DEVELOPING A GUIDELINE TO MAP, DESCRIBE AND CATALOGUE SURFACE GEOTHERMAL FEATURES

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ABSTRACT

Geothermal features are an obvious expression of a geothermal system, and can be used to determine parameters of the sub-surface system by mapping and characterising them. They are also an indicator of the system behaviour. Identifying the locations of geothermal features and monitoring their heat, water flow, and chemistry can provide aspects of the data needed for fundamental science and to support informed decisions about management options.

Currently there are no formal guidelines or procedures in place for mapping or monitoring of surface geothermal features. This paper outlines development of procedures for the collection of data from surface geothermal features. A national standardised methodology will provide capability for consistent description of geothermal features throughout New Zealand. Consistent description supports comparison between sites, over time and supports significance testing. Studying and monitoring their surface expression will contribute to many aspects of the geothermal knowledge base.

1.INTRODUCTION

1.1 Background

Geothermal systems often have some form of surface expression, which is associated with heat and mass being discharged from the geothermal system. This is typically referred to as a geothermal area and today they have high intrinsic value. They are variable and may not always reflect the size or nature of the subsurface system. Geothermal surface features can change due to natural perturbations, for instance weather patterns, climate changes, or earthquake and volcanic activity. They can also change due to human activities, such as nearby production for geothermal energy or land use practices.

Geothermal features are an obvious expression of a geothermal system, and can be used to determine parameters of the sub-surface system by mapping and characterising them. They are also an indicator of the system behaviour and response to reservoir utilisation or natural variation, if in an undisturbed (non exploited) natural state. Identifying the locations of geothermal features and monitoring their heat, water flow, and chemistry can provide aspects of the data needed for fundamental science and to support informed decisions about management options.

Currently there are no formal guidelines or procedures in place for mapping or monitoring of surface geothermal features. This paper outlines development of procedures for the collection of data from surface geothermal features.

A national standardised methodology will provide capability for consistent description of geothermal features throughout New Zealand. Consistent description supports comparison between sites, over time and supports significance testing. Studying and monitoring their surface expression will contribute to many aspects of the geothermal knowledge base.

1.2 Project history

The geothermal resources of the Taupō Volcanic Zone are managed by two regional councils; Bay of Plenty and Waikato, under the Resource Management Act (RMA). These councils have had different management approaches in the past. In revising the Bay of Plenty Regional Policy Statement (RPS) several changes were made to improve policy alignment across the Taupō Volcanic Zone. This included a process to determine the significance of surface features.

Under the RMA, the council must consider outstanding landscape and natural features. In this context geothermal surface features are unusual. Most landscape features are locally uncommon, but become more common at a national level (e.g. waterfalls). Geothermal surface features and ecologies are the reverse; they are locally common and nationally rare.

This means that the criteria typically used in RMA to determine natural feature significance would capture all of them. That outcome would preclude any extractive use of the resource. Hence an initiative to develop criteria for determining significance of surface geothermal features, to provide focus for protection efforts is needed.

It was also recognised that to test any significance criteria would need a catalogue of surface geothermal features to test against. However there is no recognised guideline for the capturing of data about surface geothermal features or characterising them. A national standardised methodology will provide this capability and then support comparison and significance testing.

Mapping of geothermal features in New Zealand has been systematic in only some areas. Mapping projects have included:

- those formally published such as Lloyd (1959, 1975, 1972) covering Waiotapu, Whakarewarewa and Orakei Korako respectively. Gregg and Laing (1951) at Wairakei; Glover et al.(1992) mapped

Waikite area, while Espanola (1974) covered Tikitere and Taheke.

- those found in University thesis, like Keywood (1991) who mapped features at Waimangu and Rotomahana.
- part of unpublished maps or reports held in GNS Science and other collections (e.g. Universities).

GNS Science, Bay of Plenty Regional Council and Waikato Regional Council hold collections of these data and for some areas have collated portions of these collections.

1.3 Classifying Surface Geothermal Features

Surface geothermal features in New Zealand are hydrothermal in nature, being water or steam dominated; with most groupings having gradational boundaries. A classification was developed for the Bay of Plenty Regional Policy Statement (RPS) and has been adopted for the guideline (Fig 1). The surface features range from those that are in high energy states (fluid or steam), through over-flowing to non-over-flowing pools (lower energy).

Surface geothermal feature types and habitats			
Geyser		Mud Geysers	Fumarole
Primary Flowing Springs	Mixed Flowing Springs	Mud Pots	Steaming Ground
Primary Non-Flowing Pools	Mixed Non-Flowing Pools	Mud Pool	Heated Ground
Primary geothermal fluid	*Primary diluted geothermal fluid*	*Mixed diluted fluid and/or steam heated*	*Steam fed*

Figure 1: A schematic representation of surface geothermal features and habitats. These can range from eruptive overflowing to non-flowing states. The fluids range from primary geothermal fluids, to mixes and steam.

Three broad categories of habitats are also supported by surface geothermal features (Fig. 1). These are:

1 the atmosphere above and around them,

2 the aquatic environments of pools, lakes, marshes and streams which they flow and seep into, and

3 areas affected by heated or hydrothermally altered ground.

Three major types of fluids are common in surface geothermal features. Some features receive hot 'primary' geothermal fluids directly (or almost directly) from depth. These are usually classed as alkali chloride waters and are saturated (with respect to temperature) with SiO_2; and their outflows form silica deposits. These fluids may also have dissolved CO_2 and H_2S components. In other features the fluids will mix and become diluted, usually with shallow ground waters and by interaction with CO_2-rich bicarbonate fluids. Some will also be influenced by steam, condensing to produce more acidic fluids (H_2SO_4), often referred to as acid sulphate fluids and muds. The third type of geothermal feature is dominated by steam passing through ground to heat the ground and form warm to hot ground. If enough steam passes through it will develop into a fumarole.

The various feature types are discussed in detail in the guideline (Scott, 2012).

2. THE GUIDELINE

When describing a geothermal feature provision needs to be made for a mix of hard (quantitative) data like temperatures, water level and flow which will be directly measured, with soft data (qualitative) like colour, ebullition height and gas bubbles that will be estimated and have less precision.

The guideline provides standards and processes for mapping and locating geothermal features, classifying them and surrounding habitats, feature identification, description, uses and threats. Aspects of field equipment and safety are also included, with an appendix on sampling waters.

2.2 Procedures and Protocols

A field data form design has two parts;

1) Feature identification, name, type and location. This also includes an estimate of errors in the location data.

2) Feature description, includes size, colour, clarity or turbidity, gas, temperature, water level or flow. Also included are sampling data, uses and threats, photography details and additional data like wind speed and air temperature for heat flow calculations.

To allow for back-capture of data, all available older field forms or data bases were checked. Fields were created on the field data form to accommodate data from older descriptions. This is to allow for all historic data to be collected into GIS based catalogues of existing and past surface features. This will in turn provide the capability to carry out trend analysis over time.

The guideline outlines in detail the procedure for completing the field data form. It's important that each feature is associated with a known geothermal system and also becomes unique with an ID, names (current and historic) and location. A series of two letter codes are provided for each geothermal field, with a third letter F added (ie KAF for a surface feature at Kawerau). This is consistent with the practice of identifying production bores and the newly introduced vegetation data plots (Luketina pers com). Procedures for the use of GPS locations and errors are outlined, map sheets and coordinate systems.

Many attributes can be recorded about a geothermal feature, to improve knowledge about that feature. Some may be transitory. Some may require significant laboratory work (chemistry). The time of the day or season of the year may influence factors like visibility, due to steam. The primary visual and physical attributes to record are the physical size, colour of the pool, clarity/turbidity, ebullition, odours, temperature, water level or over-flow rate, wind speed an air temperature and activity in the feature. The locations of measurements, sampling or photographs also need to be recorded, to ensure that photo points and sampling points are consistent over time.

Provision for a sketch map is also included on the field data form. This is used to record dimensions, locations of ebullitions, depth and temperature measurements and overflows. Also of importance are nearby features, and direction to north. Photographs can also be used as they capture the spatial and visual attributes of the features, showing the entire feature and its relationship to adjacent items. This can also identify sampling sites etc. Protocols for photo cataloging are also included.

2.3 Testing and evaluation

As a part of the development of this guideline it was field tested by GNS Science staff undertaking a heat flow survey of selected features at Whakarewarewa (Prieto pers com.) and as part of the routine monitoring of selected features in the Rotorua Geothermal Field monthly (Graham et al. 2012). The forms were modified based on feed back during these projects.

Since completion of the guideline and its preparation for publication the field sheets have been routinely used for hot spring monitoring at Kawerau and Rotorua.

3. SUMMARY

The adoption of the guideline by all those doing surface feature description and analysis will enable consistent data to be collected about surface geothermal features and the establishment of a catalogue of the features and their characteristics. Creating unique identity and location data will allow future resurveying to ascertain changes. These may be natural or induced by near by exploitation.

The establishment of a uniformly defined catalogue of surface features will:

1. Support the use of criteria to test for significance.
2. Provide for more uniform management of the geothermal surface features in New Zealand, particularly in the Taupō Volcanic Zone
3. Provide the capacity to compare the characteristics of surface features over time.

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