THREE DIMENSIONAL CONCEPTUAL MODEL OF ORAKEIKORAKO AND TE KOPIA GEOTHERMAL SYSTEMS, TAUPO VOLCANIC ZONE, NEW ZEALAND

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ABSTRACT

Orakeikorako and Te Kopia are two geothermal fields of the Taupo Volcanic Zone located 5 km apart along active NE trending rift faults. While it is acknowledged that the geothermal activity at Orakeikorako and Te Kopia are closely related with the active faults, the connection between the two fields is not well understood and it is possible that these two fields were once a single larger geothermal system. The purpose of this paper is to better define and visualise the subsurface geological settings and structural framework of the Orakeikorako and Te Kopia area.

A three dimensional geological model of these two geothermal fields has been developed using Leapfrog Geothermal. The model is built from continuous log data from six exploratory wells from Te Kopia and Orakeikorako, constrained at surface by the 1:250,000 regional geological map, and complemented by recent mapping in the Paeroa Block area. The 3-D geological model is subdivided in six stratigraphic layers (metasedimentary basement, Reporoa Group, Whakamaru Group, Huka Group, Maroa Group and surficial deposits), and basaltic and rhyolitic intrusions. The displacement in the Te Kopia area by the Paeroa fault and its subordinate faults produces a relay ramp that dips northeast. In the Orakeikorako area, the displacement by the Matangiwaikato and East Wainui faults also produce a relay ramp that dips southwest.

Complementary to the stratigraphic model, a clay alteration model and a temperature model are presented as part of this paper. Clay alteration ranges from smectite through smectite-illite, to illite. The comparison of alteration and formation temperatures seems to indicate cooling in the Orakeikorako and Te Kopia geothermal fields that may be due to groundwater incursions along the active faults.

1. INTRODUCTION

The Orakeikorako and Te Kopia geothermal systems are two of >20 geothermal systems located in the Taupo Volcanic Zone (Bibby et al., 1995). Orakeikorako is situated about 30 km northeast of Lake Taupo and Te Kopia is located about 10 km northeast of Orakeikorako, along the Paeroa Fault (Figure 1).

In 1965, four exploratory wells were drilled in Orakeikorako to a maximum depth of c. 1400 meters and two exploratory wells were drilled in Te Kopia to assess the field's potential for electricity generation. Geological mapping in Orakeikorako and Te Kopia was first conducted by Grindley (1959) and Lloyd (1972), then modified by Wilson et al. (1984). The subsurface geology was described by Grindley (1965), Steiner (1977) and Bignall (1991; 1994).

Orakeikorako and Te Kopia geothermal fields are now classified as protected geothermal systems by the Waikato Regional Council and both are famous touristic destinations. Since any exploration activity is prohibited in that area, there is only limited subsurface geological data available.

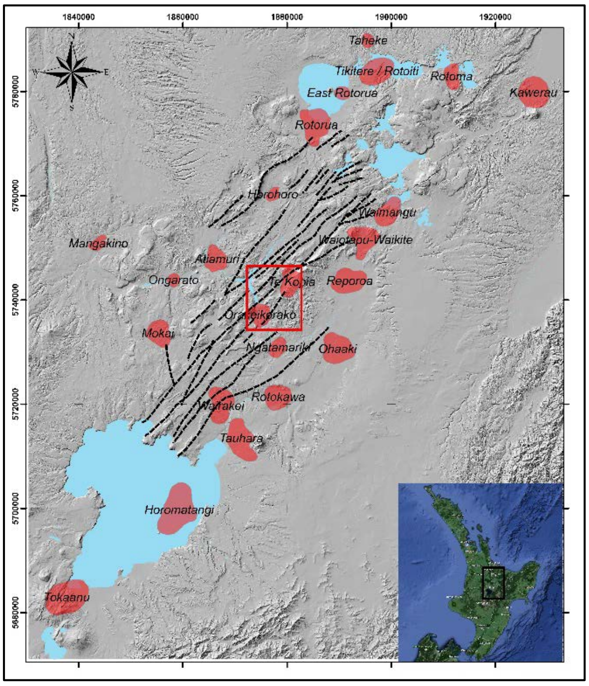

Figure 1: Map showing the location of Orakeikorako and Te Kopia geothermal systems.

A three-dimensional (3D) conceptual model of Orakeikorako and Te Kopia geothermal systems can assist in understanding their geological setting and subsurface condition. Our approach is to combine detailed geologic mapping (Leonard et al., 2010; Downs et al., 2014) with subsurface geology data (e.g. lithology, alteration) and temperature data from six exploratory wells (Bignall, 1994), and structural data from GNS's Active Fault Database (Jongens and Dellow, 2003), so that all available geologic data are incorporated into a 3D conceptual model.

Stratigraphic Key		Model Stratigraphy		Age	Rock Type and Description
	Surficial Deposits		Surficial Deposits	≤ 25.4 ka ± 0.2 ka	Consists of unwelded Oruanui and Taupo Pumice Alluvium, with some deposits of lake sediments and fall deposits (Manville, 2001; Wilson, 2001)
Basalt Lavas - lavas with High -alumina content (Wilson et al., 1995); Rhyolite lavas - Crystal-poor, flow banded to perlitic textured (Wilson et al., 1985)	Hydrothermal Breccia	Basalt Lavas	Huka Group	Unknown	Multicolored hydrothermal eruption breccia with clast-supported texture and sparse sinter & ignimbrite clast. Mainly silificied with scrystal-poor and sparse matrix (Downs et al., 20014)
	Hinuera Formation			≤ 20 ka ± 0.5 ka	Consists of laminated, commonly current-bedded rhyolitic sand and gravels, quartz and feldspar crystals, fragments of ash and pumice, lava fragments which overlain by recent volcanic ash. Hinuera Formation overlies disconformably on Kakuki Breccia, Orakeikorako Tuff and Umukuri Block (Lloyd, 1972; Manville & Wilson 2004, Leonard et al., 2010)
	Akatarewa Basalt Formation			30 - 45 ka	Consists of phreoatomagmatic and scoria beds which lies between the rhyolite fall deposits (Lloyd, 1990; Leonard et al., 2010)
	Umukuri Dome		Maroa Group	189 ka	Dome shaped rhyolite, consist of plagioclase-orthopyroxene±quartz±hornblende rhyolite lava domes and carapace breccia (Leonard, 2003)
	Orakonui Formation			256 ± 12 ka	consists of soft, nonwelded to slightly sintered ignimbrite. The upper sheet lays a soft, grey coloured ignimbrite, quartz-rich, containing minor pumice and rhyolite inclusions. (Grindley, 1961; Lloyd, 1972; and Leonard et al., 2010)
	Kakuki Formation			Unknown	Has characteristic of fine grained and contains olivine and accessory of plagioclase microphenocrysts (Wilson et al., 1986)
	Huka Falls Formation			330 ka	Consists of siltstones, mudstones and sandstones which derived from silicic volcanic rocks and deposited in shallow lacustrine environment. The HFF has appeared to thicken to the southeast which overly and cap the Waiora Formation.
	Paeroa Subgroup (Paeroa, Te Weta, Te Kopia Ignimbrites)	Rhyolite	Whakamaru Group	339 ± 5 ka	Rhyolitic ignimbrite groups, crystal-rich (plagioclase, quartz, biotite, pyroxene and hornblende), with range of pumice contain. Variably welded with poor to rich of lithich (obsidian, rhyolite, ignimbrites and andesite lavas; Hedenquist, 1986; Keall, 1988; Brown et
	Akatarewa Ignimbrite		Reporoa Group	950 ± 50 ka	Rhyolitic type ignimbrite with characteristic of green coloured, coarse grained with lenticular texture, crystal-rich, (Bignall, 1994; Wilson et al., 2010)
	Mesozoic Metasedimentary Basement		Mesozoic Metasedimentary Basement	Late Jurassic	Quartzofeldspathic sedimentary rocks, massive, fine grained, consists of minor component of interbedded mudstone (Wood et al., 2001; Leonard et al., 2010)

Figure 2: Stratigraphy of the Te Kopia – Orakeikorako geothermal systems. (Modified from Lloyd, 1972; Bignall, 1994; Downs et al, 2014)

2. GEOLOGICAL SETTING

The Orakeikorako and Te Kopia system are located on the western margin of the Taupo Reporoa Belt (TRB). The geology of the geothermal systems is mainly characterised by volcaniclastic deposits, rhyolite / andesite and rare basaltic products with their reworked equivalents (fluvial sediments).

The main geological feature in this area is the uplifted Paeroa fault block which exposed the 339 ± 5ka Paeroa Subgroup (Downs et al., 2014). It is uplifted and tilted ~7° eastward, rising up to 500 m and extend over 25 km along strike as a result of the slip on the westward facing Paeroa Fault (Berryman, 2008). The northern Paeroa block was uplifted and tilted to the southeast which is the result of a combination of primary depositional feature of an ignimbrite fan (Downs et al., 2014), tectonic tilting (Berryman et al., 2008), and a structural resurgence related to the Paeroa Subgroup magmatic system (Healy, 1964).

Hydrothermal and surface manifestations at Orakeikorako are spread over 1.8 km^2. The surface manifestations consist of hot pools, springs, hydrothermal eruption craters, geysers, silica sinter deposits and acid alteration zones. At Te Kopia, the surface manifestations are dominated by steam discharge and patches of altered ground along the base of the scarp for over 2.5 km and several large active fumaroles on the footwall. In some areas occur shallow steam-heated ponds filled with dilute sulphuric acid, derived from rainwater and steam condensate (Sheppard and Klyen, 1992; Martin, et al., 2000).

The surface hydrothermal activity at Orakeikorako and Te Kopia is closely related with the NE-SW trending normal faults that bifurcate from the main Paeroa Fault. The Paeroa Fault is an active normal fault, downthrown to the northwest, with a fault scarp of up to 550 m that gives a clear geomorphic expression (Grindley et al., 1994). The northern and southern boundary of the Orakeikorako geothermal system are delimited respectively by the Whakeheke Fault and Matangiwaikato Fault, which are splaying from the Paeroa Fault. Surface hydrothermal activity at Orakeikorako also occur on these subordinates and bounding faults (Lloyd, 1972). Bignall (1994) reports that the well preserved surface displacement by the silica sinter in Orakeikorako clearly show the intimate association between the faults and hot springs which occur at the foot wall of the fault plane.

3. CONSTRUCTION OF THE 3D MODEL

3.1 Input data

The 3D conceptual model of the Orakeikorako and Te Kopia geothermal systems is constructed from various sources of information:

- Topographic data (Digital Terrain Model from LINZ, 2013);
- QMAP Rotorua 1:250,000 geological map (Leonard et al., 2010) with the accompanying interpreted geological cross section;
- Recent mapping in the Paeroa Block area (Downs et al., 2014);
- Subsurface geological data from exploratory wells (Bignall, 1994) includes lithology, clay alteration, fault zone, and measured well temperature;
- GNS Science's Active Faults Database (Jongens and Dellow, 2003)

The geological map of Rotorua (Leonard et al., 2010) and recent mapping in the Paeroa Block area (Downs et al., 2014) have been used to set the lithological contacts at surface (from geological map) and subsurface (from geological cross-section). These maps include lithological units boundaries, faults, and caldera boundaries. The relevant data have been incorporated into the 3D conceptual model to be used to constrain the base of the model.

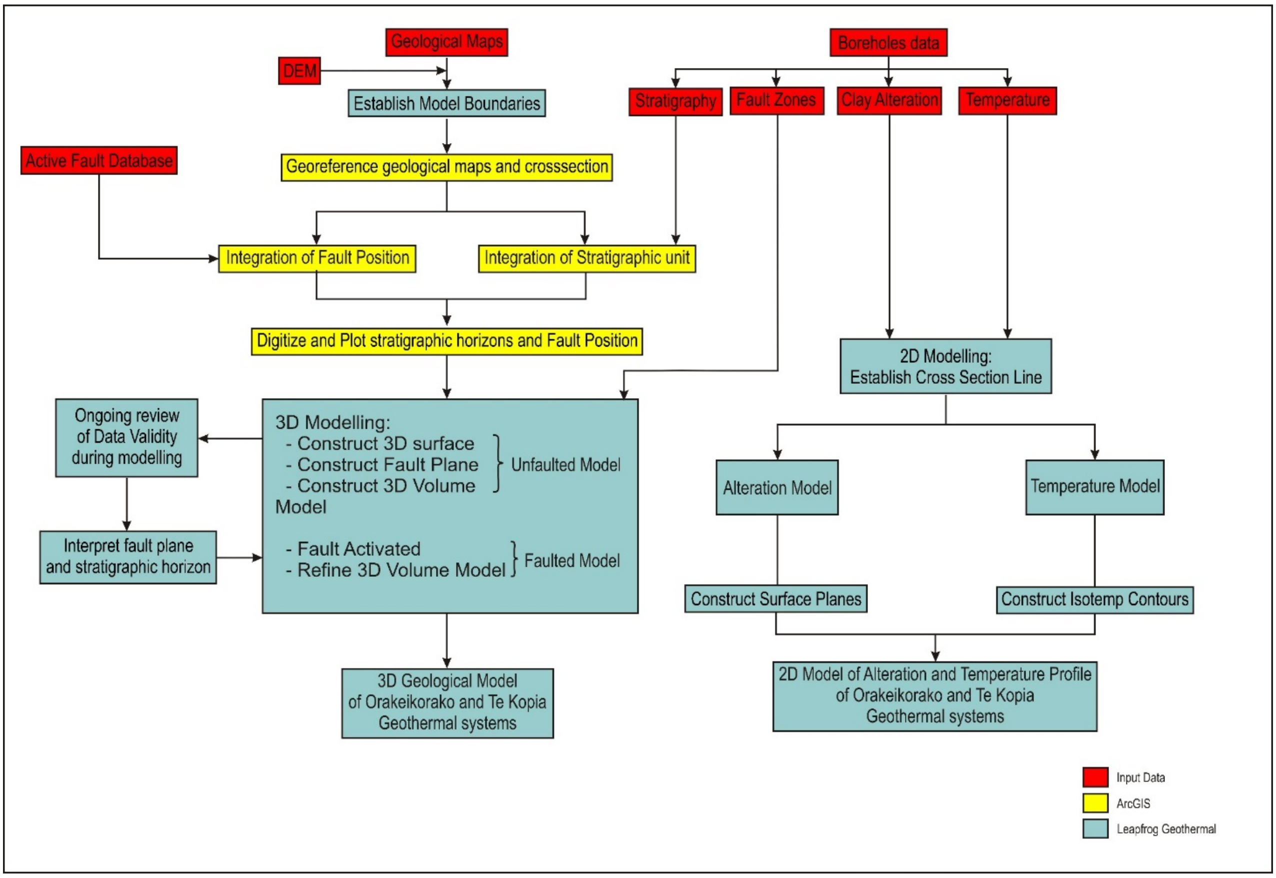

Figure 3: Flow chart detailing data input and work flow to build a 3D Geological Model and 2D Alteration and Temperature Models of Orakeikorako and Te Kopia geothermal systems.

Borehole data from six exploratory wells at Orakeikorako and Te Kopia geothermal systems were used to constrain the distribution of lithological units at depth and likely fault location beneath the system.

Clay alteration and well temperature data from boreholes were also used to build 2D profiles of alteration and temperature. The GNS Active Faults Database (Jongens and Dellow, 2003) was used to complement the geological maps (e.g. Leonard et al., 2010; Downs et al., 2014). The database contains detailed information such as strike, dip, slip rate and date of last movement. It was used as the main source in the selection of key faults to be integrated into the model.

3.2 Building the 3D conceptual model

3.2.1 Geological model

The process of developing the 3D model is shown in Figure 3, but it can be simplified into four steps; a) data preparation and data import, b) boundary definition, c) creating a contact surface for each stratigraphic and alteration unit, and creating fault surfaces (e.g. stratigraphic boundaries and faults location), and d) creating 3D geological volumes and 2D profiles of alteration and temperature of the Orakeikorako and Te Kopia geothermal systems.

The boundary of the model is established based on the density of available data in the study area, where the extrapolation is at a minimum. The location of borehole data is the main consideration beside the presence of surface geology data and interpreted geology cross-section. Based on the available data, the geological model covers 3.8 km in depth and 9.4 km x 10.6 km at the surface.

Once the boundary of the model has been defined, the next step is to create 3D volumes, each representing a category (e.g. stratigraphic horizon, clay zone). In this project, we are using 3D modelling software Leapfrog Geothermal to construct a representative 3D model of the subsurface of Orakeikorkao-Te Kopia area. Continuous log data from six boreholes (Bignall, 1994) are used as the main input to build contact surfaces that are then constrained at surface by surface geological maps (Leonard et al., 2010; Downs, 2014). The continuity of the geological formations at depth are controlled by the exploratory wells, interpreted geological cross sections (Leonard et al., 2010; Downs et al., 2014a, 2014b) and the faults in the area which are derived from the active fault database (Jongens and Dellow, 2003).

For the modelling purposes, the stratigraphy of the area has been simplified into 8 units (Figure 2). The unfaulted geological model is built from contact surfaces between each unit interval. Each surface represents a geological process (e.g. deposition, erosion or intrusion). Once the chronology between each contact surface is established, each computed volumes represents a geological formation.

The fault planes are combined into the model to form a fault network based on the relative faults relationships and faults chronology. When activated, the fault network subdivides the modelled area in faulted blocks. Leapfrog Geothermal automatically combines the stratigraphic model and the fault network to generate a complex geological model. Refinement of the contact surfaces where factual data is scarce is necessary to build a geologically reasonable model.

3.2.2 Alteration model

The alteration model was developed based on the clay alteration data from the boreholes (Bignall, 1994). The alteration was modelled by separating the Orakeikorako and Te Kopia geothermal systems, one for each geothermal system, to acknowledge possible limitations due to the distribution of the drill holes along an alignment. The models of clay alteration and temperature profile were rendered as 2D cross-sections while the geological model was rendered in 3D model. The clay alteration data were divided into three categories; a) smectite alteration; b) interlayered illite – smectite alteration; c) illite alteration. The volumes were generated after contact surfaces between each alteration zone were processed and displayed.

3.2.3 Temperature model

The temperature model was developed from downhole temperature profiles from the six boreholes (Bignall, 1994). The temperature data are numeric values that were used to build an interpolant model. Isosurfaces are computed for a series of selected temperature values and displayed. As per the alteration model, the temperature models were built as separate individual models, one for each geothermal system. The extent of the temperature model is the same as the alteration model.

4. RESULTS

4.1 3D geological model

The 3D geological model of Orakeikorako and Te Kopia covers an area of 9.4 km x 10.6 km to a depth of 3.8 km. The geological model consist of six stratigraphic layers (metasedimentary basement, Reporoa group, Whakamaru group, Huka Group, Maroa Group, and surficial deposits) and two intrusions, one basaltic and the other rhyolitic, as inferred from descriptions of continuous core from six drill holes (Bignall, 1994) and geological cross sections (Leonard et al., 2010; Downs et al., 2014). The Huka group is modelled dipping to the southeast about 7˚ (Berryman et al., 2008). The metasedimentary basement, Reporoa group, Whakamaru group, Maroa group and surficial deposits were modelled according to the available cross sections and borehole data, while the rhyolitic and basaltic intrusions were interpreted as bodies with sub-vertical contacts (Downs et al., 2014; Figure 4).

The geological model is partitioned into 13 blocks by 12 faults (Figure 4; Table 1). The faults are all normal faults with various strikes and dip directions (Table 1). The fault network affects the architecture of the subsurface stratigraphy. Grabens and horsts form where adjacent normal faults have a different dip direction (northwest and southeast series). Fault blocks 5, 8 and 11 are grabens which formed from two normal faults dipping away from each other (Figure 4).

The top surface of metasedimentary basement is modelled based on the interpreted cross-section from Leonard et al. (2010) while the bottom of metasedimentary basement is not modelled and beyond the base of the model. The shallowest depth of metasedimentary basement is identified in fault block 11 at about 1800 m below surface. The shallowest depth of the overlying Reporoa Group is similarly within fault block 11 (North of TK-2), whereas the deepest upper contact of the Reporoa Group is identified on the southwest part of fault block 12 (south of Orakeikorako), which is mainly controlled by two normal faults dipping to the southeast (Figure 4).

Table 1: Properties of faults in the 3D model of Orakeikorako and Te Kopia Geothermal System.

Symbol	Fault Name	Strike	Dip	Dip Direction
A	Whirinaki	NE - SW	60°	NW
B	Puketarata-Whirinaki	NE – SW	60°	NW
C	Puketarata 3	NE – SW	75°	NW
D	Puketarata	NE – SW	75°	NW
E	Puketarata 2	NE – SW	75° - 80°	SE
F	Paeroa-Orakeikorako	NE – SW	75° - 80°	NW
G	Paeroa	NE – SW	80°	NW
H	Paeroa 2	NE – SW	80-83°	NW
I	East Wainui	NE – SW	80°	SE
J	Matangiwaikato	NE – SW	80°	SE
K	Orakonui	NE – SW	75°	SE
L	East Paeroa	NW – SE	85°	SW

The Whakamaru Group is exposed to the surface in two places, the first one to the west of Te Kopia, (fault block 11, northern part of fault block 5 & 8, and southern part of fault block 7) and the second one in the northern part of fault block 3 (Figure 4). West of Te Kopia (fault block 8) the Whakamaru Group is forming a graben which is controlled by northeast-striking faults (Figure 4).

The most widely distributed lithologies at surface belong to the Huka Group which deposited after the Whakamaru Group. The Huka Group filled all the downthrown blocks created by the fault framework. The thickness of Huka Group in the southern part of fault block 12 is more than 850 m (Figure 4).

The surficial deposits were modelled near the Paeroa fault and near Lake Ohakuri with thicknesses of less than 5 meters due to the minor fall deposits and lacustrine sediments (Manville and Wilson, 2004).

The intrusions in the model were divided into two types of lithologies; rhyolite and basalt. The rhyolite intrusion did not reach the surface and has been classified as a sill, which may have been fed by the intrusion of magma along the fault plane, whereas the basalt formed as a dike and is exposed at the surface (Downs et al., 2014).

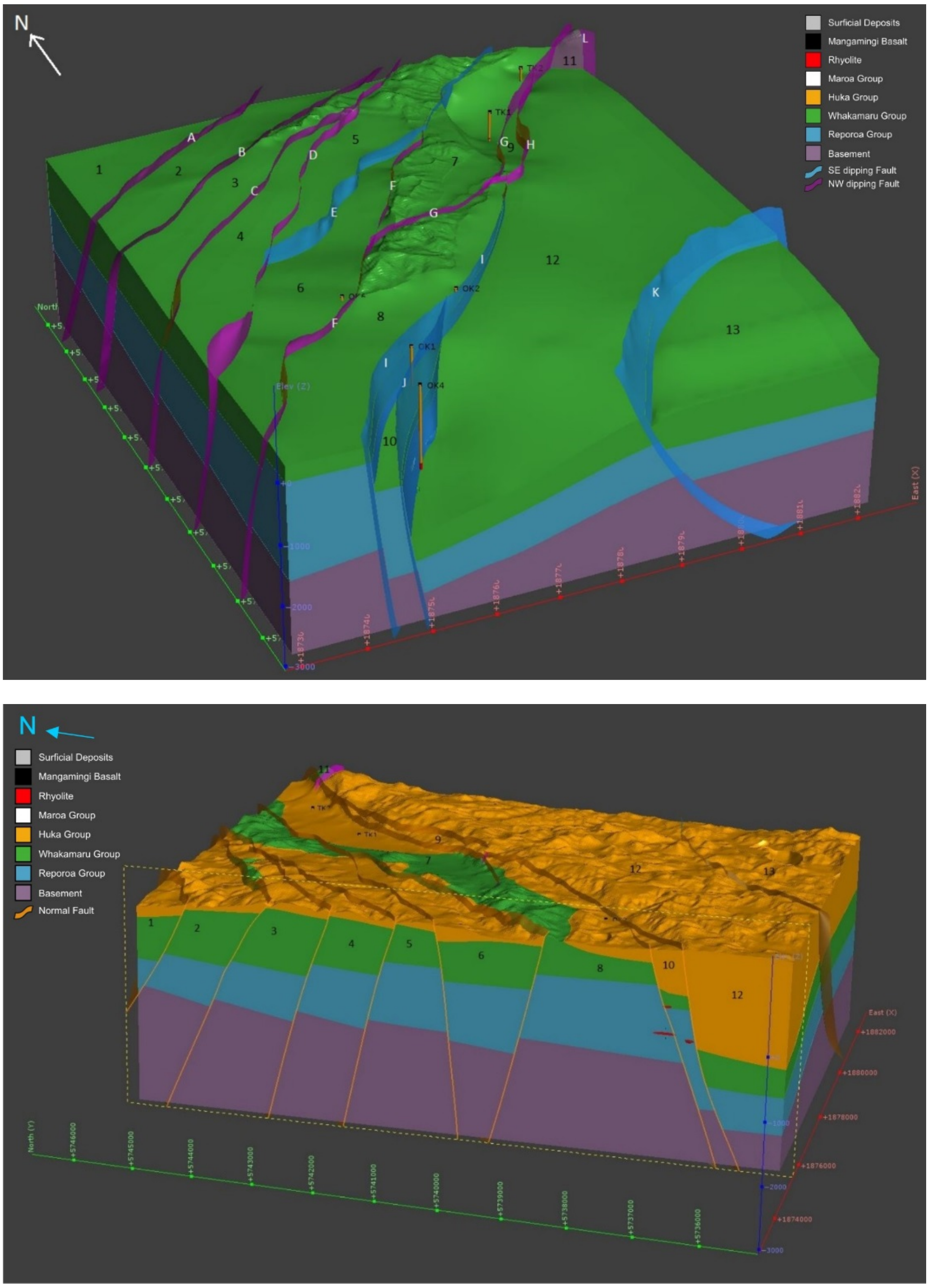

Figure 4: 3D geological model of the Orakeikorako and Te Kopia geothermal systems. Upper: the model is partitioned into 13 fault blocks by the action of 12 faults. Numbers represent the fault block; letter represents the faults as listed in table 1. Bottom: N-S sliced view of the model. Numbers represent the fault blocks.

The displacement between two parallel faults (Paeroa and Paeroa-2 faults) that strike NE-SW in the Te Kopia area produces a relay ramp represented by fault block 9 (Figure 5). The relay ramp dips to the northeast, parallel to the fault. On the west side of the relay ramp, an asymmetrical half-graben formed in the northern part of fault block 7 (Figure 5). In Orakeikorako, the junction of sub-parallel Matangiwaikato Fault and Wainui Fault produce a ramp that dips to the southwest (south western part of fault block 12, Figure 5).

4.2 2D clay alteration model

The hydrothermal alteration zones in Orakeikorako and Te Kopia geothermal systems were identified from continuous cores from six drill holes. The distribution of hydrothermal alteration has a correlation with depth and temperature. The alteration is divided into three clay zones: Smectite, Interstratified Illite – Smectite, and Illite.

The first clay zone encountered by the boreholes is smectite alteration. This type of alteration occurred at different depths in the study area. In the southern part, smectite was found down to ~125 m depth in well OK-4, and deepen to the north (Figure 6). In the northern-most well, TK-2, the smectite alteration occur down to ~625 m depth, which overprinted the illite alteration (Figure 6).

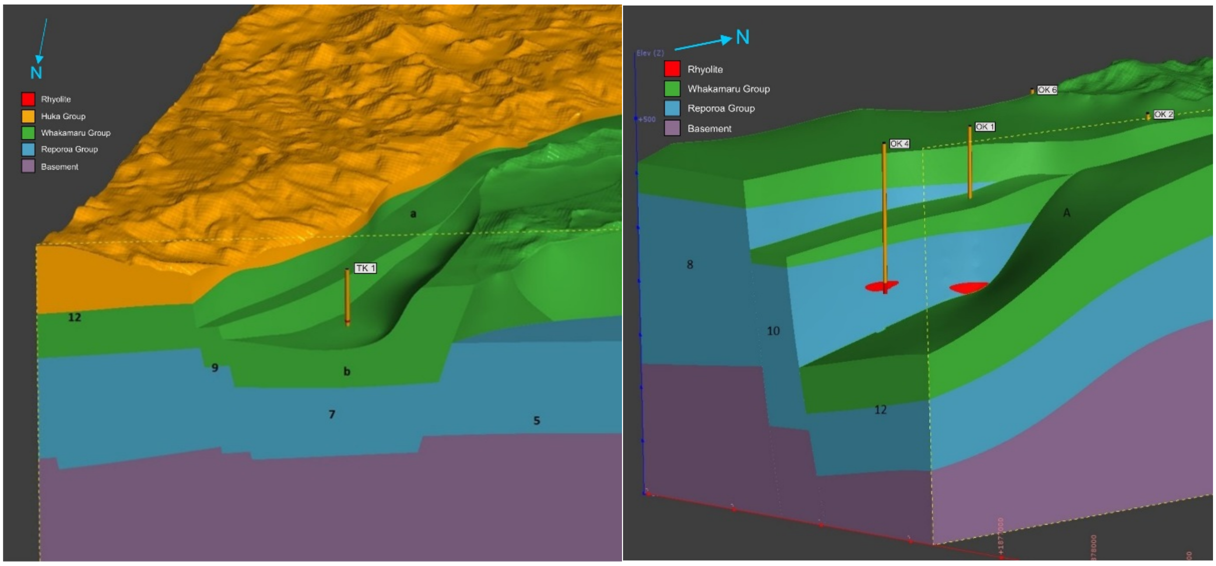

Figure 5: Left: Relay ramps formed at the junction of Paeroa faults and Paeroa 2 faults. Letter "a" represent the relay ramps that dips to northeast, while "b" represent the asymmetrical half graben. Right: Relay ramps formed at the junction of Matangiwaikato and Wainui faults. Letter "A" represents the relay ramp.

The interstrafied illite-smectite zone was encountered by several boreholes including OK-1, OK-4 and OK-6 and TK-1. The occurrence of interstrafied illite-smectite alteration in Orakeikorako is deepening northward (from OK-4 to OK-6), whereas in Te Kopia, it is only localised near TK-1 (Figure 6). The thickness of this alteration zone is only up to ~150m in Orakeikorako area and less than 40 m in Te Kopia.

The illite alteration occurred beneath the smectite and interstrafied illite-smectite zone. The shallowest occurrence of illite is in OK-4 at 103 m depth, and deepens in the other Orakeikorako wells. It becomes shallower in the Te Kopia wells at c. 350 m depth.

4.3 2D temperature model

The temperature model is illustrated by four isotherm surfaces representing 100° C, 150° C, 200° C and 250° C. The surface temperature across the modelled area is less than 100° C. In the Te Kopia area, the temperature reaches 150° C at a depth of ~275 m, and varies from 120 m to 550 m in the Orakeikorako area (OK-4; Figure 6). A similar pattern apply to the 200° C isotherm. A temperature inversion is identified in the models at both ends of the cross section. OK-4 and TK-2 both have reversed temperature from 200° to 150° C. The highest isotherm in the model is 250°C recorded in Orakeikorako wells, OK-6 and OK-2, while in Te Kopia area the isotherm 250° C was modelled between TK-1 and TK-2 based on the interpolation between those two wells.

5. DISCUSSION

5.1 Stratigraphic Architecture and Fault Network

The stratigraphy of Orakeikorako and Te Kopia model include 2 intrusions, one rhyolitic and the other basaltic. The identified rhyolite dikes are located near the faults. Fault planes act as natural weak zone and represent a possible way out for intrusions. No rhyolite was identified at surface. Therefore these intrusions were interpreted and modelled as sub-vertical bodies which intruded through fault zones and stopped at depth as sills. In contrast, the basaltic intrusion were interpreted and modelled as sub-vertical bodies that reached the surface through the fault planes.

The stratigraphic offsets of basement, Reporoa and Whakamaru group are created by several sets of active northeast-striking normal faults due to active rifting of the TVZ (Wilson et al., 1995). These group are deeper towards the northwest and southeast, while the shallowest occurrences are northwest of the Paeroa fault which controlled by two normal faults that dip away from each other (northern part of fault block 5 & 8, and southern part of fault block 7; Figure 4).

In Te Kopia, a relay ramp structure (fault block 9) was identified and modelled between Paeroa Fault and Paeroa 2 Fault; Figure 5). The relay ramp dips to the northeast, constrained by the Paeroa Fault and its subordinate fault. In Orakeikorako, the junction of sub-parallel Matangiwaikato Fault and Wainui Fault produce a ramp that dips to the southwest (southwestern part of fault block 12; Figure 5). NW-striking fault linkages are interpreted as forming due to the growth of relay ramps. Although it cannot be modelled due to lack of constraints data and the relatively small scale of these features, these NW-SE striking fault linkages may have a correlation with the NW-SE lineament observed from the topography above the relay ramp structure in the Te Kopia Area. These surface expressions are absent in the southern part of Orakeikorako. The relay ramp is constrained with borehole data and geological cross-sections. These fault linkage zones between the subparallel normal fault result in an increased fracture density that can enhance hydrothermal fluid flow and/or groundwater incursions, which can lead to temperature cooling in the Orakeikorako and Te Kopia geothermal systems.

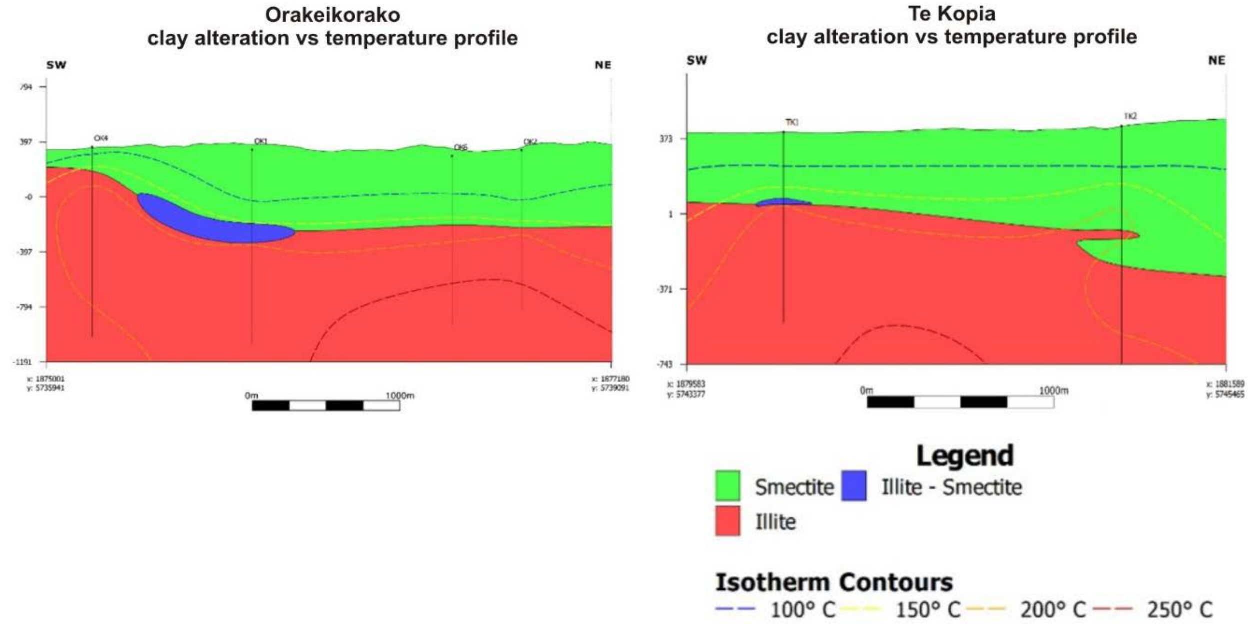

Figure 6: Orakeikorako and Te Kopia alteration model in separated cross-section. OK-4 and OK-6 are projected to the cross-section.

The fault network created in this model is representative of the major faults present in this area, based on the Active Fault database (Jongens and Dellow, 2003). They were modelled using their relative strike and dip data retrieved from the database and geological maps (Leonard et al, 2010; Lloyd, 1972). Several faults are correlated with inferred fault zones from borehole data (OK-1 and OK-6). The borehole data (based on drilling record of slickenside texture) suggested that faults were penetrated in TK-1, TK-2, OK-1, OK-2 and OK-6. However, three wells (TK-1, TK-2 and OK-2) in the 3D model do not go through faults. It is reasonable to infer that the faults that penetrated by those three wells are synthetic fault splays that merge with the major faults at depth.

Some of the faults (East Wainui fault) are inferred based on borehole stratigraphy. The depth difference of the lithology contact between Huka Group and Whakamaru Group in OK-2 and OK-1 is around 800 m while the horizontal distance between those wells is less than 1000 m (Figure 4). Hence, a steep normal fault was inferred in between these boreholes to account for the depth difference. This East Wainui Fault is also coincident with a surface fault trace.

5.2 Formation Temperatures Compared to Alteration Temperatures

The occurrence of smectite in the study area is associated with mordenite. Smectite is usually stable at temperature up to 150°C while mordenite is stable up to 160°C (Steiner, 1977). Illite is usually restricted to temperature above 220°C (Steiner, 1977) and occur beneath the smectite alteration zone. Interlayered illite – smectite occur locally in between smectite and illite alteration. It is stable at temperature 140°C – 220°C (Browne, 1978).

Based on the occurrence of characteristic hydrothermal mineral assemblages, water/gas chemistry, and fluid inclusion (Bignall, 1994), the major upflow zone occurs below OK-2, which has also a lateral outflow towards Te Kopia. The fluid discharged from Te Kopia is an outflow which is diluted by steam heated near-surface waters (Bignall, 1994). The temperature profile produced in this study also show temperature inversions below TK-2 (~110 m RL) and OK-4 (-790 m RL) which are indication of outflow zone (Figure 6).

Figure 6 indicates an overall correlation between formation temperature and clay alteration. The clay alteration reflects the forming temperature of the clay mineral at that time, while the formation temperature reflects the current temperature in the reservoir at the time of measurement. Comparing the 2D profiles of formation temperature and clay alteration, it appears that the alteration signature indicate higher temperatures than the formation temperatures. This suggests that cooling seems to have taken place in Orakeikorako and Te Kopia geothermal systems. It is possible that this cooling is due to the fault activity and groundwater incursions along the active faults.

6. CONCLUSION

The 3D conceptual model of Orakeikorako and Te Kopia geothermal system has been carried out using Leapfrog Geothermal version 2.6.2 to visualise the structural framework and the subsurface distribution of geological units. Six stratigraphic layers and two intrusions were modelled using data from six exploratory wells, regional geological map, recent mapping in Paeroa Block area and GNS active fault database.

The presence of faults have a major influence and control the architecture and stratigraphy of the Orakeikorako and Te Kopia geothermal systems. Two ramps dipping to the SW and NE in Orakeikorako and Te Kopia, respectively, have been interpreted and modelled. A half graben structure also has been identified and modelled in the Te Kopia area. More data such as geophysical dataset (e.g. gravity maps, magnetotelluric data) need to be acquired to give better constraints on the architecture and stratigraphy of Orakeikorako and Te Kopia geothermal systems.

The 2D clay alteration zone gives a paleo temperature record of the Orakeikorako and Te Kopia geothermal systems while the formation temperature profile has been built using measured temperature data from six exploratory well. The upflow zones have been identified in Orakeikorako and Te Kopia geothermal systems. Temperature reversals are identified at both end of the model and likely represent outflow zones. The correlation between formation temperature and clay alteration temperature suggest that cooling has taken place in the Orakeikorako and Te Kopia geothermal systems that may be due to the groundwater incursions along the active faults. Surface temperature was not included in the models. This could be implemented in future development of the model and to better constrain the temperature model.

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