Exploring Eastern Tasmania: A Novel Geothermal Province

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Over the past two years KUTh Energy Limited has undertaken geothermal exploration across its tenements in eastern Tasmania. The initial phase of this program is now nearing completion and has yielded a variety of results. Although not previously recognised as geothermally prospective, a program of systematic heat flow mapping has now revealed the presence of a significant surface heat flow anomaly in the central Midlands area. Values of high (>90mWm^{-2}) heat flow are found to be spatially associated with the sub-cropping extension of high-heat-producing granite bodies. A series of sedimentary units, extensively intruded by dolerite sills, lie above the granite and combine to provide the insulation necessary for a classic Enhanced Geothermal System (EGS) target. Bisecting the northern portion of the heat flow anomaly is the Tamar Conductivity Zone (TCZ), a region of high crustal electrical conductivity that has been mapped in detail by recent magneto-telluric survey work. This feature, which may indicate the presence of large-scale fracture permeability in the crust, remains open directly along strike from the region of highest recorded heat flow.

Keywords: Tasmania, heat flow, magneto-telluric

Exploration Methods & Results

To effectively explore Eastern Tasmania for its geothermal potential a variety of techniques were required that were capable of discerning key elements of the EGS target beneath extensive Jurassic dolerite cover. Critical amongst these were the magnitude and distribution of heat flow, the depth of insulator (depth to top granite), the quality (thermal properties) of the insulator and the location and nature of the TCZ. The size of the area under investigation further necessitated that any technique used should be economically applicable at a regional scale. To meet these needs, an exploration program was devised that comprised shallow drilling for surface heat flow determination, gravity interpretation, rock property determination and magneto-telluric (MT) data acquisition.

Surface Heat Flow Determination

A program of pattern drilling of shallow boreholes was designed to investigate surface heat flow across the tenement area. Holes were drilled on a 20km grid spacing at 36 locations. In all cases the holes were percussion drilled to 100m with diamond core cut to total depth at ~250m. Heat flow estimation was performed by Hot Dry Rocks Pty Ltd and was based upon application of 1D thermal modelling. Data used in the modelling was collected by Hot Dry Rocks and comprised precision down hole temperature logs and thermal conductivity values determined from core samples using a divided bar apparatus.

At the time of writing, surface heat flow data were available for 31 holes with five holes still outstanding (Figure 1). Heat flows determined to date are of high quality and reliability with analytical uncertainties typically <5%. The data are spatially consistent, defining a large area (>4100km^2) of anomalously high heat flow (>90mWm^{-2}) in the central portion of the tenement area.

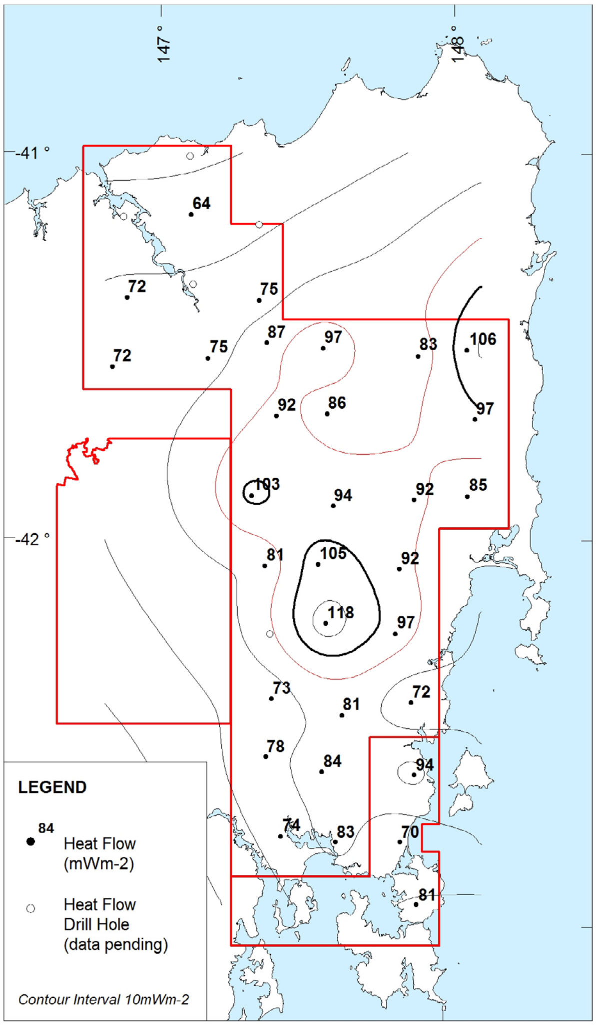

Figure 1: Contoured surface heat flow field for Eastern Tasmania based upon new data acquired during KUTh Energy's recent exploration program. The 90mWm^{-2} contour, shown in red, encloses an area of over 4100km^2 inside the tenement area (outlined in bold red).

Gravity Interpretation

Estimation of the depth to top granitoid was undertaken by Dr. David Leaman using source modelling of gravity data and following the method of Leaman and Richardson (2003). An infill survey of ~500 gravity stations was undertaken to improve the regional gravity coverage across the tenement area. These data were used to create an updated version of the Tasmanian mantle source model MANTLE03. This model was in turn used to determine the residual Bouguer gravity anomaly from which the depth and shape of top granitoid was interpreted (Figure 2).

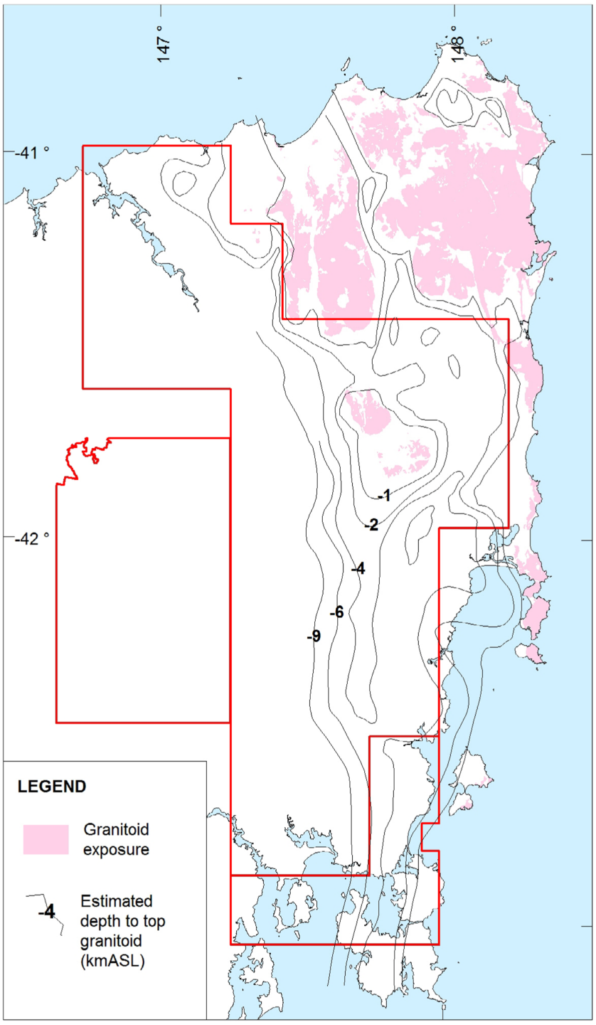

Figure 2: Contoured surface showing estimated depth to top granitoid. Image combines new data derived from KUTh Energy's gravity data acquisition with the existing contours of Leaman and Richardson (2003).

Rock Property Determination

Rock units predicted to overlie the granites in significant thicknesses are Jurassic Dolerite, Tasmania Basin sediments (Parmeener Supergroup) and the Ordovician-Devonican Mathinna Supergroup. Thermal conductivity values determined from these rocks by divided bar analysis from KUTh drill core are summarized in Table 1 together with data from an independent study of this region (H. Goh, 2008). These results confirm the relatively good insulating properties of both the Dolerite and the Tasmania Basin sediments. Predictably, the turbidite sequences of the Mathinna Supergroup display variable thermal conductivities, depending upon rock type and grainsize. Of particular interest in these units, however, was the observation of a strong thermal anisotropy associated with the development of fold axial cleavage (Figure 3). This effect, which was observed most strongly in fine-grained mudstone and shale, serves to significantly reduce the insulating advantage of the fine-grained lithologies wherever heat flow is directed along the cleavage plane.

Unit	Lithology	n	Mean	2σ
Jurassic Dolerite	dolerite	97	2.17	0.35
Parmeener (Tasmania Basin)	sandstone	17	3.54	1.85
	siltstone/mudstone	19	2.39	1.83
Mathinna	sandstone	8	4.48	1.27
		24	*4.38*	*1.48*
	siltstone/mudstone	18	3.64	1.24
		16	*3.44*	*1.28*
	shale	*18*	*2.71*	*1.36*
Devonian Granite	granite	*31*	*3.48*	*0.4*

Table 1: Thermal conductivity values (W/mK) determined from core for Eastern Tasmanian rocks. Values in italics are taken from Goh (2008). All values are from wet samples.

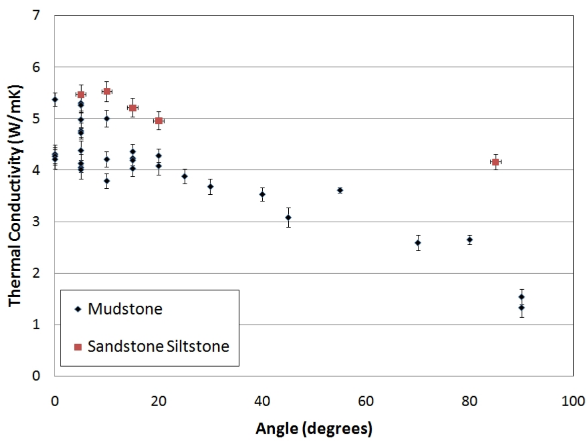

Figure 3: Thermal conductivity versus foliation angle (0° = vertical foliation) for the Mathinna Supergroup. Results indicate a strong thermal anisotropy that is most distinct in the finer grained lithologies.

Magneto-Telluric Survey

An MT survey, comprising 96 stations located at 1km intervals along two E-W lines, was undertaken to better constrain the nature and location of the TCZ anomaly (Figure 4). Full tensor time series data were collected by Moombarriga Geosciences for ~12 hours at each site to ensure resolution of apparent resistivity and phase data in the range 300-0.01Hz.

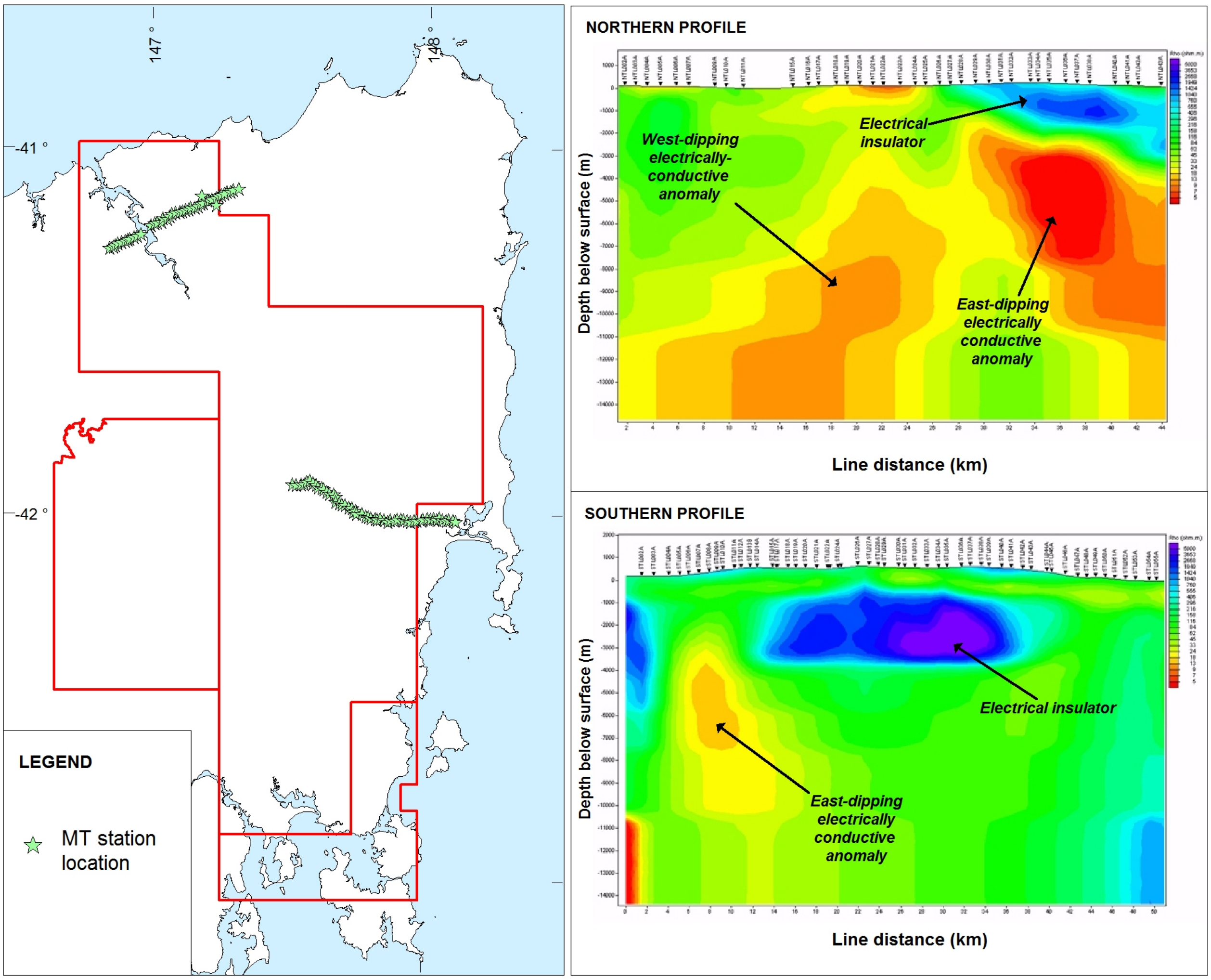

Figure 4: MT survey location and 2D modeled profile results for two lines across Eastern Tasmania. Models are inversions of TM and TE shifted data. Resistivity range 5ohm.m (red) to 6000ohm.m (purple), maximum depth below surface is 14km, line distance northern line = 44km, southern line = 50km.

2D modelling of data generated by this survey was performed by Dr Adele Manzella of the *Consiglio Nazionale delle Ricerche-Istituto di Geoscienze e Georisorse* (CNR-IGG) in Italy. Data were found to be of high quality with relatively few incidences of major signal noise. As part of the modelling Dr Manzella applied a systematic process of data validation to identify, correct or remove poor or biased data. A manually derived 'static shift' correction was applied to compensate for distortion effects produced in the electromagnetic field by near-surface features.

The 2D models produced by Dr Manzella for this survey are presented in Figure 4. In both cases these models have been refined by the use of *a priori* constraints regarding the location of resistive bodies determined in 1D inversion models. No assumptions were made regarding the location, size or intensity of electrically conductive anomalies or of the nature or distribution of the existing geology. Comparisons of TE, TM and joint TE-TM inversion models for the two lines indicated a good agreement for the northern line whilst the southern line displayed significant differences indicating these data are influenced by 3D effects.

The models derived from the MT data indicate the presence of large electrically conductive bodies within the crust in the vicinity of both survey lines. In the northern profile, a strong east-dipping conductive body is observed at a depth of 2.5km and is interpreted to have a thickness of no less than 2km. This body, together with a weaker west-dipping conductor, confirms the presence of the 'Tamar Conductivity Zone' (TCZ) in this region.

An east-dipping electrically-conductive anomaly is also identified at the western end of the southern MT profile at a depth of 3.5 - 4km. This body lies directly along strike from the east-dipping feature identified in the northern profile and is interpreted to be an extension of the TCZ along the Tamar Lineament (Figure 5).

An electrically insulating anomaly is seen located to the east of the interpreted east-dipping TCZ anomaly in both the northern and southern profiles. At present the identity of the geological feature causing this anomaly remains speculative.

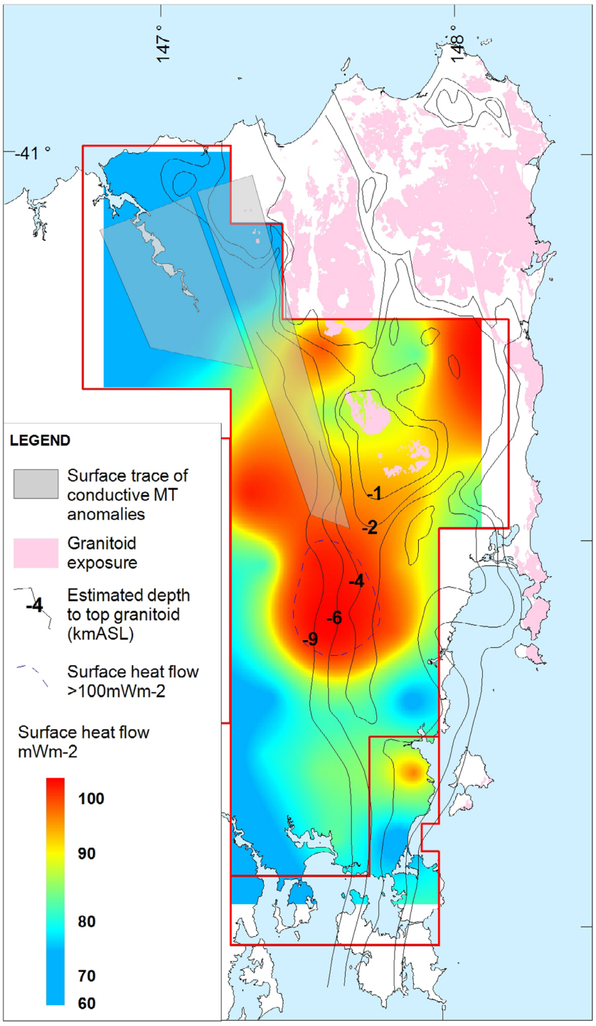

Figure 5: Data compilation of KUTh Energy Ltd's new geothermal exploration results in Eastern Tasmania.

Discussion

Collation of new and existing data for Eastern Tasmania indicates the presence of a significant thermal anomaly in the centre of this region (Figure 5). A large area of elevated heat flow (~4100km^2 >90mWm^{-2}) is seen to spatially coincide with the predicted extension of known granite bodies 3-4km under cover. Flat-lying Mesozoic cover sequences of the Tasmania Basin and intrusive Jurassic Dolerite sills provide up to 1km of good insulating cover at surface. Beneath these lie the deformed flysch of the Palaeozoic Mathinna Supergroup, the insulating qualities of which have been shown to depend upon the orientation of its structural grain. Evidence from field mapping in the north-east indicates that the Mathinna comprises an older recumbently folded unit in the West which is juxtaposed against younger upright folded sequences in the East (Powell *et al.*, 1993). Recent data suggests that the contact between these units is faulted implying that the older strata may occur at depth in the east (Reed, 2001; D. Seymour *pers. comm.*). This in turn suggests that the Mathinna section at depth will contain a mixture of upright and horizontal foliations and its bulk properties are therefore likely to be those of a moderate to good thermal insulator. Combined, these data confirm the potential of this area as a Hot Rock or EGS development target. Further geothermal modelling work to estimate a thermal resource and predict temperature distribution with depth in this area is now underway.

MT survey work has confirmed the existence of the Tamar Conductivity Zone in the north and increased its known extent into the south where it remains open along strike from an area of very high heat flow (>100mWm^{-2}). Whilst the nature of this feature is not uniquely defined, its geometry and location suggest that it is a crustal scale structure, most likely a fault or fracture system. It is plausible that this system may be permeable, containing electrically conductive fluid and/or hydrothermal alteration minerals. The possibility of a southern extension of this feature, and of its relationship to the area of very high heat flow, remains open. Further MT survey work is currently in progress to address these issues by better defining the 3D conductivity structure of the southern region.

Summary

A program of systematic geothermal exploration undertaken across Eastern Tasmania has identified a significant new geothermal province. A broad area of anomalously high heat flow (>90mWm^{-2}) is found to spatially coincides with high-heat-producing granite at depth beneath insulating cover. Hot Rock or EGS prospectivity in this area may be further enhanced by the potential for *in situ* fracture permeability associated with the Tamar Conductivity Zone. This feature, which has been detected by an MT geophysical survey, remains open along strike from an area of very high heat flow (>100mWm^{-2}). These targets will be further delineated by exploratory work as part of KUTh Energy's ongoing Tasmanian work program.

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