WHAKAREWAREWA THERMAL ACTIVITY - YESTERDAV AND TODAY

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ABSTRACT

A recent re-survey of the thermal features in Whakarewarewa shows that changes in that activity have occurred since the previous scientific survey (by E.F. Lloyd, W.M.Crafar and H.W.Hunter, Geological Survey, Rotorua) in 1969. To put these changes into perspective it has, however, been necessary to seek out information about the system and its features well before that first survey.

In this paper we briefly discuss the Whakarewarewa system and the changes that have taken place over time. In the first part of the paper we briefly summarise the current ideas relating to ttie initial development of this thermal system and the reported changes that occurred up to about the time of the Tarawera eruption (in 1886). The changes that occurred in the roughly 100 year. period. following Tarawera are covered in the second section. During this period, man's activities within Whakarewarewa have almost certainly played a significant role in influencing change and some of these influences and changes are discussed. Many questions still remain.

INTRODUCTION

Over recent years there has been concern that the abstraction of hot fluid from beneath Rotorua City and the area around Whakarewarewa may be affecting the thermal activity in the Whakarewarewa Thermal Reserve. Such activity does, howeverr change naturally with time and hence it is important to be able to distinguish between natural change and changes that may have been induced by such fluid abstraction. In this particular area the assessaent of change is further complicated by the fact that many of the features have also been more directly affected by work that has been carried out by various people in Whakarewarewa itself.

In this paper we discuss the changes that have occurred over time, due to natural processes up to arid through the Tarawera eruption period and due to a combination of natural processes and man's activities from that date to the present. Interactions between man's activities arid the behaviour of specific features is only pinpointed when the evidence of interaction is unequivocal. The purpose of the exercise to date is purely to establish the changes that have taken place and not to apportion any blame for that change.

Whakarewarewa is sited at the southern end of Rotorua City. A map of the area showing the features and zones discussed is presented in Fig. 1. The features in the field fall into two categories: chloride (water) and acid (sulphate). The two types behave differently under stresses and with time. The chloride features, flowing hot springs and geysers, are controlled primarily by hot water coming up from depth. They quickly mirror any pressure changes and hence have a high sensitivity to stress of any sort. They generally deposit sinter as the silica saturated water discharges arid cools. Areas of such features are thus readily identified. Channelling of the water up faults and cracks also results in these features being grouped in specific areas. In Whakarewarewa the main groupings are at Geyser Flats, in the Maori Village area, around Roto-a-Tamaheke, on the Uaikite mound and along the Puarsnga stream.

Acid (sulphate) features tend to result when discharge rates are very low or the primary fluid maintaining the feature is steam. They are thus less sensitive to stress and most outside influences. These features do not, in general, deposit sinter - the acid, in fact, attacking silicate rocks and hence speeding their disintegration. In contrast with the chloride features they do not appear to be associated with specific flow paths and hence tend to be dispersed throughout the field. Typical acid features are fumeroles, steaining ground, and turbid water and mud pools. Often basically steam-heated surface water features, they can vary markedly in form with season and rainfall.

FROM WHAKAREWAREWA FORMATION TO THE TARAWERA ERUPTION

The geological history of the drear with specific emphasis on Whakarewarewa, ha5 been presented by Lloyd (1975). We will thus only touch on this briefly. Recent reevaluations of geological evidence have, however, led to the readjustment of estimated dates for some early events. The Rotorua caldera was formed in an eruption that took place about 140,000 years Before Present (BP). This massive eruption clearly obliterated all that existed in the Rotorua area before that time and hence serves as an appropriate starting point for this discussion. The Whakarewarewa area was further modified by the local eruption of Ngawha Crater about 50,000 years BP. There is some evidence that thermal activity in Wtiakarewarewa pre-dated that event. At about the same time the Rotoiti Breccia, from an eruption outside of the Rotorua caldera, dammed the outlet to Lake Rotorua. The lake level thus rose to about 80 metres above the present level. The flooding would certainly have stimulated some migration (outwards and upwards? of the thermal activity. Old spring sinters in Utuhina Valley west of Hemo Gorge tend to confirm this. These sinters are, howeverr at a level that would still have been flooded when the lake wa5 at its highest level. As the lake sediments do not cover them, they probably were not laid down until after ttie lake water began to fall. Later

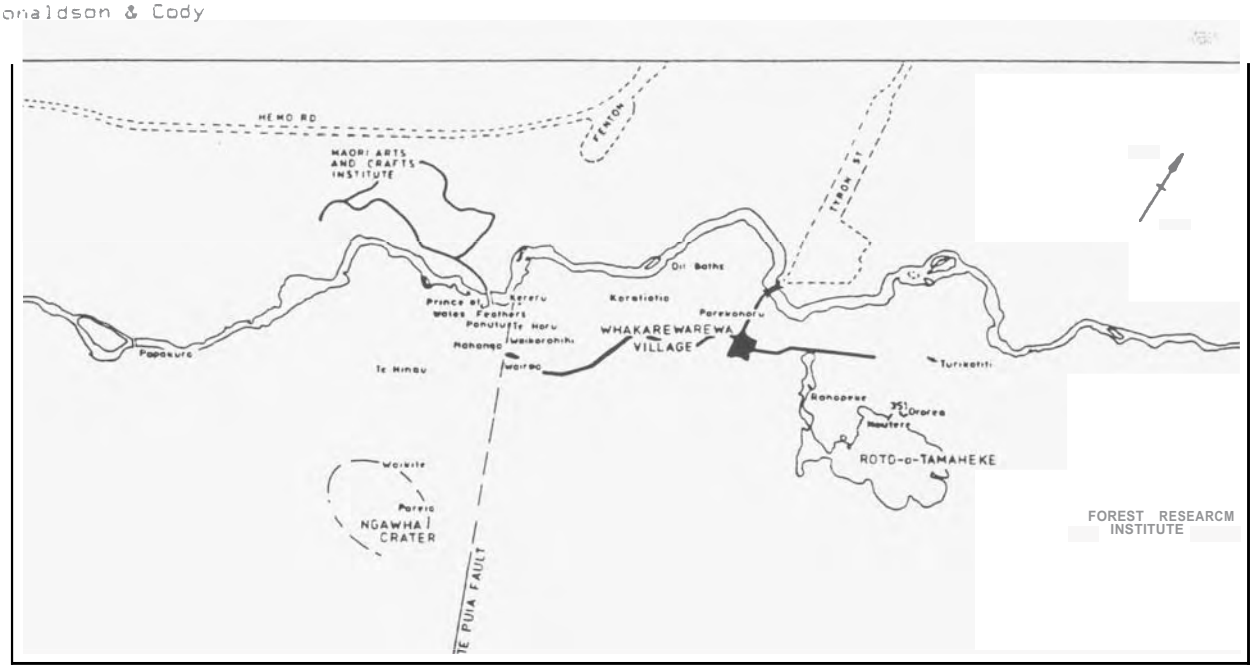

FIGURE 1 **MAP OF WHAKAREWAREWA**

lake movements are documented by Kennedy, Pullar and Pain (1978), the major drop in level to about 10 metres above the present level not occurring until about 20,000 years BP. At that time the thermal activity would have started to migrate back down, with minor fluctuations occurring as the water table adjusted with other later lake level movements (total range ~ 15m) and with the cutting down of the Puarenga stream channel.

Within Whakarewarewa itself the major indicators of historic change are the old disintegrating sinter beds. These are found primarily to the south of Geyser Flats and west of Waikite mound (consistent with the downward migration of activity). In both areas old geyser or spring vents may still be identified. Taupo Pumice ash is present in the uppermost sinters at Pareia, Te Hinau and north of Puapua. It is overlaid by a remarkably uniform layer of about 100m of sinter in each case. Thus there must have been chloride water discharge throughout this area for a period after 186 A.D. More intact sinter sheets, no longer sustained by overflowing discharge water are found in the Maori Village area and along the northern side of Roto-a-Tamaheke. Thin sinter beds in the diatomaceous 1ake sed iments beneath the surface sinters at Roto-a-Tamaheke indicate that there have been water level retreats in this lake in the past (over a period in excess of 13,500 years).

In ttie Maori Village area old sinters indicate that Te Waro-a-Ngawai was once a flowing sititer-depositing spring. This feature was, howeverr clearly identified by early European visitors as a mud pool. Any changes must have thus taken place more than 150 years ago. Other old sinters stand up about 2m above the present rim of pools in ttie Korotiotio area and old sinter edges may be seen 0.8m above the present sinter lip. These high levels of sinter sui-face and the retreat of waters to 2m · below ground level in some pools in more recent times, together with the ongoing record of hydrothermal eruptions, suggest that this area has long been unstable* with water levels dropping lower and lower witti time. This could be tied in with the downcutting of the Puarenga Stream, the bottom of the sinter apron of one terrace in the area is now more than 2m above the current water channel, or with the drop in lake level that

As Maori occupation of Whakarewarewa pa sites was intermittent until about 1878, little information appears to be available about the Whakarewarewa activity prior to the arrival of the Europeans in the 1630s. Almost all features are named but only a few names give us any clue as to the possible past nature of their behaviour. The name Wairoa ("long water"), for example- does suggest that the Maoris had at some time seen the geyser perform in style. There is nothing in the European writings that indicated that it did anything equivalently riotabler or anything at all for that matter, until after the Tarawera eruption. The lack of Maori names for a few specific features that we observe today, or that have been observed since the Tarawera eruption may also be significant.

From the arrival of the first Europeans until the early 1870s visits to Whaka-rewarewa were intermittent and widely spaced in time. The information available for this period is thus sparse and disconnected. With the opening up of roads and the developing interest in Rotomahana (the Pink and White Terraces) in the 1870s, more visitors started to come through the area and more of these itinerants at least paid a passing visit to Whakarewarewa. The newspapers also began to take more interest in the goings on in ttie area and in the thermal activity. More information is therefore availabler although much relates to (often not clearly defined) geyser performance. Ttie overall impression gained relating to the latter is that little of significance was seen in the early 1870s, Waikite commencing a rather 1engthy rest period in 1869 and other features apparently doing very little. Pohutu appears, howeverr to have come to life in 1874, playing intermittently up to 15-30m for a period of some two years. For a period from 1876 attention then moved to Te Horu, which is mentioned as discharging massive volumes of fluid with upwellings of up to 6-7m.

Waikite played in a limited way in 1879. kfter a pause it performed almost incessantly for some months in 1881, stopping again until late in 1885. During this period there was not much mention of any activity on Geyser Flats, reports primarily mentioning only one small geyser in constant action.

On 10 June 1886 Mount Tarawera erupted.

White Terraces were concerned, but it also had both physical and social implications for Whakarewarewa. The obliteration of New Zealand's premier tourist attraction meant that lesser lights gained greater status, and Whakarewarewa was at the forefront in that regard. There also appears to have been an enhancement in the activity in this area. Certainly all the geysers on Geyser Flat- along with Wairoa and Waikite further south appear to have started a new lease of life or otherwise improved their performance. This enhancement, interestingly, did not coincide with the eruption, but followed some weeks later. It is suggested therefore that one of the many earthquakes that followed the eruption opened up some cracks in the Te Puia Fault, a lineation along which most of these geysers lie (Lloyd, 1975) and thereby permitted more fluid and heat to reach the geyser reservoirs. We might also conjecture that a crack on this fault line may also have opened up at the surface alongside the Pohutu vent, thus allowing the establishment of the feature that Malfroy (1891) called the Indicator and that we, today, call the Prince of Wales Feathers. The apparent lack of a Maori name for such a distinctive feature9 its omission on the first survey map of the area (produced in 1885), and the lack of any description of the play of such a pre-cursor in the descriptions of Pohutu and Te Horu eruptions prior to 1886, all tend to suggest that it did not exist earlier. CA new surface crack about 5-7mm wide opened up in this area in late July/early August this year (1984). It runs north from the Prince of Wales Feattiers towards Kereru].

Clearly, the Te Puia lineation has existed for a long time and many features have existed along it. We may conjecture that the post-eruption jolt merely re-opened old cracks rather than created new ones. As these had closed up before, we might well expect at least some of them to commence closing up in the relatively short term. Any closure cycler whether short or long termr would mean some sort of decay of activity in this area. As we note below some decay of this nature did in fact occur.

FROM *THE* TARAWERA ERUPTION *TO* TODAY

At the time of the Tarawera eruption Rotorua Township was being developed. The continuation of this development and upsurge of tourism to Whakarewarewa following the eruption meant that more interest was taken in the features and more inforination became available. Several detailed guidebooks appeared in the 20 years Following the eruption and an increasing interest in photography inspired a wide range of pictorials. Waimangu geyser also stimulated further interest in thermal activity.

The tourist interest and the spa development in the Rotorua area also prompted a desire to improve both the physical and bathing attractions of the area. Thus over this same 20 year period there were a number of modifications of various features carried out. These works took place in most chloride feature areas. Camille Malfroy, the Rotorua resident engineer, made quite significant changes on Geyser Flat. These mainly related to the redirection of discharge waters away from or into different features. By his work on the Indicator arid his sandbagging around Waikorohihi, he was able to induce *Pahutu* to play almost regularly twice a day. His works may also have induced the breakout of ttie Torpedo in the Puarenga stream below the Geyser Flat terrace. This feature was on the Te Puia Fault and remained active until about the middle of this century. Details of his work are given in his 1891 paper (Malfroy, 1891).

The modifications in ttie Waikite drear *in* themselves, probably had very little direct effect on any thermal activity. There stone walls were built across the path of the discharge waters flowing down the mound, the aim being to induce the formation of terraces similar to those that had been destroyed at Rotomahana. Although Waikite waters are reknowned for their silica depositions they clearly have not flowed enough since the construction to have achieved that aim.

In the remaining two areas, around the Maori Village and to the north of Roto-a-Tamaheke, the modifications were primarily to divert the waters to specific sites for bathing purposes - to the Oil bath in the Village drear and to the Spout Baths and the baths in the Government Gardens in the Roto-a-Tamaheke area. In the former area the diversions were mainly of surface waters in a zone where there were virtually no downstream features. The overall effects were thus probably not all that great. One large poolr a popular bathing pool in the centre of the open drear drained out some years ago. It is unlikely, howeverr that that drainage was induced by any particular local manipulations.

THe modifications and manipulations to the north of Roto-a-Tamaheke probably brought about more change in this area than all the works in all the other areas put together. The original spout bath was a waterfall between Roto- a-Tamaheke and a large pool by the Puarenga stream called Turikore. This pool was wiped from existence by the diversion of the water from the waterfall. Other features at the lower level would almost certainly have been also affected by the diversion of this water and of further discharge water to the downtown baths. The removal of water from this area ceased in *1963* when the water levels in and around Roto-a-Tamaheke collapsed. The collapse has been blamed on the withdrawal of water that was taking place at that time and certainly pumps were being used at the time of final collapse. Modriniak (1948), who actually observed the final drop, howeverr remarks on its suddenness and both he and Lloyd (1975) suggest a deep-seated, rather than a surface cause.

While, in general, most changes in features in the area are not well documented, we do have a reasonably clear picture of the changes in geyser activity that have taken place since Tarawera because of their prominence and interest to tourists. Wairoa's upsurge, for example, was relatively short-lived and soaping was well entrenched as the modus operandi for its eruptions even by the turn of the century. In spite of the introduction of a regulation that soaping could only be carried out "by government decree", even this additive ceased having any effect in a relatively short time. (There are, howeverr reports of one iiiinor natural eruption of this geyser in 1940 and of soaped eruptions in 1952 and late 1958/early 1959. There have been no responses to aoapings since that date).

Waikite, in contrast, kept up its more or less cyclic pattern of active and dormant periods for at least 80 years. It last played in March 1967, but as dormant periods of more than 10 years occurred in the past, we clearly cannot yet classify it as extinct. Vandals have not, however, helped its cause as its vent is no longer open. We have no clear

indication of the long term pattern of play of its immediate neighbour, Pareia. This geyser last played in January 1969 arid from December 1979 to April 1980. Rubble ha5 now also been dropped into its vent.

On Geyser Flatr Waikorohihi appears to have been the most consistent performer throughout the period. Its neighbour, Mahanga, has also played consistently for the past 20 or so years, although today at times it does appear to react to some degree to barometric changes. Lloyd (1975) comments on its starting up in 1961 after eruptively clearing its vents. The main geyser in this area, Pohutur has naturally attracted most attention and has thus been reported on and timed intermittently throughout the period. Malfroy (1891) had it erupting twice a day for a period, but this cycle was not maintained for many years. By the 1930s eruptions of Pohutu had become almost a rarity and at least one three year dormancy was noted. An upsurge in its activity has occurred since that time and over the past few years it has been performing better than at any time since first European observation.

Any changes in the behaviour of most of the above geysers appears to have been either intermittent or cyclic. However? information relating to the two other features on Geyser Flat (Te Horu and Kereru) and to the spouter Papakura on the bank of the Puarenga stream to the southwest of this group, suggests that changes in the behaviour of some of these features may be following a specific trend. Te Horu's massive eruptive discharges are, for exampler reported as continuing et least in to the early part of this century. By the 1960s these massive surges seem to have ceased. No overflows haver in fact, been observed since the late 1960s. Kereru appears to have followed a similar pattern of change. Early photographs and reports indicate it as playing, at least on occasions, to well above the level of the upper terrace. Such plays still occurred (unfortunately we have no measure of their regularity) as recently as 1974. Observations over the past few years suggest that major plays have only been observed twice since about 1980 (both observations this year - 1984). Papokura was not reported on prior to the Tarewera eruption (it is not marked on the 1885 survey map), but it does receive considerable attention in the post-Tarawera guide books. Around 1890 it was regularly referred to as the Giant's Cauldron. It was usually described as dangerous to approach and as playing up to 6-7m. Reports in the 1940s and *1950s* also remark on the height of its play (~5m). Over more recent times- well prior to its demise in 1979, a height estimate of about 2m would probably have been realistic. Even allowing for the quality of the observations it is difficult not to conclude that the decay here has occurred over some significant period of time.

Several other geysers have existed at various times in other parts of Whakarewarewa - along the Puarenga stream and in the Roto-a-Tanaheke area. Early guidebook maps, for example, rite one geyser in Roto-a-Tamaheke itself and Ororea (Spring 351) beside that lakelet has a history of geyser rctivity. The major changes in this area have unfortunately affected the activity on move than one occasion and hence detailed data about the behaviour of either of these geysers is not likely to provide us with useful information. Similarly geysers in the Puarenga stream are likely *to* be more *Inf* luericed by stream conditions than other outside factors.

Other changes that have occurned in Wtiakarewarewa over this period are much more difficult to trace. Certainly there have been several major events like the collapse of features around Roto-a-Tamaheke in 1942-3, the more recent (1982) collapse of Ororea and adjacent springs in that same area? and the demise of Papakura in 1978. Many Other reported events are, howeverr merely single events in the sequence that occurs in any active thermal area. Local eruptive events have occurred in Whaka rewa rewa throughout the lifetime of the field and we can only comment on change in this sequence if we can note a change in the frequency of activity. Public concern must stimulate increased awareness and we might thus expect observations ana reports to be higher now than a few years ago. External factors- like increasing vehicular traffic, could also stimulate additional events of this nature - many that have been reported over the past few years haver for exampler been along tracks or in other areas where traffic could have damaged the containing structure.

To seek out other trends the scientific survey of all thermal features in Whakerewarewa carried out under the supervision of E.F.Lloyd in 1969 was repeated earlier this year. The intercomparisons show the changes that have taken place over the most recent 15 year period. While there are no preceding scientific surveys of this nature to give us earlierr equivalent, information and hence enable us to establish possible longer term trends, many early guidebooks, photographs, and other records do give us information about spccific features or feature groups. Earlier land and tcpographic surveys also give us other pertinent information. Relevant surveys were carried out, for example, *by* E.G.Goldsmith in 1885 and by G.I.Martin in 1924.Aerial photographs of the area have been available since 1937.

In general terms relatively little change appears to have taken place in most acid feature areas in either the medium or the short term. Many recorded changes in such areas may, in fact, be related more to the weather cycle than to any thermal factor. Nonetheless, a few features near the southwestern margin of the field have virtually disappeared since the Lloyd survey and a few features to the southwest of Waikite now appear cooler. At the northeastern end of the field a cooling trend has also been noted. This ties in with a trend noted in the chloride features in that area.

The greater changes have taken place in the chloride feature areas. We have already commented on some of these, the changes in geyser activity. These changes, cover practically all that were met in the Geyser Flat and Waikite areas.

In the Maori Village area most comment relates to the two main chloride features - Parokotioru and Korotiotio. These have been attractions to visitors since the earliest of times. both have shown some change over the long term period. Although Parekohoru has erupted on the rare occasion, such activity is probably not significant here. What is relevant is that in the past it did have a significant discharge. Today that discharge is relatively small arid on at least two occasions it has ceased or virtually ceased altogether. Whether this change is recent or part of the long term trend is impossible to say. Korotiotio has never been as placid as Parekohoru. Sections of this multi-vent feature have always boiled vigorously arid it has been described as a geyser by writer.

Blowouts have also occurred on more than one occasions in the past. Its water level has, howeverr clearly dropped. Early photographs show the water lapping the top of the vents. Today it is well below the surface, the major fall of 0.7m in water level having occurred in November 1981.

The major changes over the total time period of this study have clearly taken place in the area around (to the north of) Roto-a-Tamaheke. As has been indicated, at least some of the changes must been brought about by man's activities in that area. Since the 1940s, howeverr direct interference has been very limited. Most springs appear to have recovered by the mid-1990s although subsidence that took place during the collapse has clearly altered the discharge pattern. Most of the discharges and flows now take place below the sinter crust. Between the 1969 and 1984 surveys significant cooling has taken place in features throughout this drear both chloride and acid, the mean temperature drop being of the order of 7 degC. There are also now no boiling springs along the northern and northeastern shores of Roto-a-Tamaheke, the last such springr Spring 354, ceasing boiling in July this year. Unfortunately no chemical data was collected from any features in this area during the 1969 survey and hence we cannot say whether or not dilution by cooler ground or rain water is the cause of this change.

On the longer term, this is by no means the only change in the area. We have already mentioned the loss of Turikore and the probable effect earlier works had on other features at this lower level. Historical maps and photographs also show a different form for the feature Rahopeke to the west of Roto-a-Tatnaheke. This was a small pool, a popular swimming hole in earlier times. Today it is a very large'pool connected to the end of Roto-a-Tamaheke and clearly too hot to swim in. Man made channels and dams in the area probably contributed to this changer as the opening and closing of these markedly affected water levels in Roto-a-Tamaheke.

CONCLUSION

Although at this stage a lot . more information still needs to be collected and assessed9 our general conclusion is that significant changes have taken place in most chloride feature areas in Uhakarewarewa over the past hundred years. Following a minor upsurge in activity of features along the Te Puia Fault immediately after the Tarawera eruption- the general trend would appear to be one that we might associate with a more or less general drop in water level (and hence discharge) throughout the area. On a long term historical basis this trend is in the direction that might be expected. Unfortunately, we do not yet have the information to be able to say whether the changes that we have noted are all very recent, or part of the long term pattern of change. It was hoped that differences noted in data from the two scientific surveys would help in this regard, but the main information to date from the analyses of this survey data relates primarily to the apparent cooling down of features in the Roto-a-Tamaheke area. The analyses are continuing and more information is currently being sought.

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It is impossible in a short paper of this nature to attempt to reference even a fraction of the information sources accessed, or even acknowledge the many people and groups who have assisted us in our search for information. We are nonetheless very grateful to all those people. We should likes however, to record our thanks to a few of the major groups who have helped over an extensive period - General Assembly Library, Alexander Turnbull Library (including the Manuscript and Photographic Sections), Rotorus Public Library, and the Lands and Survey Department (Aerial Photographic Section and Rotorua Office).

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