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THE WHANGAIROROHEA GEOTHERMAL FIELD

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SUMMARY - Whangairorohea is an important geothermal prospect situated between Ohaaki-Broadlands to the east and Ngatamariki to the west. It is characterised by a broadly shaped moderate resistivity anomaly, the presence of several hot springs, widespread sporadic silicification, and probably a hydrothermal eruption crater. Exploitation induced gravity changes at Ohaaki-Broadlands during the period 1967-1974 have propagated to within at least 1 km of the Whangairorohea springs suggesting that there is, indeed, a body of hot wafer underlying the area and which has been drawn upon as a result of pressure reduction at Ohaaki. There is a very strong likelihood that there is a significant, but as yet undetected, thermal flux from this system that enters directly into the Waikato River which bisects the prospect. The Whangairorohea system is presently poorly recognised and is in need of further investigation.

1. INTRODUCTION

The Whangairorohea springs are located about 25 km northeast of Taupo township at the confluence of the Waikato River and the Whangairorohea stream. They are situated between the Ohaaki-Broadlands power station about 5 km to the south-east, Ngatamariki hot springs about 7 km to the south-west, and Golden Springs 6 km to the north-east (Figure 1).

Two little-known hot springs occur at the location but there is almost no information published about it. There are, however, some areas with lower resistivity values in the vicinity that were measured as part of a regional resistivity survey. Although these values don't appear to have been low enough to have warranted further attention at the time, they do suggest the presence of some geothermal activity. There has also been a decrease in gravity values due to reservoir testing at Ohaaki, which appears to have extended at least as far as Whangairorohea, suggesting that there is indeed a body of hot fluid in the vicinity. Neither the low resistivity values nor the decrease in gravity appear to have been correlated with the presence of the thermal activity at Whangairorohea.

Based upon the direct and indirect evidence for the existence of a geothermal field at Whangairorohea further ground investigations were undertaken and it was found that there is considerable evidence of recent thermal activity in the area (Figure 2). Hot water seeps were located as well as numerous and widespread areas of silicification and rare silica sinter; some of the silicification is extensive and preserves a river terrace. A probable hydrothermal eruption crater and a small NE-SW trending fault scarp have also been identified.

2. PREVIOUS WORK

2.1 Thermal Features

No mention is made of hot springs in the vicinity of Whangairorohea in the Rotorua-Taupo regional survey of Grange (1937), and therefore the earliest reference appears to be the investigation of Gregg and Laing (1951), published in Gregg (1958). This consists of a heat flow estimate for the Whangairorohea stream and mention of the existence of two hot springs there.

The springs may also have been overlooked by early land surveyors. No mention is made of them by Stokes (1987) in an otherwise comprehensive compilation of the location of thermal features in the Taupo region based upon 1890's Department of Lands and Survey records.

The springs at Whangairorohea are marked in on several maps produced in the late 1950's and early 1960's (Modriniak and Studt 1959; Grindley 1960, 1961), however, all of these appear to make use of the original mapping of Gregg and Laing. Grindley (1965) referred collectively to Whangairorohea, Golden Springs, and Reporoa as the Reporoa basin geothermal fields.

More recent reference is limited to a listing in Mongillo and Clelland (1984), attributed to Healy, which gives temperatures of 42 and 56°C for two features. Bennie (1983), as a part of a preliminary investigation at Ngatamariki, also marked the locations of two hot springs at Whangairorohea, but again their locations appear to have come directly from Gregg and Laing and there is no mention that the site was visited.

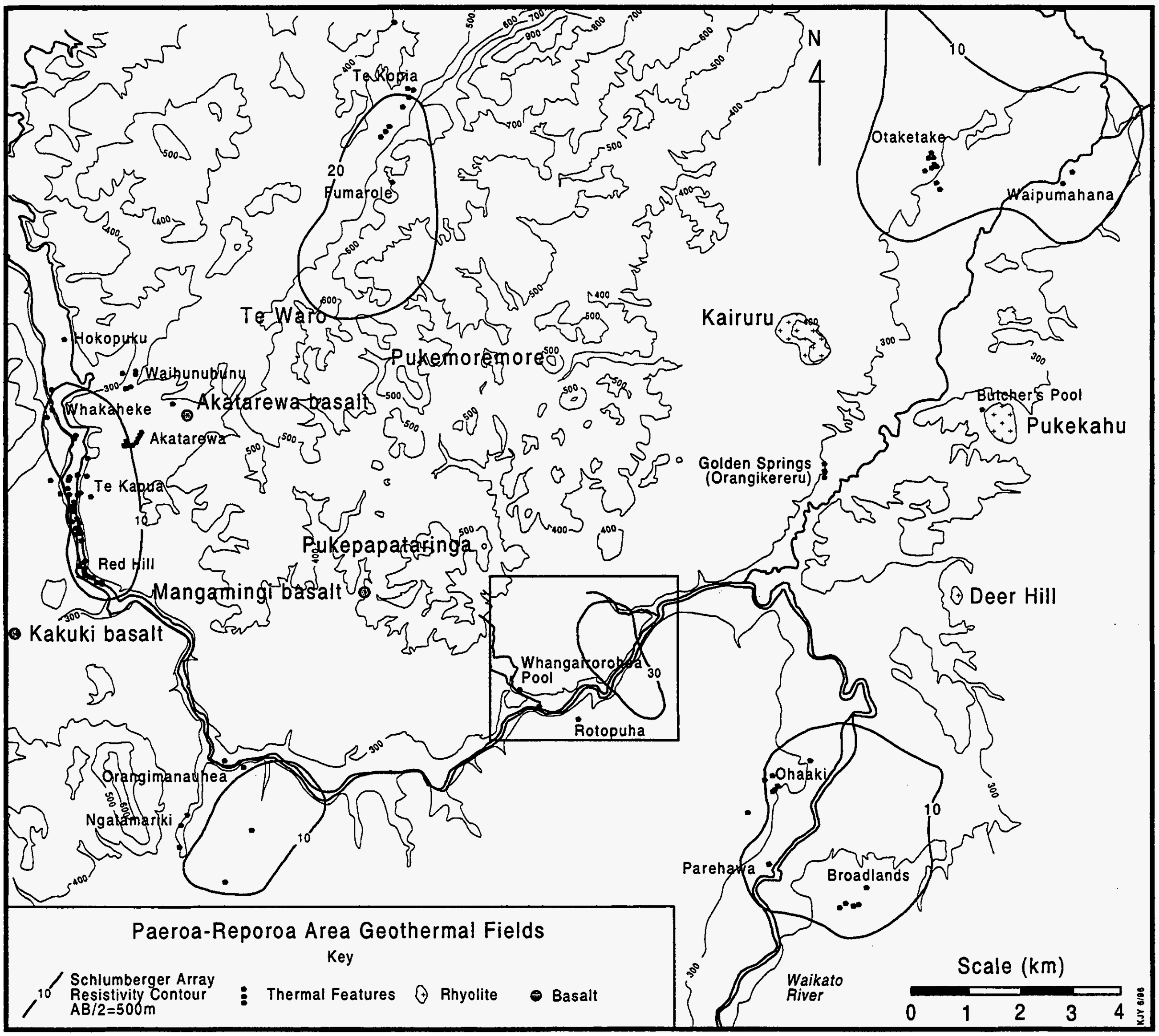

Figure 1. Map of geothermal fields within the Paeroa-Reporoa area. Schlumberger resistivity contours indicate the extent of each field, individual thermal features indicate areas of fluid upflow. The location of small basaltic cones and rhyolite domes also indicate zones where fracturing of the basement has occurred.

2.2 Electrical Resistivity Surveying

A small 30 ohm-m resistivity anomaly has been contoured at Whangairorohea (Figure 1) on the AB/2=500m regional resistivity survey (Geophysics Division 1985). Compared to the nearby fields of Ohaaki-Broadlands and Ngatamariki this anomaly is neither extensive nor is it particularly low, nevertheless, it is good evidence that there is hot fluid in the vicinity.

The individual data used for contouring in the regional survey are given in Bennie (1983) and these allow for further interpretation (Figure 2). . The 30 ohm-m contour on the regional survey encloses just one site on the southern side of the river (21 ohm-m) and two sites on the northern side (18 & 26 ohm-m), however, there are other values of a similar magnitude near Rotopuha (32 ohm-m) and at the Whangairorohea stream some distance inland (22 ohm-m). Therefore, it seems probable that the overall area of low resistivity could be considerably greater, perhaps by 2 or 3 times, than previously considered.

The survey on the northern side of the Waikato River rises to over 60m above the river level suggesting the possibility that some masking of low resistivity values by the overlying pumice might have occurred. Clearly a more detailed survey along the lower river terraces or a water-borne survey (Bennie and Stagpoole, 1985) along the river would provide considerably more information.

2 3 Gravity Surveying

Hunt (1984) presented evidence of gravity changes at Ohaaki-Broadlands for the period 1967-1974 when substantial reservoir testing without re-injection occurred at Ohaaki. The net result of this between 1967 and 1974 was that a negative gravity anomaly developed over the whole of the Ohaaki-Broadlands field and propagated westward outside the field towards

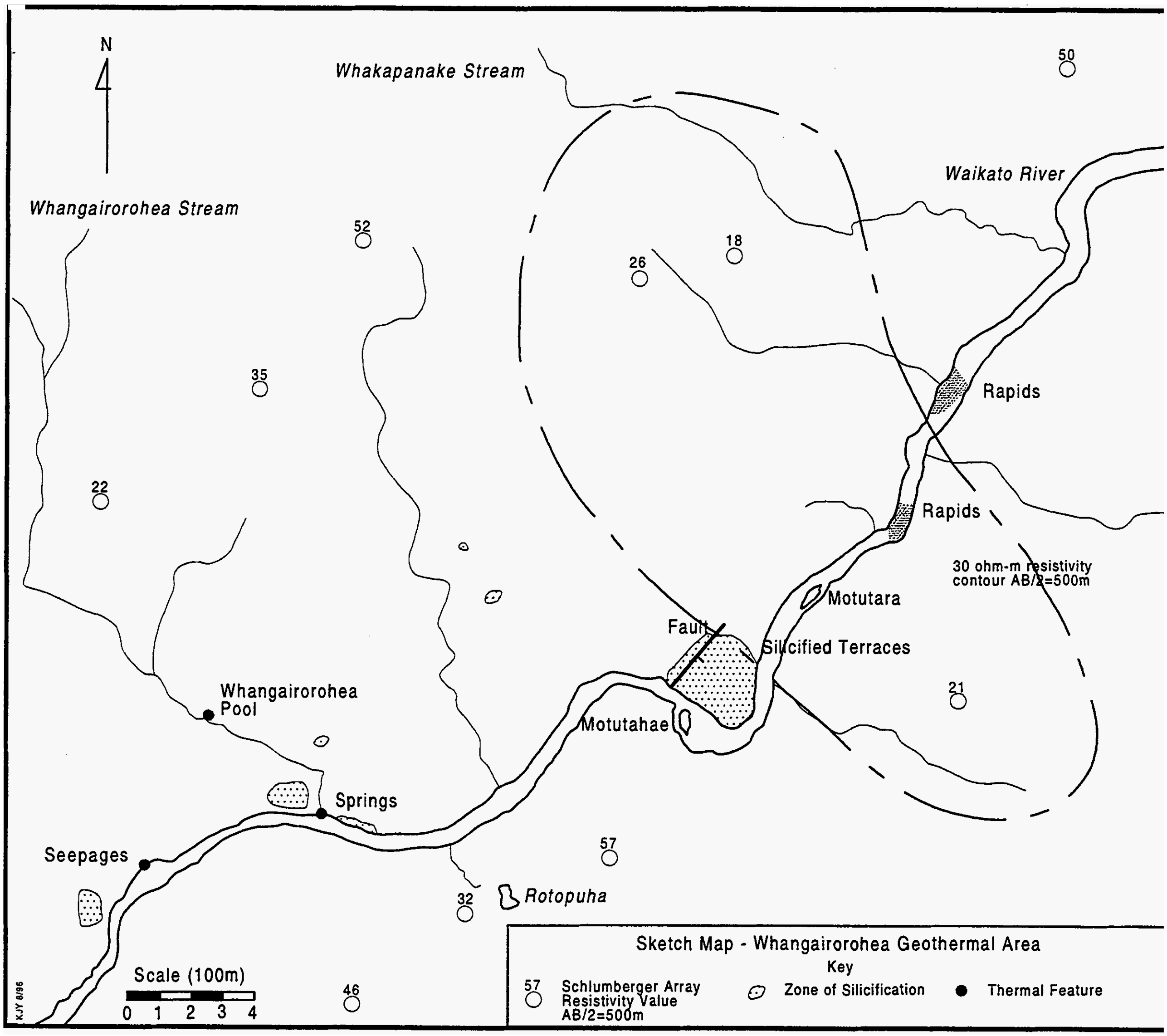

Figure 2. Sketch map of the Whangairorohea geothermal area drawn from May **1941** aerial photographs. Thermal features and silicification show the location of present and **past** thermal activity. The location of individual Schlumberger resistivity values indicates the presence of areas of low resistivity outside the present **30** ohm-m contour.

Whangairorohea. This anomaly extended at least to the westernmost gravity station surveyed, about **1** km distant from the Whangairorohea springs. The absence of further stations to the north and northwest precludes determining the true extent of this zone.

It seems most likely that fluid drawdown during testing of the Ohaaki section of the reservoir drew fluid from the east of Whangairorohea into the Ohaaki system leaving behind a saturated vapour zone. Hunt **(1984)** refrains from making such a suggestion, but having discounted the **only** other possibility, that of a variation in local groundwater level, leaves the whole question open.

At Wairakei and Tauhara (Allis and Hunt **1986),** changes in gravity attributed to fluid withdrawal at the Wairakei borefield have propagated out towards Tauhara over distances at least **as far as** those between Ohaaki and Whangairorohea. Therefore a similar process seems likely to have occurred.

3. RECENT INVESTIGATONS

3.1 Springs and Seeps

Three areas of hot wafer discharge are known at Whangairorohea at present (Figure 2). These are;

a) Springs at the mouth of the Whangairorohea stream

b) A large **10-15** m diameter pool on a terrace about **1** m distant from the edge of the bank of the Whangairorohea stream.

c) Several small, previously unrecorded, springs/seeps on the bank of the Waikato River about 500m down-river from the Whangairorohea stream mouth.

At the Whangairorohea stream mouth, the springs are located in the pumice stream bed; cold water flows over the top and masks their presence. Their areal extent is about **10 m**^{2} and measured temperatures range between

40 and 45°C at 10 to 20 cm depth within the pumice bed. There is a very weak gas ebullition, assumed to be CO_2, with no detectable H_2S odour.

Adjacent to the Whangairorohea stream, some 500 m up stream from the mouth and on the eastern bank, is a large 10 to 15 m diameter pool which occurs on a terrace 5 to 6 m above the level of the stream. The edge of the pool extends to less than 1 m from the lip of the terrace and a vertical drop to the stream below - very clearly this is a perched pool. The pool is assumed to be the site of a small steam eruption, no bottom is visible. No outflow from the pool has been observed, the temperature at the periphery is about 30°C and weak steam can be seen rising from the centre.

On the Waikato River about 600 m down-river from the Whangairorohea stream mouth there are a number of hot water seeps along a 10-20 m strip of the river bank and located at river level. Temperatures here are a little higher than at the Whangairorohea stream mouth with a maximum of about 53°C at 20 cm depth. Unfortunately it is impossible to tell at present how much fluid might also be entering the Waikato River through the river bed itself'. It would be very surprising if these river level seeps were the sum total of the fluid flux that is entering the river. Moreover, the river bank is embayed by 10-15 m here (Figure 2) and this suggests that the hot seeps are destabilising the river bank in periods of high river flow.

The presence of hot springs on the southern bank of the Waikato River has not yet been investigated although Grindley (1961) indicates that there is one opposite the mouth of the Whangairorohea stream. The filling of Lake Ohakuri in 1961 also needs to be taken into consideration as the subsequent backing-up of the Waikato River flooded several hot springs at Ohaaki (Stokes 1987) and therefore it is very likely that the pre-1961 springs at Whangairorohea may also be covered and now feed directly into the river bed.

3.2 Rotopuha

A pond, called Rotopuha, occurs in the Tahorakuri forest on the south side of the Waikato River. It is about 75 m long by 40 m wide and occurs close to the Waikato River, but at least 20 to 25 m above river level in pumice breccia of the Orakonui plateau (Lloyd 1972). Although some swampy areas exist nearby, the pool is conspicuous as the only free standing body of water on the entire plateau. The inference is that this is hydrothermal eruption crater, either collecting rain or with a bottom feed. The feature is pinched in the centre suggesting that it could also be two eruption craters that have coalesced.

There is an outflow from this feature - it has no visible inflow - which appears to seep through the northern wall and then into a short stream that falls into the Waikato River. Swamp vegetation grows around the edge of the feature but, for the most part, the pond is free stranding water and this suggests that it is deep.

3.3 Sinter Mounds and Silicified Terraces

Silicification and, more rarely, sinters occur at Whangairorohea over a large area (Figure 2) and are all previously unrecorded. The areas can be subdivided into four groups;

a) Silicification and isolated sinter occur sporadically for 150 to 200 m along the northern bank of the Waikato River on both sides of the Whangairorohea stream mouth.

b) Silicification/sinter mounds occur on the northern bank of the Waikato River, 700 to 800 m down river from the Whangairorohea stream mouth, near the site of the hot water seepages.

c) Two isolated sites of silicification occur on the sides of inland gully heads NE of Whangairorohea stream

d) An area of extensive silicification occupies and probably preserves river terraces in a bend in the Waikato River about 1200 m upriver from the mouth of the Whangairorohea stream

The silicification, for the most part, appears to be cemented pumice and probably formed from springs of sub-boiling temperature. Where exposed as scarps between terraces the silicification looks very much like indurated pumice breccia that occurs on higher ground to the north and north-west.

Along the Waikato River bank, directly west of the Whangairorohea stream and also in the vicinity of the Waikato River seepages, there are large silicified apron blocks that form part of large silicified mounds that have slumped and are obviously hydrothermal in origin. Several of these silicified mounds reach 5-8m above the surrounding river terrace and are 30-40 m in diameter.

Directly east of the Whangairorohea stream mouth the sinters have been bulldozed and there are pieces of milky-white sinter along the river bank suggesting earlier boiling springs there.

At the heads of two gullies inland and NE of Whangairorohea stream is further evidence of silicification. These outcrops appear isolated, however, they are aligned in a NE-SW trend with the silicification at the Waikato River seepages and the silicification in the vicinity of the Whangairorohea stream. Therefore, it seems that the location of past thermal activity in the area has been determined by structural controls

The silicified river terraces about 1200 m upriver from the Whangairorohea stream occupy a large area on two or three levels with possible water-flow structures preserved in the surface and indicating flow towards the present river. Individual levels are separated by 2 scarps, the upper-most scarp appears in air-photos to be a fault and has maybe 2-3 m of vertical displacement on it. The lower scarp is less distinct. The upper scarp projects on a NE-SW strike to Rotopuha (Figure 2), lending credibility to a hydrothermal origin for that feature. An extensive search in the river bed on the northern side of the river, and adjacent to the terraces, failed to detect any areas of anomalous heat flow down to 10-20 cm in the river bed

The 1941 aerial photographs show two sets of rapids in the pre-dammed river about 700 and 1000m above the silicified terraces, these indicate a feature that is quite resistant, such as an andesitic dyke, a rhyolite, or silicification. Of these, silicification seems the most likely although an andesitic dyke to known to cross the Waikato River nearby at Ngatamariki (Parekauau Andesite, Lloyd 1972).

Thus at Whangairorohea, in addition to the two previously recorded hot springs, a further area of hot water seepage has been found There are also a number of sinter mounds and an area of extensive silicification. The fluid flux here was much greater in the recent past (post Taupo eruption) and may still be quite substantial. It seems almost certain that some of the present fluid is entering the Waikato River undetected through the river bed.

Rotopuha is probably a hydrothermal eruption crater; it lies on a NE-SW trend fiom a fault scarp that passes through, and vertically offsets, the area of most extensive silicification. In addition, there are two sets of rapids in the river that also suggest that there may be silicification there. The natural manifestations of past and present thermal activity cover several kilometres of the river bank and up to 500-600 m inland.

4. DISCUSSION AND CONCLUSIONS

There are 3 independent lines of evidence for geothermal activity at Whangairorohea:

a) The presence of an extensive, but poorly traversed, low resistivity zone.

b) A nearby negative gravity anomaly associated with 1967-1974 reservoir testing at Ohaaki-Broadlands.

c) The presence of at least 3 areas of hot spring activity, widespread silica mounds, silicification, and probably a hydrothermal eruption crater.

The thermal manifestations at Whangairorohea appear to fall into two distinct zones along a NE-SW trend. These are;

a) Whangairorohea pool, Waikato River springs/seeps, associated silicification, and gully head silicification.

b) Rotopuha, the silicified terraces, and fault scrap.

It seems most likely, therefore, that thermal activity at Whangairorohea occurs in a number of distinct and structurally controlled upflow zones. Given the low resistivity values to the north-west it is possible that more than two zones exist.

Healy and Hochstein (1973) suggested that Reporoa is an outflow of Waiotapu, and the proximity of Whangairorohea to Ohaaki prompts similar comparisons. However, the regional geology and the fact that the springs at both places occur at the same elevation (320 m) preclude this.

The most important feature of the regional geology is the fault trend. The strike of the western fault bound margin of the Paeroa range defines the regional fault trend in the Paeroa-Reporoa area and is approximately NE-SW in direction. The effect of this can be seen in the alignment of local thermal features along the trend at Te Kopia, and Akatarewa at Orakeikorako (Lloyd 1972) on the western side of the fault block (Figure 1).

In the Reporoa basin at Ohaaki the thermal features (Mahon and Finlayson 1972) and heated ground (Allis and Weber 1984) are aligned along the NE-SW trend. At Ngatamariki, the Ngatamariki and Orangimanauhea springs are aligned along the NE-SW trend; in addition, at Ngatamariki, the 30 ohm-m resistivity contour shows a tongue of lower resistivity trending NE towards the Mangamingi valley. At Reporoa (Grange 1937) the Waipumahana springs are aligned along the NE-SW trend.

In addition to spring alignments there are a number of basalt cones and rhyolite domes in the area (Houghton et al., 1987; Healy et al., 1964). Basalts are an important indicator of basement fiacture as they are small, localised, and originate at the mantle boundary One occurs at Mangamingi about 4 km NE of Ngatamariki, and two others occur at Orakeikorako. The rhyolite dome of Deer Hill is about 4 km NE of the Ohaaki springs and the dome at Kairuru is 4 km SW of the Otaketake springs at Reporoa. These occurrences suggest underlying NE-SW basement fiactures.

At Whangairorohea, Rotopuha and the silicified river terrace project NE towards Golden Springs and indeed onto Waipumahana at Reporoa. It seems most likely, therefore, that Whangairorohea represents a separate geothermal field situated along the trend of the Reporoa basin with at least two NE-SW aligned zones of upflow. Whangairorohea geothermal field is indeed as Grindley first referred to it, a member of the Reporoa basin geothermal fields.

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