the country (Hochstetter, 1859).

Hochstetter assembled twenty-three persons for the counterclockwise survey of the Central North Island. The Auckland provincial government commissioned the survey and arranged for Drummond Hay to act as interpreter and leader, Bruno Hamel as photographer, Julius Haast (1822−1887) and draughtsman and cartographer Augustus Koch (1834−1901) to assist with the survey, and a group of Māori guides, porters and support staff. The survey timing in late autumn, across the high country, was not ideal and Hochstetter encountered inclement weather at times. For example, on one occasion his party was delayed at Tarawera for three nights due to heavy rain.

The survey proper began at Rangiriri, south of Auckland on 10 March 1859 and ended 68 days later at Mount Maungatautari on 17 May 1859. It proceeded with rest periods along the way and slow going, due to the weather. Hochstetter established 33 observation stations and recorded 664 bearings, along with altimetry. The stations, locations, bearings and dates are in Table 1.

Hochstetter's Survey Observation Stations					
		Bearings		Bearings	
Station	Location	per Station	Date	per Page	Notes
Recce	Rangiriri	2	10.3.1859	2	
1	Taupiri	16	12.3.	16	
2	Kakepuku	35	17.3	21	
3	Waipa Read's	7	31.3	14	
4	Aotea	11	23.3	15	
5	Awatoitoi	4	1.4	17	
6	Orahiri	10	2.4	15	
7	PukeAruhi	11	4.4	12	
8	Mairoa	3	6.4	13	
9	Pukewhau	1	7.4	15	
10	Ngariha	7	10.4	12	
11	Taringamotu	5	11.4	19	
12	Puketapu	8	12.4	15	
13	Oruanui	5	22.4	25	
14	Maroa	4	23.4	18	
15	Tutukau	13	25.4	18	
16	Waikite	7	26.4	22	
17	RotoKakahi	3	26.4	22	
18	Papawera	22	28.4	24	
19	Papawera II	12	28.4	13	
20	Kakerangi	25	28.4	22	
21	Station 21	26	29.4	18	
21a	Puai	3	29.4	0	
22	Whakarewarewa	37	3.5	15	
23	Ngongotaha	44	4.5	12	Folio D
24	Rotoiti	7	5.5	16	Folio E
25	Moura	2	5.5	56	Taupo 1
26	Omatuku	11	6.5	125	Taupo 2
27	Tauranga	4	12.5	56	Taupo 3
28	Taiharu Falls	7	12.5	16	Taupo 4
29	Wairere Falls	5	13.5	_	
30	Okauia	3	15.5	_	
31	Waiho	10	16.5	_	
32	Whanake	13	17.5.59	_	
	Totals	**383**		**664**	

Table 1. Hochstetter's survey observation stations.

Figure 11 reproduces Hochstetter's major bearings. The illustration is impossibly complex if all 664 bearings are included. The western and eastern surveys are apparent, divided by the Kaimai Range. The western and eastern baselines are in red and Drury's coastal survey error is depicted by short red rays extending from the baseline at Maketu and Matatā (see also Figure 17).

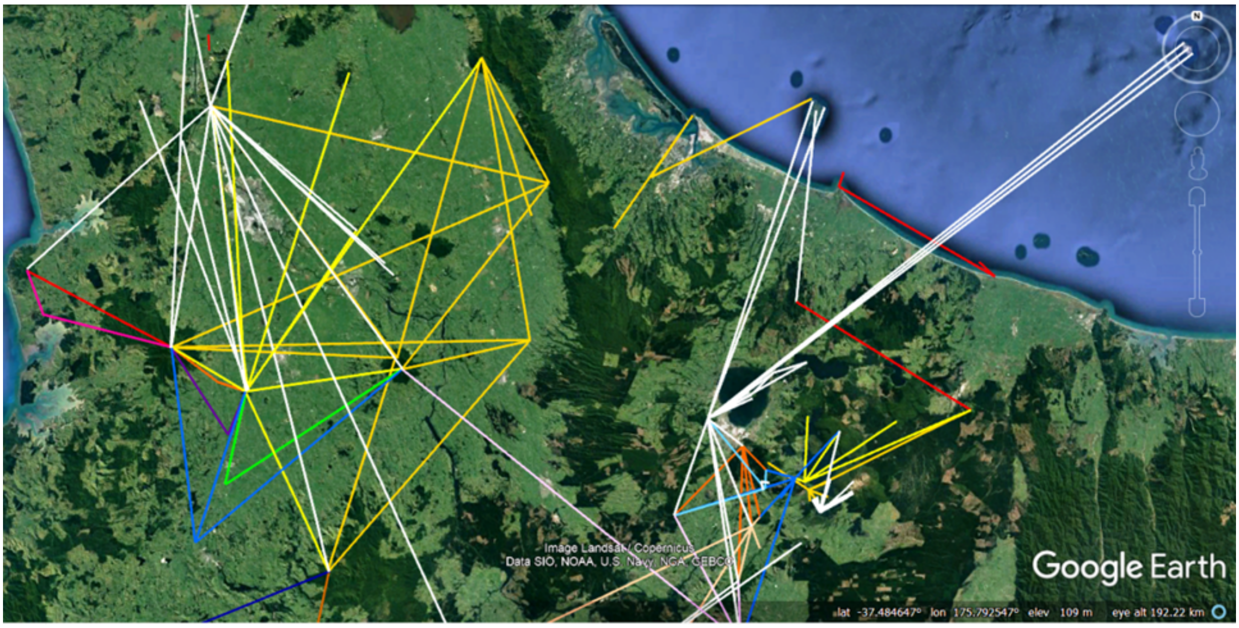

Figure 11. Major survey landmarks and bearings rendered in Google Earth™.

3.4 Twin surveys

Two stations are conspicuous i.e. Kakepuku and Ngongotahā, with 35 and 44 bearings respectively. This points to two survey branches: from the west and east coasts, anchored by Admiralty baselines and triangulated across the island to meet in the centre, with the Kaimai Range forming a demarcation. The twin branches are in Figure 12, with Kakepuku and Ngongotahā shown by white rays. Note, the coloured rays were a construction aid, which has been left *in situ*, as a reading aid.

On the eastern branch, Mount Ngongotahā is marked *sehr wichtige Position* (very important position). At these stations, Hochstetter took the angular distances of horizonal features starting at 12 o'clock and working clockwise. Using the Sine Rule and the Karioi−Pirongia baseline, on the western branch he established the Taupiri−Pirongia distance. With this and observations from Taupiri and Kakepuku, he found the Taupiri−Kakepuku distance. Beginning triangulation, he moved clockwise, finding the distances to the 35 landmarks visible on the skyline from Kakepuku.

A similar approach was taken at Ngongotahā where he listed seven coastal landmarks by Drury, enabling the formation of east coast baselines by Welcker. Welcker's latitude and longitude notes are annotated against two of these i.e. Maketu headland and Matatā estuary. An Admiralty baseline lay in between. Welcker's coordinates for the baseline are found on Folio page 17. It was 17.5 NM (nautical miles) in length with an error of 1.7 NM against Google Earth coordinates in Figures 12 and 17.

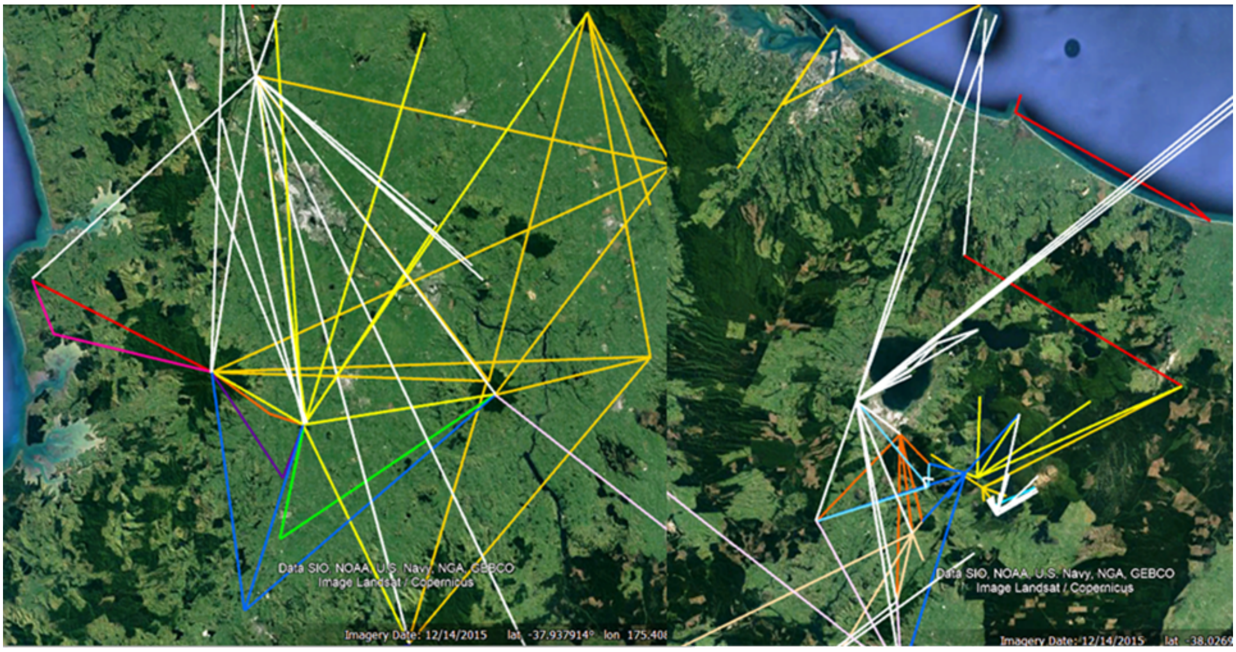

Figure 12. Western (left) and eastern (right) survey branches (Google Earth™).

Welcker received for the period, accurate survey baselines. This enabled checking for observational errors accumulating as the survey progressed. As discussed, Welcker calculated observation station reciprocal bearings. He made 59 reciprocals from 18 observation stations. Twelve of these were on observation stations including five from Ngongotahā and two from Taupiri; the latter being at the start and finish of the survey. A final reciprocal was also made from Pirongia. These were probably for resection and validation. Over 160 years later, some of these reciprocals establish the Pink and White Terrace locations as shown in Figure 18. Welcker may have exploited the Karioi−Pirongia baseline extension to Kakepuku. The known distances and angles enabled Welcker to apply a *similar triangles* approach to distances.

3.5 Expedition photography

Expeditions in the nineteenth century employed an artist to record events. Gradually, photographers were included. Hochstetter was the first to employ a dedicated photographer, and to use photography on an inland survey expedition in New Zealand. The government granted his request and appointed Bruno Hamel. In those early days of wet-plate photography, Hamel's bulky equipment and shooting and processing requirements impeded the party (Bunn, 2019a). Delays waiting for favourable weather and light, and on-the-spot processing; were an encumbrance. There was little appreciation by some in the party, of the difficulties photographers faced. Haast, writing in his field notebook, remarked:

> Our photographer is dissatisfied so far, the weather is not in his favour, either it is too windy or too hot; he always finds something that prevents him from producing a good view and subsequently we only have very few views that are worthy of the effort and compensation for the many delays. (Nolden, 2015).

Once he saw the plates, Hochstetter appreciated Hamel's work and found the photographs useful, although he would have seen only the glass negatives during the expedition. Prints were available in July 1859 when Hamel produced and published the first New Zealand photograph album (Hamel, 1859). The expedition was unusually well illustrated, with artist and cartographer Augustus Koch appointed. Hochstetter as survey leader and diarist conducted the geological survey and acted as an additional artist. In Gotha, Hamel's photography assisted Welcker with topographic and landmark detail. The photographic prints ensured Petermann had an enhanced resource of illustrations over and above the usual sketches and paintings of earlier expeditions.

3.6 Survey lake mapping – Lakes Taupō, Rotomahana and Rotokakahi

Hochstetter collected data for three large-scale lake maps. These were lakes Taupō, Rotomahana and Rotokakahi. He also sketched and painted Lake Rotorua. Folio Section E and the last Folio page contain 16 proximal bearings from Lake Rotokakahi. These triangulate key villages, Motutawa Island and Mount Moerangi.

Folio Section D contains 12 observation stations around Lake Taupō and notes on key numbered peaks. Three accompanying Folio pages contain a twelve by fifty-one cell matrix of landmarks and 253 bearings, sufficient for Petermann to produce an accurate, large-scale map of Lake Taupō. This was the most intensive and detailed section of the Folio and Hochstetter invested days in the bearings. He intended a large-scale map of Lake Taupō, but it was relegated to an inset map in the central North Island map produced at Gotha.

Instead, the third planned lake map of Lake Rotomahana became the only large-scale New Zealand lake map printed at Gotha. Hochstetter's series of Rotomahana lake sketches and manuscript maps were later catalogued and published (Nolden & Nolden, 2013).

Figure 13. Hochstetter's manuscript map of Lake Rotomahana, 30 April 1859 (Nolden & Nolden, 2013: HCB 3.5.10).

It was only after Hochstetter's manuscript map in Figure 13 was first reproduced in 2011 (Johnston & Nolden, 2011), that errors in the engraved published map in Figure 1 were noted (Bunn, 2017a). Paramount, was the disorientation of Lake Rotomakariri, in Figure 14 lying parallel to the Steaming Ranges. In the published map, it lies perpendicular to the Steaming Ranges, the North-South ridge in Figures 1 and 18. Hochstetter's lithograph of Lake Rotomakariri in Figure 14, confirms it lay parallel to the Steaming Ranges (Bunn & Nolden, 2018). Figure 14 is notable for it shows the peaks along the Tarawera massif as Hochstetter saw them, and from a similar elevation and perspective as Station 21. Tarawera peak appears marginally higher than Koa. This supports the Tarawera bearings in Iteration VI (Bunn, 2019b).

Figure 14. Lake Rotomakariri. Plate 9 no. 6 from Hochstetter (1864). Lithograph with draft labels and captions by Hochstetter (Hochstetter Collection Basel).

Hochstetter's manuscript map in Figure 13 orients to magnetic north. Petermann's published version of Hochstetter's map in Figure 1 orients close to true north. It is therefore apparent that Welcker copied Hochstetter's proximal magnetic bearings *as if* they were on true north. This fitted his planned map size, scale, borders and orientation but confused later researchers and led to the deformed lake in Figure 1. Welcker likely started with a bearing ray diagram and indicative lake length. Using a draft 29 April 1859 map, he infilled the shoreline around the bearings. Unfortunately, he omitted Ngahutu. This together with the proximal bearing errors discussed below, and what might be described as a degree of creative license led him to elongate and misshape the lake into a right-angled triangle. The lake had an equilateral triangle shape in all of Hochstetter's maps and those by Stephenson Percy Smith (1840−1922) and Ron Keam (1932−2019), (Keam, 2016).

Hochstetter, after locating his observation station on Puai Island near the lake centre, moved it to the southern shore possibly due to steaming-fog (Bunn, 2019b). When the Hochstetter manuscript and engraved maps are georeferenced over the resected Station coordinates in Google Earth, the original Hochstetter bearings to the three Terraces are replicated on the maps. This validates the survey mapping. See Figure 18, showing the three Terraces, Pink and White Terrace bearings, observation stations, survey baseline, proximal landmark locations i.e. Rangipakaru Hill, Steaming Ranges and the old/new lake shore overlap; with the Lake Rotomahana bearings.

3.7 Rotomahana Basin – Folio and Diary proximal and distal landmarks

Table 2 compares the proximal and distal Rotomahana Basin bearings in the Diary with those in the Folio. Proximal landmarks were destroyed in the 1886 Mount Tarawera eruption, while distal landmarks survive. In the Diary, there are 15 proximal and 14 distal bearings taken from two Lake Rotomahana observation stations. The Folio selects 26 of the 29 bearings for inclusion in the dataset that went on to form the basis for the cartography produced in Gotha.

Rotomahana Diary and Folio Bearings				
Station	**Distal***	**Proximal***	**Total**	
ex **Diary**				
Stn 21	12	13	25	
Puai Stn	3	1	4	
Total	15	14	29	
ex **Folio**				
Stn 21	10	13	23	
Puai Stn	2	1	3	
Total	12	14	26	
* Distal marks survive: Proximal marks do not.				

Table 2. Diary and Folio bearings, with totals for cross-checking.

No new bearings or landmarks were added to the Rotomahana section of the Folio, while three landmarks and bearings were excluded: two from Station 21 and one from Puai Station. These were Mr Spencer's and Waiahinekahu from Station 21 and the southwest Kumete peak from Puai. Also, Hochstetter confirmed a Diary correction to Rangipakaru Hill and the spelling of Whakaehu, while separating the proximal and distal bearings for Petermann. Additional description was provided for some landmarks e.g. Station 21 is described as being on a *low* hill. This supports the contention that the station was 30−40 m above the lake; a vital point for resection and altimetry (Bunn

2020b). *Peak A* on Kumete is described as *close to the track* i.e. on the northern branch. Kumete E is confirmed as being on Te Ariki Bay. Makatiti is described as the *highest point, forest covered hill at Lake Tarawera.* Welcker also calculated its reciprocal from Station 21, as Bunn did in earlier research (Bunn et al, 2018). This Folio note validates the 2018 presumption it was to the tree tops Hochstetter sighted (Bunn et al, 2018).

3.8 Old Lake Rotomahana dimensions

To locate the Terraces it was first necessary to determine the length and coordinates of old Lake Rotomahana (Bunn et al, 2018). Bearing 357° 0' is the *Direction of the greatest length of the lake towards the Kaiwaka outlet*. Hochstetter refers to the lake length, apparent from Station 21. In Rotomahana the *fetch* was between the inlet and exit streams Haumi and Kaiwaka (though Hangapoua−Kaiwaka at times of high-water level would challenge this). The Station 21−Kaiwaka distance would be to dense vegetation around the Kaiwaka Stream entry. The distance on the Hochstetter manuscript map in Figure 13 is ~1,600 m. That equates to the georeferenced length of 1,600−1,610 m i.e. about one statute mile. This agrees with eyewitness accounts in the historical record (Bunn, 2019b).

Importantly, Hochstetter verifies Puai Station as his *Secondary* [observation] *Station Puai Island*. This is important for Puai Station was not specified in the Diary. Puai remains a key observation Station for georeferencing and triangulation (Bunn, 2019b).

3.9 Omitted landmarks

The three landmarks omitted from the Folio do not affect the 2018−2020 published survey iterations. The landmark labelled *Mr. Spencer's* was a peak surrogate (Bunn, 2019b). Mission stations lay at lower elevations close to water along rivers or lakes and surrogate peaks had to be used. An example is Ashwell's Taupiri mission on Folio page one, where the surrogate peak behind the mission gave the mission bearing and was photographed by Hamel (Nolden & Nolden, 2012: 43; HCB 2.7.9). Waiahinekahu shared a bearing with Rangipakaru and the omission removes duplication. Hochstetter carried over a Diary error for Rangipakaru into the Folio. The correct Rangipakaru Diary bearing of 65.666º is used by Bunn in the reverse engineering. Rangipakaru Hill recently became a pivotal proximal navigation landmark at the lake (Keam, 2016; Bunn, 2020c).

3.10 Kumete Ridge Triangulation

This ridge, above the north-western shore of Lake Rotomahana, provided a series of five landmarks that Hochstetter used for triangulation. The ridge is also shown in Figure 1 where its orientation with the Terraces is seen. Unfortunately, no pre-eruption photography of this ridge is known. The Black and Pink Terraces lay below this ridge with the White Terrace across the small lake, surrounded by a horseshoe-shaped embankment (Bunn, 2022d).

Kumete A has an improved location detail from Station 21 but is omitted from the Puai Station list. It is mapped and described as *a peak on the track* in the Diary and simply as *close to the track* in the Folio. For the field study of Kumete A, the Tūhourangi track was followed up the Wairua Inlet to the old exit of Wairua Stream, adjacent to Kumete peak. From there, it crossed from the true left bank to begin the steep traverse of Kumete Ridge (Bunn, 2016). The track took a diagonal ascent, finding an easier grade. It reached the saddle on the western end of the Kumete plateau at ~440 MASL. Across the saddle where the Station 21 and Puai bearings strike, the track branched with the left branch leading north (now along a forestry road) behind the Black Terrace to the northern crossing at the Kaiwaka entry. Hochstetter took this branch while the main party turned south with the baggage around the lake, to the Haumi and thence to Puai Island to make camp, as per the mapped route. There was one small canoe at the Kaiwaka entry that day and it was simpler for the main party to walk around the small lake rather than wait at the river crossing. Hochstetter canoed to Puai Island and began making his observations.

3.11 Te Poroporo and Mamaku

The exclusion of Kumete A from Puai Island in the Folio interferes with resection. The fourth Puai bearing i.e. on Poroporo was qualified by georeferencing to restore the three-bearing resection for Puai Station. This use of the proximal feature Poroporo is no longer as an independent datum. Sensitivity testing with joint Diary-Folio, four-bearing resection did not affect georeferencing. The present research has elected to focus on the Folio and include Poroporo, as Hochstetter intended.

There is a difference in angular distance for Poroporo between the Diary and mapping. The Hochstetter and Petermann maps record azimuths of 8º and 15º versus the Diary at 1.5º. A *gap analysis* with nearby Mamaku was made. From the south, their plumes are 250 m apart and rise above similar shoreline sweeps covered in tall vegetation in Figure 15. The Diary bearings are just 1.8º apart from the two stations. Poroporo was the first landmark Hochstetter recorded on 29 April, with Mamaku later. It appears he or more likely guide Akutina Rangiheuea (?−1886) confused Poroporo with Mamaku. From Station 21 the bearing to Poroporo passes across Puai Island, affecting intervisibility. The change in bearing mix for Puai i.e. to Kumete C, Tarawera and Poroporo improves the Puai ellipse and error.

Figure 15. Poroporo (left) and Mamaku (right). Plate 9 no. 5 from Hochstetter (1864). Lithograph with manuscript labels and captions by Hochstetter (Hochstetter Collection Basel).

The Folio notes elaborate on the landmarks and dataset for Lake Rotomahana. Survey iteration V−VI findings based on the Diary are supported by the Folio, with enriched detail. The reverse-engineered locations for the old lake, Stations 21 and Puai, and the locations of the Pink, Black and White Terraces remain unchanged. The omitted Station 21 bearings leave 23 bearings to resect this station when three or four are usual (Bunn et al, 2019b).

Hochstetter was aware of the level of accuracy and precision his survey could achieve:

> It is self-evident that a map, compiled within the short space of three months, with only the help of compasses, and comprising more than one fourth of the North Island, can make no pretensions to trigonometrical accuracy. However, it gives a correct view of the river and mountain systems of the country travelled through and will be of service till something better shall have been substituted. (Hochstetter, 1867).

Hochstetter's was to be the only survey of old Lake Rotomahana and the Pink and White Terraces.

4.0 Survey error

The Folio data provide a comparison dataset to the Hochstetter Diary. The Folio contains Hochstetter's Diary data, edited for cartographic production. The Folio therefore enabled the verification of the 1859 methodology, bearings and landmarks. Triangulating puzzling proximal bearings at Lake Rotomahana resolved the measurement and observational bias detected along the Steaming Ranges between Ngahutu and Whakaehu (see below). The Diary–Folio synthesis strengthens the empirical evidence for the Pink, Black and White Terrace locations. Hochstetter's survey Diary has been analysed and six iterations published since 2016 (Bunn, 2020a). Here, the focus is on the 1860 Folio and its insight into the central question: where are the Pink and White Terraces? The 28-page Folio has six pages containing 11 *corrections* in red ink.

4.1 Petermann–Welcker and Google Earth error

Bunn et al, 2018 first published the error propagation from Hochstetter's survey. This included the error ellipses for the Rotomahana observation stations:

> The empirically determined errata included observational error to landmarks, random error from wind and steam clouds, error in resection, compass error (due local magnetic variation and inclination), declination error i.e. actual to IGRF [International Geomagnetic Reference Field] model, landmark displacement since 1859 by natural forces and Google Earth error. (Bunn et al, 2018).

In 2019 the latitude and longitude errors in engraved published map of Lake Rotomahana were examined and showed the longitude error was likely inherited from Admiralty data (Bunn, 2019b). The Folio includes these data, enabling the calculation of the latitude and longitude error in the eastern survey baseline in Figure 17. This would propagate through in the triangulation.

In Figure 16 (page two of the Folio), Station Two at Kakepuku bearings are shown. This primary station for the western survey has many asterisked peaks, and Hochstetter's and Welcker's validation distances were audited against Google Earth distances: with peaks identified in Welcker's notes and on Google Earth. In Table 2, taking Google Earth as the datum, the median error and range in Hochstetter's data (as calculated by Welcker from Hochstetter's triangulation), is 0.37 NM (685 m) and 7 NM. For the Welcker–Petermann validation, the median error and range are 0.09 NM (167 m) and 12.6 NM. Thus, the error in Welcker's mapping may generally be greater than in Hochstetter's triangulation, (this excludes the error in Google Earth). For a compass survey, the accuracy is creditable for the time, given no slope correction was applied and longitude was poorly defined for New Zealand.

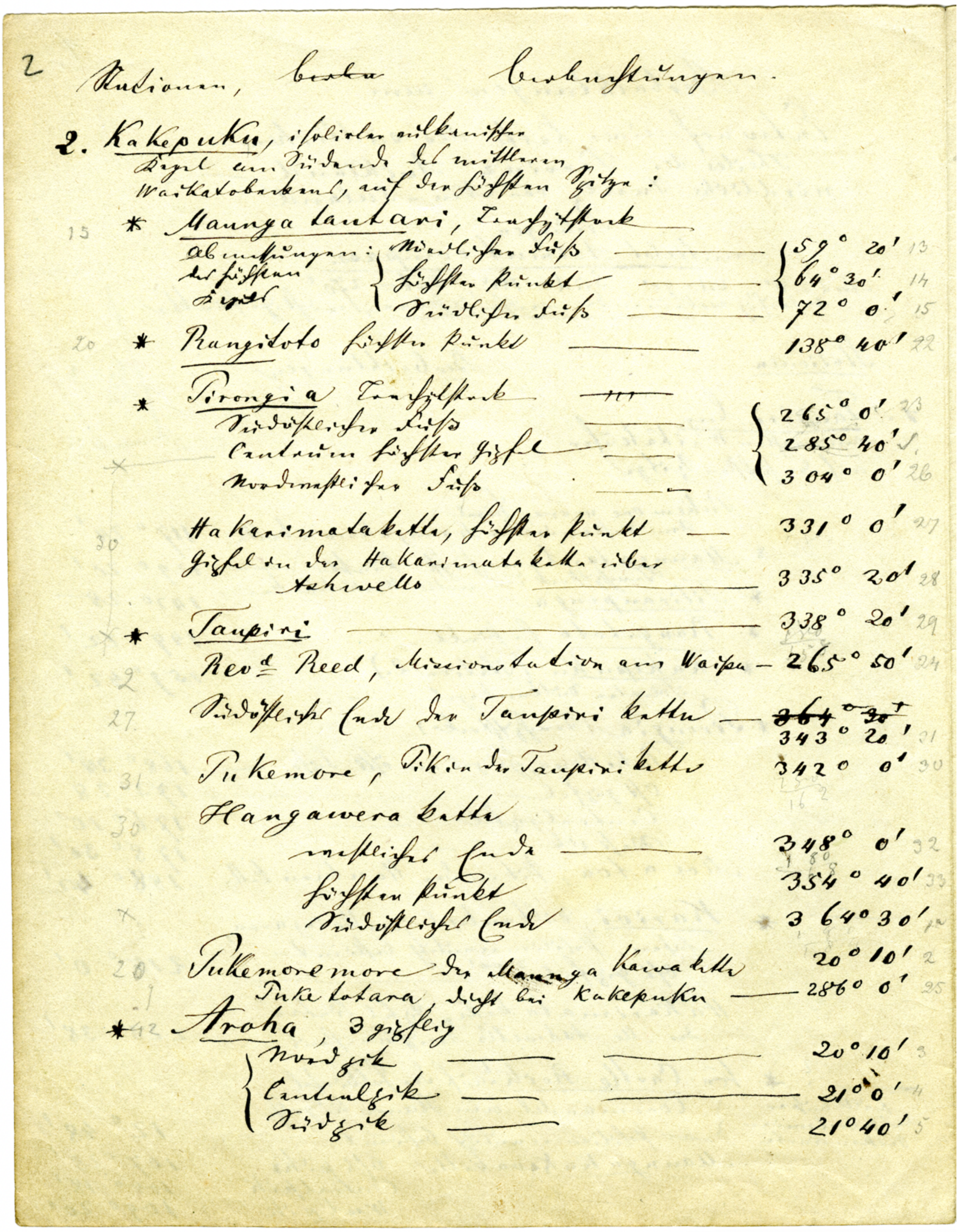

Figure 16. Folio page two (Dr Albert Schedl Collection, Vienna).

The accuracy compares favourably with the 2018 validation of Hochstetter's bearings and declination correction from Station 23 at Ngongotahā (a mean error of 0.25° and a range of 3.78°), (Bunn et al, 2018).

		Sample Survey Errata-Station 2					
			(Unit - Nautical Miles NM)				
	Folio Hr	Folio Wr	Google. E	H.Error	Wr Error	Gap Hr to Wr	
	15	14	15.4	0.4	1.4	1	
	20	22	19.4	-0.6	-2.6	-2	
	30	27	25	-5	-2	3	
	27	21	27.6	0.6	6.6	6	
	31	30	32	1	2	1	
	30	32	32	2	0	-2	
	20	25	19	-1	-6	-5	
	173	171		**-0.37**	**-0.09**	**0.29**	
			Range =	-5 to +2	-6 to +6.6	-5 to +6	

Table 3. Sample survey error for Station Two. Hochstetter (Hr), Welcker (Wr), Google Earth (Google.E).

4.2 Tarawera bearings error

In Hochstetter's Diary, there was obvious error among the Mount Tarawera bearings. In earlier articles, it was deduced that the correct bearing configuration had a transposition error in the plateau edge bearings, but there was no clear cause. With the Folio, there is a hypothesis. The northwest and southwest edges of the upper mountain plateau were stated bearings. Hochstetter then overwrote the southwest bearing *SO* (SE in English). The included angles proved transposition. The error has been corrected. Tarawera bearings cannot be ignored for Hochstetter took them so that resecting with Kumete Ridge provided perpendicular intersections. These deliver optimal accuracy when resecting reciprocal bearings onto the Observation Stations.

Today, these errors may be accounted for, thus: Hochstetter had a *blind spot* in orienting himself on 29 April at Rotomahana: the lake lay surrounded by hills; the weather was unfavourable with strong winds: his view was dominated by the Tarawera massif, as it is on new Lake Rotomahana from his 1859 coordinates. Momentarily, Hochstetter acted as if in the Northern Hemisphere. He saw the pole as *above him* i.e. northward. Looking through Hochstetter's eyes from Station 21 to Tarawera, seeing magnetic South as magnetic North: the locations are transposed as in the Diary. This confused Welcker as well, who might also have encountered this on Motiti Island, where he averaged narrow horizontal bearings to form a mid-point bearing (Dahl, 1983: 70).

To test this interpretation, the Mount Tarawera bearings from Kakerangi Station 20 were re-examined. There, a Hochstetter sketch also shows bearings on the lower slope and plateau edges. The corrected Station 21 bearings strike Mount Tarawera at adjacent locations, allowing for the angular distance between Stations 20 and 21. This strengthens the view the Tarawera bearings can safely be included in triangulation.

4.3 Rotomahana proximal landmark error

The Folio records 23 bearings from Station 21, i.e. 13 destroyed proximal bearings and 10 surviving distal bearings. The 10 distal bearings stand validated. Of the proximal bearings, Rangipakaru Hill is confirmed (Bunn, 2019b, 2022c). The remaining 12 were lost in the 1886 eruption. Hochstetter excluded Waiahinekahu from the Folio, leaving 12 landmarks. Of these, the Pink and White Terraces, Tekapo, Puai, Pukura and Kaiwaka entries are located for georeferencing verifies the Diary bearings. Ngahapu, Ruakiwi, Ngawhana, Whakataratara, Mamaku and Whakaehu cannot be so confirmed. There are errors in either the historical locations, the bearings, or both.

These six destroyed landmarks do not assist triangulation or georeferencing but should if possible be reconciled. It must be considered when the bearings were taken. It was a cold, wet, windy morning on the plateau. These landmarks lay invisible: marked only by steaming-fog plumes. One person, Akutina Rangiheuea could identify and spell them for Hochstetter. Rangiheuea would have followed his mental Māori strip-map. The waypoints began from the north where the Steaming Ranges were entered. Hochstetter approached from the south, reversing the guide’s travel. Unsurprisingly, mistakes were made. Guide Rangiheuea died in the Mount Tarawera eruption in 1886 and was never interviewed about his role.

These six landmarks are examined to reconcile the likely causes:

a) Ngahapu and Ngahutu − *Great Ngahapu* was a boiling spring, ~12−15 m long, close to the shore, south of the White Terrace base. Hochstetter records it and the associated *little Ngahapu*. This is a telltale for the large boiling spring Ngahutu was the *first* major spring encountered on the path. It is overlooked in both the manuscript and engraved maps and writings. It is in a Hamel photograph marked by steaming-fog over it and Ngahapu. Hochstetter may have had an inkling as his Figure 13 map has a note across Ngahutu's location referring to springs. Supporting our reconciliation, his 29 April map has Ngahutu in position but marked as Ngahapu (Nolden & Nolden, 2013: 72). This label was later crossed out and the correct Ngahapu location was inserted.

The Ngahapu bearing of 5º 20' bears on Ngahutu. The two springs put up similar steam plumes and from the south overlapped in Hamel's photograph (Bunn et al, 2018). As the six landmarks could only be spotted by plumes, this error likely led to an error series i.e. as Rangiheuea counted off steam plumes from north to south, following his mental map.

b) Tekapo − the Tekapo bearing of 7º 30' grazes Ngahapu on the Figure 13 map and starts an error cascade.

c) Ruakiwi − the Ruakiwi bearing of 11º 10' grazes Tekapo on the Figure 13 map and continues the cascade.

d) Ngawhana − the Ngawhana bearing of 7º 0' grazes Ruakiwi.

e) Whakaehu − this is the first landmark on the flat below the Ranges. The error cascade ends. There is an observational error of -10º.

f) Whakataratara – There is a second observational error of -10º. This is common in compass surveying and Welcker noted another on the Station 32–Rangitoto bearing. He also corrected a degree–minute transposition error from Station 6–Maungatautari and a 20º error from Station 30–Maungatautari.

The Ngahutu omission led Welcker into an error cascade, *drawing* the Steaming Ranges landmarks counterclockwise, closer to the western shore in his map. The omission does not impact other Diary and Folio landmarks, or resection of the stations and Terrace locations. It did contribute to Welcker constructing a distorted map for he relied on the six bearings, rather than combining Hochstetter's manuscript cartography, sketches and photography.

4.4 Error ellipses

With the inclusion/exclusion of certain bearings in the Folio, it was possible to recalculate the Rotomahana stations' error ellipses. For Station 21, the major axis now lies at azimuth 326º with an error of ±44 m and the minor axis at 60º with an error of ±13 m. For Puai Station, the major axis lies at azimuth 345º with an error of ±28 m and the minor axis at 70º with an error of ±9 m. The locus for Station 21 is unchanged from 2018 at 38.2705ºS and 176.4268ºE. The revised Puai landmark mix amended the Puai Station locus to 38.2630ºS and 176.4294ºE. These changes had marginal effect and georeferencing does not alter. The 2018 survey baseline remains at 830 m (Bunn et al, 2018).

4.5 Eastern baseline error

Hochstetter employed a second *Bay of Plenty* survey baseline. This was Maketu–Matatā at 17.5 NM. Welcker noted the coordinates and Bunn compared them with Google Earth. The baseline error is shown by short red rays in Figure 17. They measure a baseline of 15.9 NM versus 17.5 NM actual, with a Matatā angular error of 3.5º from Ngongotahā. This exceeds the acceptable range of 1−2º (McFadgen, 1999).

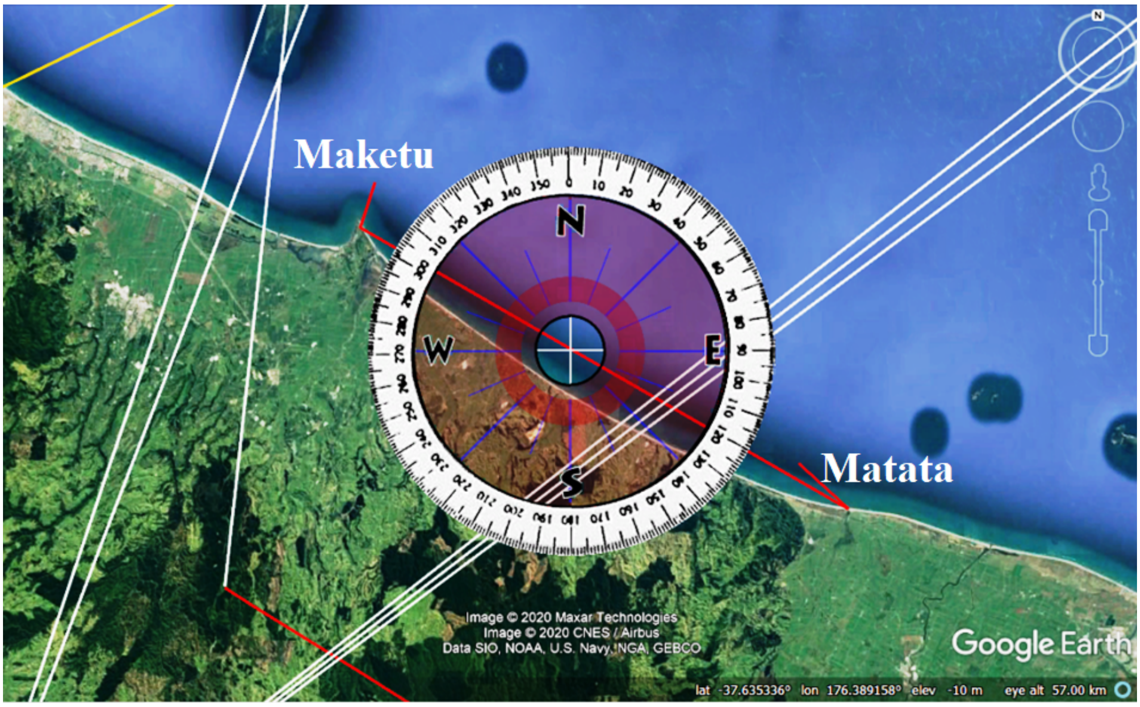

Figure 17. Maketu−Matatā eastern baseline rendered in Google Earth™.

The Maketu error is 1.4 NM and the Matatā error is 2.1 NM. The Matatā error is essentially longitude while Maketu is with latitude.

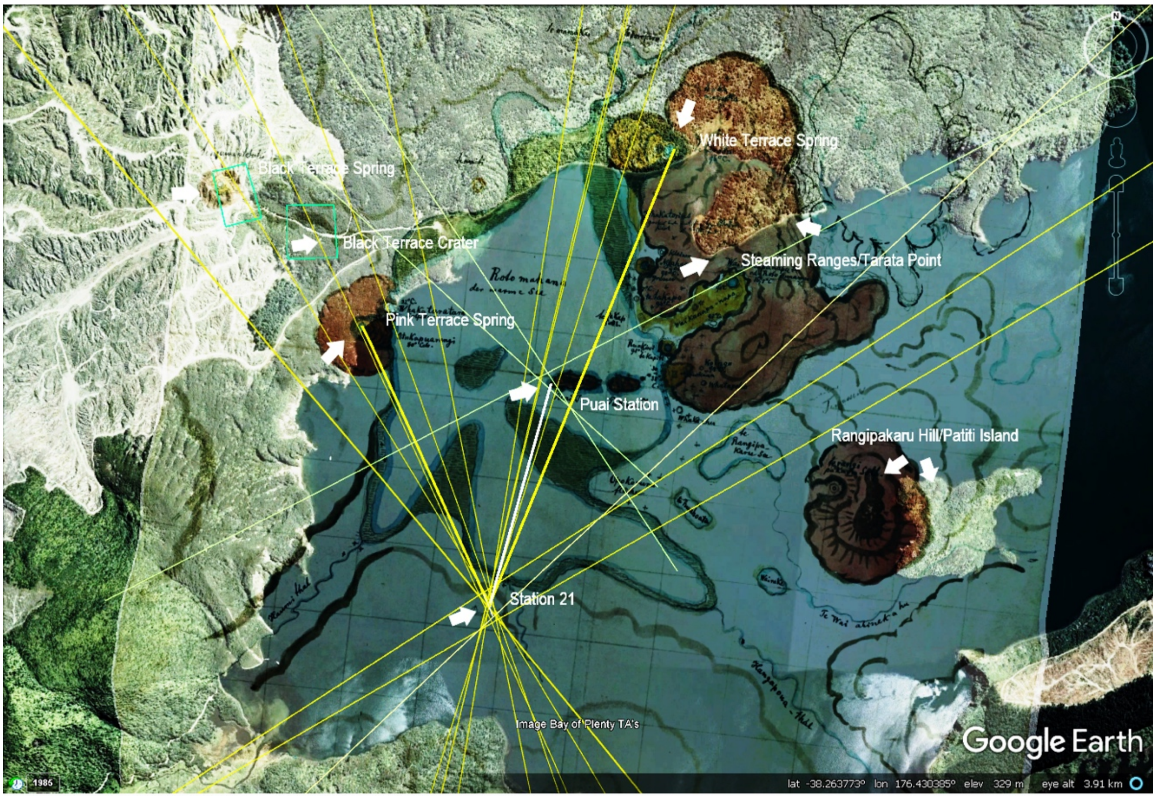

Figure 18. Hochstetter's reconstructed Folio survey bearings and 30 April 1859 manuscript map over Google Earth (Bunn, 2022).

5.0 Conclusions

This analysis of the compiled November 1860 Folio of Hochstetter's 1859 North Island survey dataset, provides greater insight into that seminal mapping of the central north island, and particularly of the Rotomahana Basin and the Pink and White Terraces.

The Folio provides Hochstetter's edited survey, in his publishing format. Prior research relied on his unpublished 1859 Diary. The Folio contains the edited dataset with additional material. It contains notes, corrections, annotations and workings by Petermann and Welcker in Gotha, which strengthens its value. Survey errors noted in Gotha and previously by the authors reveal an incidence anticipated in this type of survey. These were largely addressed by Petermann and Hochstetter in 1860, and those requiring local or later knowledge by Nolden or Bunn since 2015. Destroyed landmarks regrettably prevent error resolution for certain proximal bearings.

The Folio and Diary form a synergistic survey resource. Questions about survey design, technology, methods, daily activities and implementation are answered. For example, Hochstetter's 1860 verification of his second observation station on Puai Island is vital in locating the lost Terraces. The recovery of Ngahutu spring into the scientific record answers questions left by Hochstetter resolving his survey bearings over the Steaming Ranges and recently proved crucial in correcting the 1886 Rotomahana Basin topography (Bunn, 2022c). These Folio findings validate the Hochstetter survey Diary findings in the previous papers the authors have published on this subject; individually or together. The findings triangulate with the recent Rotomahana Basin topography and with Mātauranga Māori records (Bunn, 2022c).

6.0 Discussion

The Pink and White Terraces have been subject to controversy since before the 1886 Mount Tarawera eruption. The pre-eruption controversy concerned indigenous versus colonial ownership of the Terrace sites and exclusive rights to their rich international tourism trade. After the eruption, the traditional landowners became refugees for generations and colonial interest shifted to developing a tourism market on the new volcanic landscape and geothermal features e.g. the Waimangu Geyser, considered the most powerful geyser in the world at the time.

Since 1886 claims have been made as to the Terrace locations, but no samples of terrace sinter have ever been produced. This is why Hochstetter's survey Folio remains so significant for it provides the only archival primary source survey evidence on the location of the Pink and White Terraces at Lake Rotomahana.

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