New Heat Flow Data From Tasmania and the Emergence of Eastern Tasmania as a New EGS Province

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INTRODUCTION

Most published maps of Australian 'hot rock' plays or estimated temperature of basement at about 5,000 m show Tasmania as relatively cool and hence perhaps geothermally unprospective at those depths (eg Holgate and Chopra, 2004). This situation is an artefact of several things, including a) the dataset being largely compiled from hydrocarbon exploration and other sources which did not have geothermal mapping as their primary purpose, b) incorrect assumptions being made on the estimate of depth to geothermal basement in Tasmania and c) the use of temperature gradients as a primary tool for estimation of basement temperature.

New, systematic surface heat flow and thermal conductivity data presented here build on isolated values published over a considerable time and when combined with a new gravity model of the depth to geothermal basement, produce a strong technical argument for eastern Tasmania to be recognised as a new Engineered Geothermal Systems (EGS) or 'hot rocks' province.

Clues concerning the prospectivity of Tasmania for hot rocks first emerged over a half century ago. Heat flows of between 85 mW/m^2 and 105 mW/m^2 were reported from boreholes principally drilled for hydro-electric dam engineering investigations (Jaeger and Sass, 1963; Newstead and Beck, 1953). In the 1960s the Department of Mines calculated the heat flow from a hole drilled into the Devonian granite at Storeys Creek in north-eastern Tasmania and a value of 159 mW/m^2 was reported (Jaeger and Sass, 1963). This remains one of Australia's highest recorded borehole heat flow values.

In the 1970s and 1980s, further drilling by the Department of Mines and others continued to produce scattered high heat flow and encouraging thermal gradient values in Tasmania. The Devonian Coles Bay Granite in the far east returned 102 mW/m^2 from a borehole (Green, 1989) and this finding of a high heat production granite was re-enforced by publication of scintillometer readings for outcropping Devonian granitoids in Tasmania which showed the Coles Bay and Storeys Creek/Rossarden granitoids to be anomalously radioactive (Collins et al., 1981). Boreholes into the Tasmania Basin sediments at Glenorchy and Tunbridge, where there is no known granite at depth or laterally for many kilometres, returned values of 87mW/m^2 for the former and thermal gradients of about 40 °C/km for both (Green, 1969; Wronski, 1977).

Hence to the year 2000, anomalous to high heat flow (i.e. >85mW/m^2) and thermal gradient (i.e. >40 °C/km) values had been recorded from most areas of Tasmania and from environments both above and laterally distant from known granites. The single unambiguously cool area was in the Proterozoic metamorphic terrane of the south-west (57 mW/m^2 heat flow and 18 °C/km thermal gradient at Olga Ridge) (Wronski, 1977).

Situation in the early 2000s

In the early 2000s, the prospectivity of the Cooper Basin and some other parts of South Australia had been clearly recognised and investment capital was being mobilised to begin exploring those areas for EGS project development. The publication of a map of Australia showing 'estimated temperatures at 5 km depth' re-inforced the work published in the mid 1990s and continued to show Tasmania as relatively cool at those depths and hence possibly unprospective for EGS.

The first systematic compilation of geothermal-related data and analysis of the potential of Tasmania for geothermal energy was undertaken by Lewis (Lewis, 2005). This report synthesised the existing heat flow, temperature gradient, gravity and granite sub-surface distribution data and recognised that the published estimates of temperature at 5 km notwithstanding, all the components required for a successful 'hot rocks' or EGS play were present in eastern Tasmania. Four areas were highlighted:

- An interpreted granite cupola under the Tamar River;
- An area east of the hot Storeys Creek granite, where the granitoid extension was interpreted to lie about 4 km deep;
- An area south of Storeys Creek and west of Coles Bay, again in an area of favourable granitoid burial depth; and
- A large area of the Tasmania Basin from the Great Lake in central Tasmania to Bruny Island in the south-east, incorporating the City of Hobart. This area was recognised mainly for the potential for non-granite related hot aquifers.

The 2005 report then developed a range of thermal models for eastern Tasmania, with varying granite and overlying stratigraphic characteristics producing a range of possible thermal outcomes at 5 km depth. Finally, economic criteria were superimposed on the thermal models and key areas identified for follow-up.

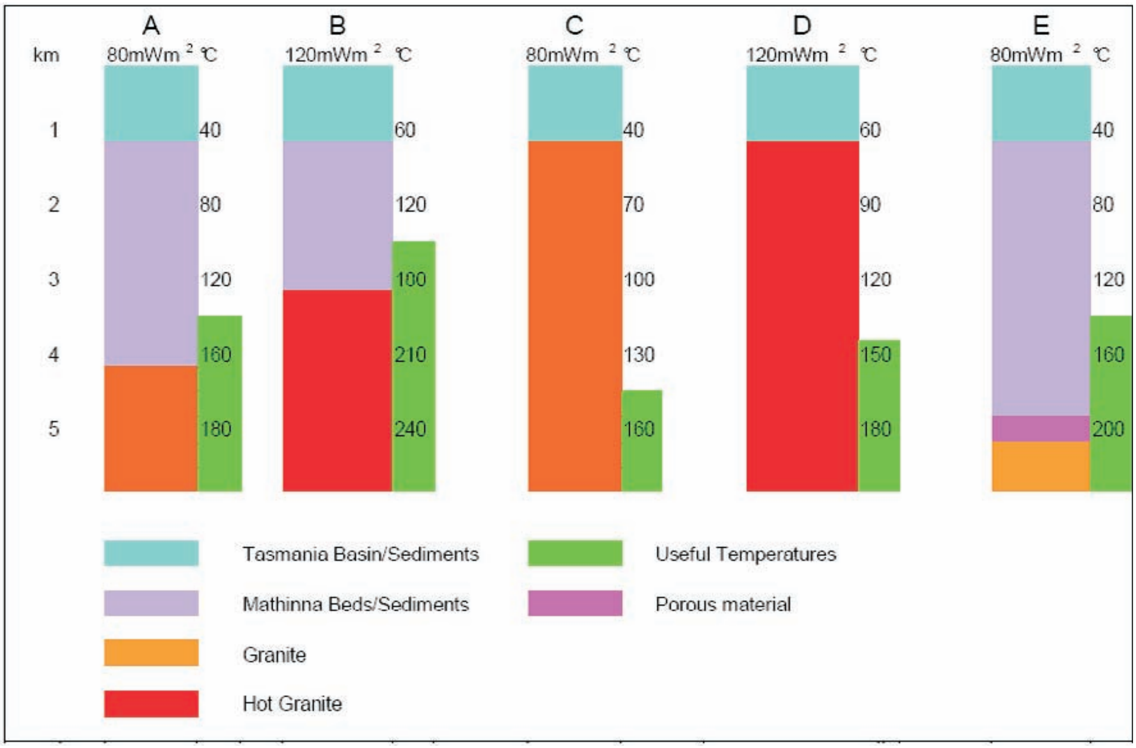

Figure 1. Thermal scenarios for eastern Tasmania from Lewis (2005).

Progress since 2005

In 2006, Tasmania's first tenement for exploration for geothermal substances was awarded to KUTh Exploration Pty Ltd. The *Mineral Resources Development Act* of 1995 already accommodated the issuing of a licence for geothermal and no legislative modifications were required, unlike nearly every other State in Australia. The tenement, Special Exploration Licence 26/2005 was 12,360 km^2 in area and included not only most of eastern Tasmania and EGS prospective areas but also metropolitan Hobart and Launceston, targeting 'direct use' heating and drying geothermal applications.

Since the grant of the first tenement, a further tenement of 1,811 km^2 has been granted to KUTh Exploration. Three tenements totalling almost 8,500 km^2 have been awarded to Geothermal Energy Tasmania Exploration Pty Ltd (GET) and one tenement of 4,892 km^2 is under application by GeoPower Pty Ltd.

NEW RESULTS

A systematic thermal drilling programme in eastern Tasmania which began in late 2007 has continued through 2008. Approximately 40 holes will be drilled by the time the programme is completed. The key parameters of the drilling programme are as follows:

- Holes vertical and on an approximate 20 km x 20 km grid, drilled into Jurassic dolerite where possible, (competent formation with low aquifer quality and flow);
- Percussion drilling to approximately 100 m depth, then HQ cored to approximately 250 m deep;
- Precollar cased with 100 mm PVC and aquifers cemented off; 40 mm PVC from the collar to end of hole;
- Holes left to achieve thermal equilibrium for at least 3 months after drilling;
- Temperature measured every 1.0 m down-hole using resistivity (thermistor);
- Thermal conductivity of core samples measured using a steady-state divided bar apparatus.

The surface heat flow results received to 1 July 2008 are shown in Table 1.

Table 1. New surface heat flow values for eastern Tasmania.

Hole ID	**Location**		**Dominant lithology**	**Equilibrated surface heat flow#**
	Northing	Easting		mW/m^2
Snow	5,358,389	572,873	Jd	92.0
Lake Leake	5,338,586	568,510	Jd	92.0
Elizabeth	5,356,701	549,501	Jd	94.0
Tooms	5,319,894	567,354	Jd	96.0
Temple Bar	5,402,059	530,426	Jd	87.0
Ben Lomond	5,402,059	546,613	Sm	97.0
Tower Hill	5,399,699	573,964	Sm	83.0
Epping	5,382,606	533,251	Jd	62.0§
	Lithologies: Jd = Jurassic dolerite; Sm = Silurian Mathinna Group sediments All holes are vertical and equilibrated for 3 months after drilling # Values have an average error margin of < 2.5 mW/m^2 § Heat flow in base of hole (268m) 92.0 mW/m^2			

Thermal conductivities were measured on core samples to derive the heat flow values. Typically five samples were taken from each cored interval and conductivities measured at a standard temperature of 30 °C using a calibrated steady-state divided bar apparatus by contractor Hot Dry Rocks Pty Ltd. Typically three samples were prepared from each specimen to investigate variation over short distance scales and to determine mean conductivity and uncertainty. Results for the above holes are presented in Table 2.

Table 2. New thermal conductivity values for drill holes in eastern Tasmania

Hole ID	Thermal conductivity#		Lithology
	Maximum w/mK	Minimum W/mK	
Snow	1.99	2.25	Jd
Lake Leake	1.96	2.18	Jd
Elizabeth	1.99	2.27	Jd
Tooms	1.82	2.07	Jd
Temple Bar	2.28	2.49	Jd
Ben Lomond	3.87	4.41	Sm
Tower Hill	4.06	5.23	Sm
Epping	1.87	2.18	Jd

Lithologies: Jd = Jurassic dolerite; Sm = Silurian Mathinna Group sediments
\# Values have an average error margin of up to +/-10%
Note: Mathinna Group sediments strongly foliated at low angle to axis of core (direction of measurement); see text for discussion

DISCUSSION

Most of the new reported surface heat flow values are anomalously high. South of the Rossarden and Storeys Creek granites, the values are consistent and within the range commonly reported from the Cooper Basin, regarded as Australia's leading EGS play to this point. In Tasmania, the strong heat flows already represent an area of about 1,200 km^2 which is open on three sides. The values also lie where the buried granite is between approximately 3 km and 5 km below the surface, reinforcing the technical model (Leaman and Richardson, 2003; Leaman, 2007).

Figure 2 shows the co-incidence of the anomalous surface heat flow with the area where the basement granites are interpreted to be between 3 km and 5 km below the surface.

North of the Storys Creek granite, the values to date are less consistent, but still relatively high on a national scale, ranging from 83 mW/m^2 to 97 mW/m^2. The subsurface distribution of the granites is less well constrained in this area. The surface value of 62 mW/m^2 at Epping, west of Rossarden appears to result from heat subtraction within the measured drill hole, as a base of hole value of 92 mW/m^2 was estimated.

In respect of thermal conductivities, the values for the Jurassic dolerite are considered typical for that rock type (Beardsmore and Cull, 2001). The values for the Silurian 'Mathinna Group' sediments are comparatively high, although consistent with Palaeozoic basement in other parts of Tasmania and mainland Australia (Jaegar and Sass, 1963; Wronski, 1977). Elevated rock thermal conductivity results for the Mathinna Group samples reflect a strong foliation, which is steeply dipping with respect to the long axis of the core and is therefore at a low angle to the direction of conductivity measurement. A predominance of quartz wackes and silicification of the particular samples measured has also influenced the measured conductivity.

Laboratory work presently being undertaken by Hot Dry Rocks Pty Ltd suggests that when measured perpendicular to foliation, thermal conductivities for the same sediments are much lower, in the order of 1.43 W/mK for one sample from the Tower Hill well, representing a decrease of

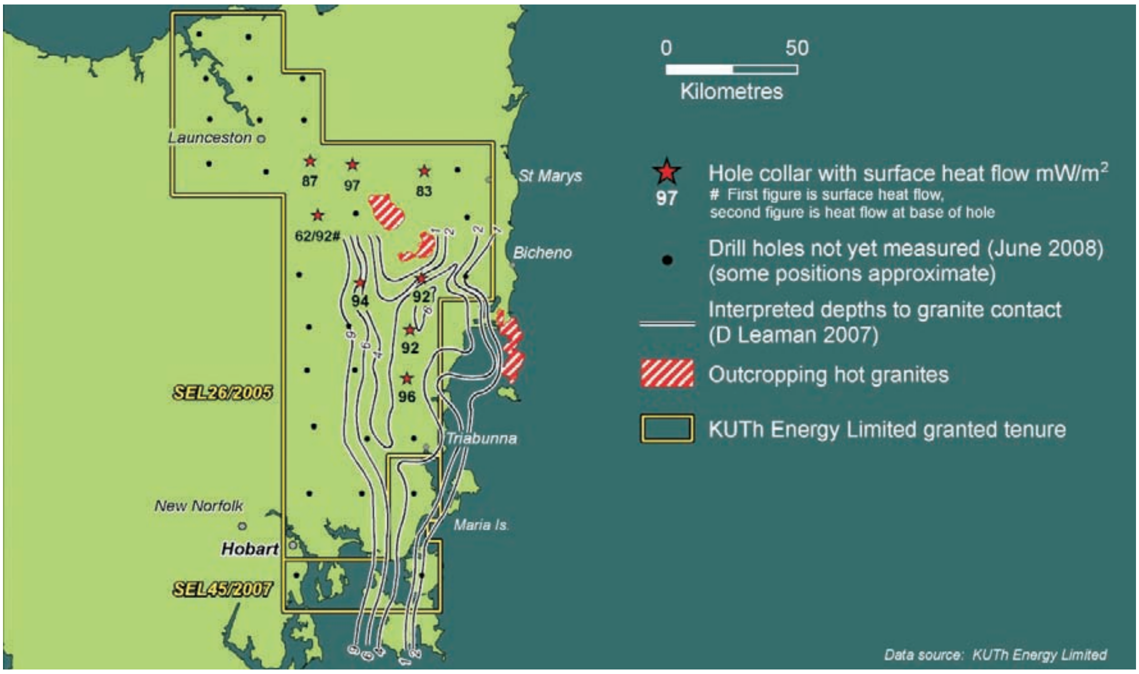

Figure 2. New surface heat flow values for eastern Tasmania set against interpreted depths to granite basement.

about 66.5% from the standard rock thermal conductivity measurement (harmonic mean) for the same sample. The Mathinna Group sediments in central eastern Tasmania are relatively poorly known and how typical these results are for the formation as a whole is unknown. Certainly parts of the Mathinna Group are carbonaceous mudstones which are expected to have a lower thermal conductivity and foliation directions in the sedimentary package will vary. This is supported on one Ordovician mudstone sample from Olga Ridge, Tasmania, which has a document thermal conductivity of 2.8 W/mK (Wronski, 1977).

CONCLUSIONS

This paper has presented new equilibrated surface heat flow and thermal conductivity values for eastern Tasmania. Of the eight new heat flow values reported, five lie between 92 and 97 mW/m^2 and a further two between 83 and 87 mW/m^2. These anomalous values were calculated from a systematic shallow drilling programme, designed to map the thermal characteristics of eastern Tasmania and build upon earlier isolated but still anomalous values reported in the previous decades. Put together with improved knowledge of the distribution of buried granites in eastern Tasmania, a strong case is emerging for eastern Tasmania to be recognised as a new thermally anomalous province in Australia. The depth and characteristics of the granites and the size of the thermally anomalous area are such that there is strong potential for Engineered Geothermal Systems type power generation in Eastern Tasmania.

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