First Annual Report

Moomba Project
GEL 185

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1 Introduction

1.1 Background

Two principal components are required for a heat reservoir within the earth’s crust to achieve the required temperature for commercial power generation:

(a) Primary heat production within the reservoir

The primary heat production from within a buried body results largely from radioactive decay of minerals within the body. Hence, large bodies which are relatively rich in such minerals will have the ability to generate anomalously large amounts of heat. In particular large, late stage granite plutons or large mineralised systems rich in radioactive minerals are potential targets.

In addition, the temperature of such reservoirs would be enhanced if they are located in an area of anomalous heat flow within the crust, such as the fairly well defined area occupying much of northeastern South Australia.

(b) Insulation of the heat reservoir

It is essential that the heat generated within the reservoir be trapped effectively, and the most efficient natural insulators are fine grained sediments, in particular carbonaceous shales or coal seams. Modelling by others indicates that around four to five kilometres of sedimentary cover would be required to blanket a granitic heat reservoir to ensure sufficient heat was retained. Large mineralised systems rich in radioactive minerals may require less sedimentary cover, possibly as low as two to three kilometres.

Following review of public domain information, the Moomba North area in the northeast of South Australia was selected as it appears to exhibit certain of the key model parameters in terms of geothermal energy as summarised above.

Importantly, Geodynamics Limited has already made significant progress in demonstrating the technical robustness of the general area for geothermal power generation. To date, Geodynamics has successfully drilled into and hydraulically stimulated the target heat reservoir (granite) in its initial well, Habanero 1. High temperatures in the target granite have been confirmed (>250°C at 4421m depth), a stimulated zone in excess of that expected has been obtained in testing and overpressures (35Mpa) have been discovered in the target granite due to existing joints and fractures containing water under pressure. This later feature is believed by Geodynamics to enhance the potential efficiency of the project.

Clearly a significant part of the initial technical risk of Eden’s Moomba North proposal has been addressed by Geodynamics work. Accordingly, Eden’s work program will benefit from Geodynamics program but will be tailored to addressing more particularly specific issues pertaining to its area.

1.2 Licence Data

Geothermal Exploration Licence 185 was granted on 14th May 2005 with an initial term of five years over an area of 494km².

Figure 1 shows the licence locations.

1.3 Period

In accordance with Section 33 of the Petroleum Regulations 2000, this report details work conducted during the first permit year of GEL185.

2 Work Requirements

The revised Year 1 work programme negotiated by Eden with PIRSA for the combined Witchellina GELs (166,167, 168) comprised:

* Geological and geophysical review (to be carried out in the area covered by GELs 166, 167 & 168).
3 Work Conducted

In year one, work has focussed on a thorough review of all available geological and geophysical data to ensure the technical robustness of the Moomba North site. Review of all relevant drilling data from both within the area and surrounds was begun. Year One work was designed to reduce the relative technical risk, and confirm that the initial assumptions about Moomba North as a suitable site and to lay the groundwork for the next stages of the work programmes.

3.1 Geological Review

During the first year of the licences, Eden has focussed on acquiring and reviewing all the available open file data relevant to the project area.

A review of the published literature on the geology of the region was undertaken. GEL185 is located near Moomba in the Eromanga Basin in close proximity to the advanced operations of Geodynamics Pty Ltd. There are strong regional trends with continuity of structural elements between the two tenements resulting in similar geothermal conditions. Consequently the Geodynamics program provides a close analogue for future operations on GEL185.

3.1.1 Structural Geology

The Cooper Basin is extensively described in Gravestock et al (1998). It is a north-easterly oriented intracratonic basin located in northeastern South Australia and southwestern Queensland. It is filled with mainly terrestrial sediments showing fluvial, coal measure and lacustrine affinities ranging from Lower Permian to Triassic age. The oldest sediments have some glacial attributes. Unconformably overlying the Cooper Basin is the much more extensive Eromanga Basin, a broad intra-cratonic sag feature containing Jurassic-Cretaceous fluvial, lacustrine and marginal marine sediments with significant coal-bearing intervals. High geothermal gradients in the area are associated with the low thermal conductivity insulating properties of the basin sediments (and in particular the coal measures).

The Cooper-Eromanga Basin sediments have been subjected to several tectonic movements that began with periods of extension during the Permian. Later wrench-induced northeast-southwest compressional stress...
caused basin-wide folding and faulting during the Triassic with reactivation of palaeofaults and structural contacts. Following reactivation in the Early Cretaceous, the Eromanga Basin suffered maximum subsidence under marine conditions. Late Miocene crustal shortening imparted a period of east-west compression on the basin resulting in widespread folding, trancurrent faulting and reverse faulting. These periods of reactivation have produced a significant number of major structural traps providing a focus for hydrocarbon exploration in the Moomba region particularly in the Nappamerri and Patchawarra Troughs along with their adjacent structural ridges.

3.1.2 Basement Condition

Numerous geophysical surveys have been conducted in the Moomba area for oil and gas exploration. The basin structure has been extensively outlined by seismic profiling and the stratigraphy has been confirmed by deep drilling. Completion logs are available in many locations. However the geothermal potential of the region has been more directly established by Geodynamics Pty Ltd in their exploratory Habanero geothermal wells. Geodynamics have previously targeted basement granites with anomalous concentrations of U, K, and Th. There are no significant lateral anomalies identified in that region and consequently the Habanero observations are immediately relevant.

In particular Geodynamics report that the initial drilling indicates that the underlying granite is a medium to coarse grained, reduced granite with relatively high abundances of radiogenic elements. The heat generation capacity, based on these abundances, is in the range 7-10 watts/m³, around three times higher than a typical granite. The granite was originally a two-mica granite with accessory tourmaline, but it has suffered from extensive burial metamorphism since being covered by the sedimentary blanket. Effectively all the biotite has been altered to chlorite, and plagioclase has been altered to albite+calcite+hydrated Ca-silicates. Widespread alaskite dykes and irregular bodies invade the coarser grained normal granite. The granite was previously dated using zircons as Carboniferous, but new monazite dating to be carried out in this project is expected to provide a better age estimate.

Evidence from borehole imaging logs indicate that sub-horizontal joints and fractures dominate the fracture systems in the granite. These fractures are expected to make ideal pathways for fluid flow and heat extraction. In an operation known as hydraulic stimulation the fluid permeability of these fractures is increased by pumping water into the fractures at high pressure. This enhanced fluid pressure causes optimally oriented fractures to exceed the critical state for slip. The resulting micro-earthquakes are mapped with an acoustic monitoring network. For the current project, a network of 4 shallow, 3 moderate depth, and one deep well has been constructed. Mapping of micro-earthquake hypocenters with this network will then provide the basis for positioning the production wells. Similar projects overseas have shown that following slip, the permeability of a granite joint is enhanced by many orders of magnitude.

3.2 Modelling & Interpretation of Geophysical Data

Public domain magnetic and gravity data were compiled and re-processed.

3.3 Thermal Data Review

Professor James Cull from Monash University reviewed geothermal constraints for the area and undertook preliminary modelling of thermal parameters.

3.3.1 Geothermal Constraints

The geothermal exploration program conducted by Geodynamics has been accompanied by extensive documentation on geological and geophysical conditions in the area. Many details have been released at public meetings, in conference proceedings and in company progress reports. Similar geothermal conditions are expected for any future developments in GEL 185.
Geodynamics report that temperatures of approximately 240°C are observed at depths of 3700m near the top of the granite basement. The temperature gradient in the granite results in an increase in the rock temperature by ~3°C for every 100m into the granite. The high temperatures at these depths relate to a number of independent geological conditions coinciding in the area:

- the presence of low conductivity sediments overlying the granite;
- the optimal thickness of these sediments which allows access to hot rock without needing to resort to the expensive drilling equipment required for drilling beyond 5km depth;
- a granite chemistry containing relatively high abundances of radiogenic elements giving high heat productivity (high heat production or HHP granite);
- the previous unroofing of the Palaeozoic granite which resulted in brittle unloading features; and,
- the existence of high tectonic stresses in the sediments and granite leading to low fluid permeability, conductive heat flow and minimised heat loss by convection.

There are multiple seismic sections available in the area and the subsurface structure is relatively well known from extensive programs of oil exploration. Similarly several deep wells have been drilled on the margins of GEL185. However interpretations are largely irrelevant in view of the extensive direct geothermal data available from the Geodynamics drilling program at Habenero.

### 3.4 Recommendations from Data Review

Cull (2005) concluded that in view of the proximity of the Eden Energy GEL in relation to the Habanero drilling conducted by Geodynamics no additional survey work is required in the immediate future. It is anticipated that technology developed for the Habanero site can be readily adopted or modified for the extraction of geothermal power on the adjacent blocks.

In the longer term, several specific drill sites will be selected in relation to regional lineaments and favourable stress fields identified from airborne magnetic data. Direct targeting of hot rocks or saline fluids within shear zones may be possible using magnetotelluric (MT or AMT) profiles to detect zones of anomalous electrical resistivity and surveys options will be assessed.
4 Year 1 Expenditure

Table 1

Commercial in Confidence

5 Year 2 Work Programme

Activities scheduled for Year Two are designed to secure funds for subsequent, higher cost aspects of the work program, better define the target reservoirs by conducting specific, targeted geophysical surveys (if required) and selection of a suitable initial test drill site.

Work planned for the second year of GEL 185 will be designed to increase our knowledge of the depth to basement and heat flow in the project area.

Part of this aim will be accomplished by assessing the use of a magnetotelluric (MT) survey.

6 Compliance with the Petroleum Act (Reg. 33)

6.1 Summary of the regulated activities conducted under the licence during the year

Eden has not undertaken any regulated activities as defined under the Petroleum Act in GEL 185 during the licence year.

6.2 Report for the year on compliance with the Act, these Regulations, the licence and any relevant Statement of Environmental Objectives

Given that no regulated activities were undertaken during the reporting period, many of the regulations are inapplicable at this stage and no non-compliances have been noted, with the exception of late submission of this report.
6.3 **Statement concerning any action to rectify non-compliance with obligations imposed by the Act, these regulations or the licence, and to minimise the likelihood of the recurrence of any such non-compliance**

Eden recognises the importance of achieving regulatory compliance and is committed to achieving appropriate practices in its management strategies, work practices and procedures. Eden is committed to operating in an environmentally and socially responsible manner.

6.4 **Summary of any management system audits undertaken during the relevant licence year, including information on any failure or deficiency identified by the audit and any corrective action that has, or will be, taken**

Eden is a new company and is developing appropriate systems and documentation to cover Field Operations, Environmental Management, Health and Safety issues and compliance checklists to ensure the requirements of relevant Acts and Regulations are met.

Eden’s activities have been essentially desktop studies at this stage and no management system audits have been undertaken as yet.

6.5 **List of all reports and data relevant to the operation of the Act generated by the licensee during the relevant licence year**

Most of the work conducted during the first licence year comprised compilation of various public domain data and preparation of a number of memoranda by consultants. The contents of the memoranda have been incorporated into this report.

No new surveys or data relating to the tenement have been acquired.

6.6 **Report on any Incidents reportable to the Minister under the Act and Regulations during the relevant Licence Year**

No reportable incidents occurred.

6.7 **Report on any reasonably foreseeable threats (other than threats previously reported on) that reasonably present, or may present, a hazard to facilities or activities under the licence, and a report on any corrective action that has, or will be, taken**

No threats have been identified.

6.8 **Statement outlining operations proposed for the ensuing year**

See Section 5 above.
7 Key References
