Geothermal targeting technologies

Background

Geothermal explorers are confronted with crucial investment decisions in an environment where both the quantity and quality of basic data relevant to their prospects is limited. However, while geothermal explorers operate in a data limited world, it is not data free. In most geothermal plays relevant geological and shallow temperature data are available. For some plays basic heat flow data and relevant thermal property databases are also available. In this context, the quickest route to more robust geothermal targeting lies in developing methodologies for evaluating the significance of the available data in the context of the regional geological framework.

To date the industry has relied largely on insights gained from a particular class of geothermal prospects (the enhanced geothermal system or 'egs') revealed, on the one hand, by deep drilling in the Cooper Basin and, on the other, by the recognition of anomalously high heat flows associated with exceptional enrichments in heat producing elements within the South Australian Heat Flow Anomaly. While much of the industry has been focussed on the 'egs' style prospects associated with the South Australian 'hot rock' province, it is now clear that there is diverse range of geothermal prospects. For example, exceptional insulation and the possibility of natural convection provide new opportunities for geothermal resources in many of our sedimentary basins such as the Gippsland and Otway Basins. Each prospect-style will be characterized by distinct thermal signatures, and there is an urgent need to develop appropriate strategies for evaluating geothermal resource opportunities in the different prospect styles.

This document outlines a plan for developing improved geothermal targeting strategies suited to the needs and timescales of industry. The plan is to develop:

1) a comprehensive suite of prospect specific targeting strategies, appropriate to the full diversity of Australian geothermal prospects.

2) a coherent and efficient workflow for integrating all available information into a more rigorous framework for assessing uncertainties and quality of available data.

On the longer term there is a need for a much more robust heat flow data set against which to evaluate the thermal structure of the Australian continent. There is no quick fix available here, with the problem reflecting lack of past investment in basic heat flow studies. Fortunately, there is already a renewed effort in understanding the thermal structure of the continent, through GA's onshore energy program and ARC supported geothermal research at the University of Melbourne. Any new program in developing an appropriate suite of geothermal targeting technologies must be closely aligned with these ongoing programs designed to improve the baseline heat flow dataset.

In addition there is clear need to develop additional geophysical techniques to augment our understanding of the geothermal prospects in non-traditional ways. We know for example that remote sensed data can be used to monitor the thermal state of the surface of the Earth. If such methods can isolate signals of less 1 in 10,000 of derivative data related to heat flux through the surface, they could in principal isolate the crustal heat flow variations from those induced by climatic and paleoclimatic effects. This is a tall ask, but one that has the potential to be transformative. Similarly seismic and other geophysical probing methods carry some thermal signatures (eg. seismic velocity is temperature dependent) that help in understanding the thermal structure of the crust, and are presently underutilized. Evaluating such potential represents a high-risk strategy for the industry, but one that has transformational potential.

This proposal outlines a research program that addresses these issues in the context of the needs of industry.

The needs of industry

Efficient targeting of geothermal resources must attach to two questions:

1) at the tenement scale the geothermal explorer is interested in prospect appraisal in order to build an appropriate exploration case (egs, aquifer, power generation, direct use etc). How can the explorer make informed estimates of prospects at the tenement scale?

2) at the reservoir scale the geothermal explorer needs to understand how to 'reduce risk' in targeting drilling programs. How does the explorer define optimal targets at the reservoir scale?

A key ingredient in efficient optimal targeting lies in understanding and evaluating uncertainties in the thermal structure of the shallow crust. The explorer needs to be sensitive to temperature variations as little as 5°C at depths of up to 5 kilometers. The ability to isolate and predict such subtle variations at depth, and quantify uncertainties, in the face of sparse and often poor quality near-surface data presents a major risk. While the is no substitute for deep high quality heat flow data, the lack of existing deep bore holes in most regions combined with the short time-scales for exploration investment decisions demands dealing with available constraints. The need is therefore to develop methodologies that provide robust evaluation of the reliability of available constraints. In many ways this represents a classic opportunity for new approaches to geothermal inversion.

A research program for "geothermal targeting technologies"

To address the issues raised above in the context of a research program for geothermal targeting technologies, several parallel research programs will need to be undertaken. In orders of priority, assessed against the immediate needs of industry, the research program need to deliver:

1) *a suite of prototype exploration models for the Australian Geothermal Industry*.

2) Near surface expressions of deeper thermal anomalies depend on the nature of the geothermal prospect. 'Egs' prospects associated with anomalous heat production are associated with positive heat flow anomalies. Insulator dominated prospects can be associated with negative surface heat flow anomalies. Combined hot-rock insulator systems will have complex surface expressions that need careful elucidation. Convective systems will show surface heat flow patterns unrelated to distribution of subsurface thermal property structure. Understanding the range of prospects and their surface expressions is therefore crucial and will need to be understood in a regional context. This program will produce a suite of appropriate targeting methodologies appropriate to the range of geothermal prospects that Australia offers. Key targets will include our most prospective acreages, including the South Australian Hot Rock province, the Gippsland and Perth Basins.

3) *An efficient thermal modeling workflow that includes inversion capability*.

4) A key to successful targeting will lie in evaluating the reliability of the information we have already at hand. By applying geophysical inversion methodologies uncertainties can be evaluated in a quantitative sense giving a framework for evaluating the significance of the available information, and how best and most efficiently to add new value, for example by designing optimal shallow drilling campaigns. To do so requires development of efficient workflow's that link available constraints to geothermal computational engine. Many of the

appropriate geothermal computational solvers are already available and extremely scalable versions are being developed under the federal government's NCRIS AuScope initiative. There is an obvious opportunity to integrate with these developments in AuScope by adding inversion approaches and developing efficient and transparent methods for inputing geological constraints (through such technologies ad Geomodeller).

5)

6) *Assessments of new geophysical technologies.*

7) Acquisition of high quality heat flow data is painfully slow and expensive (especially when drilling costs are factored in), and there is a clear need to advance new geophysical methods for assessing geothermal prospects. Geophysical imaging techniques offer some insights, while remote sensed data offer different avenues. For the longer term benefit of the industry there is a need for an adventurous program in evaluating new, potentially transformative, but high risk techniques in the context of an appropriate set of geothermal testbeds in each of the main prospect types.

8)

Budget

	UoM		Industry				Federal
			HDRL		Intrepid		
	In kind*	Cash*	In kind*	Cash*	In kind*	Cash*	Cash*
Year 1	220		102		102		600
Year 2	220		102		102		520
Year 3	220		102		102		540
Year 4	220		102		102		560
Year 5	220		102		102		580
Total	**1100**		**510**		**510**		**2800**

*in $1000's

Budget Justification

Federal funding will be used to support appointment of three key research staff (at postdoctoral level) in each of the three main program areas, research assistance serving all three programs including acquisition of crucial new data and development of testbeds for each of the prototypes, and the requisite infrastructure to initiate the projects in a timely fashion.

The University of Melbourne will provide in kind support for a project leader at 0.5 ft equivalent, and accommodation of appointed staff and access to university facilities as needed to conduct their research.

Industry partners will contribute effective theme leader contributions at 0.2 ft equivalent, plus access to existing computational resources to the value of $50k per year.