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Frome Project - Statement of Estimated Geothermal Resources

Introduction and concept

Geothermal Resources holds 100% of 10 Geothermal Exploration Licences (GELs) located in the Frome Basin region in northeastern South Australia (Figure 1). These GELs cover an area of approximately 5,000 square kilometers and are collectively referred to as the Frome project.

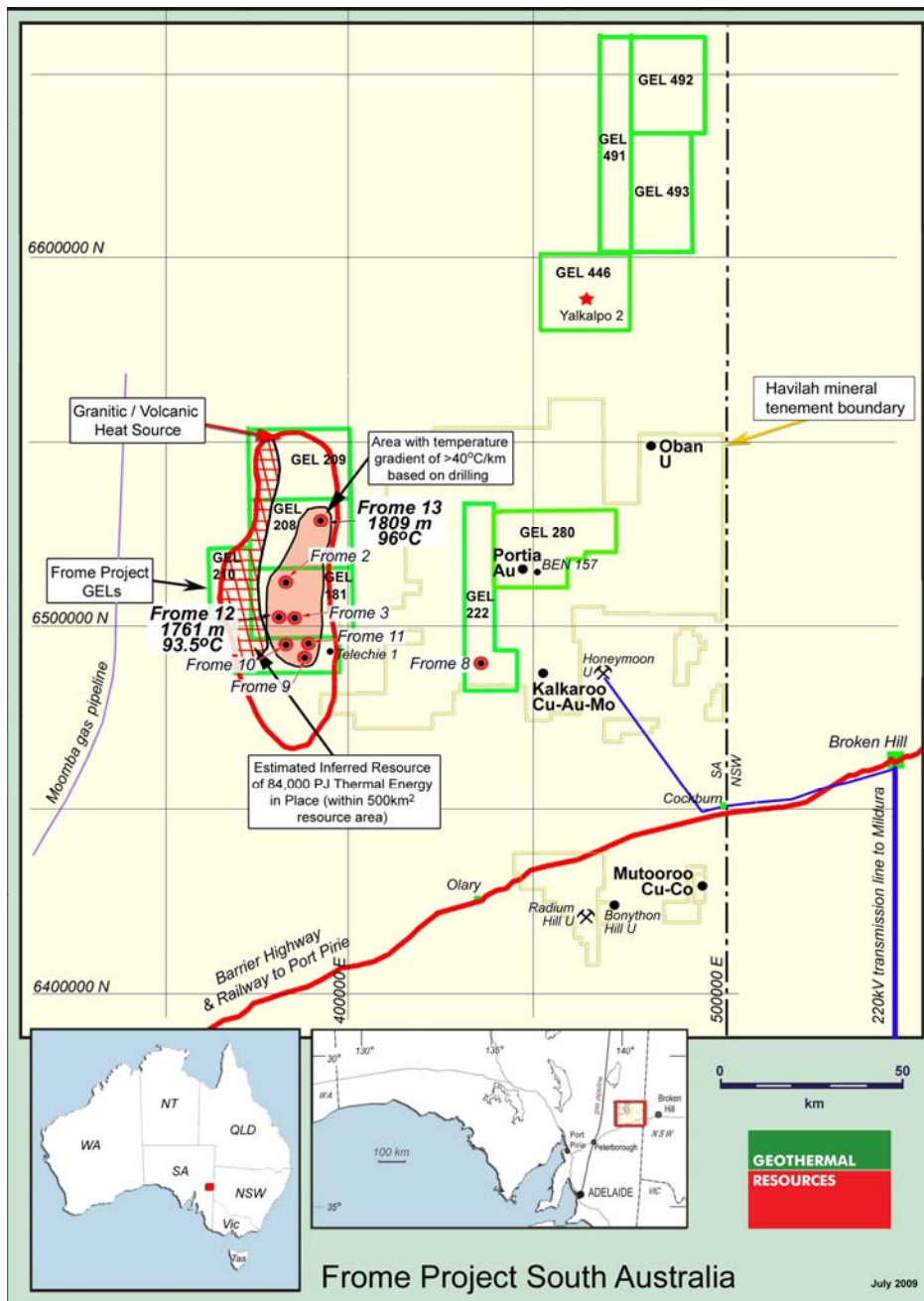
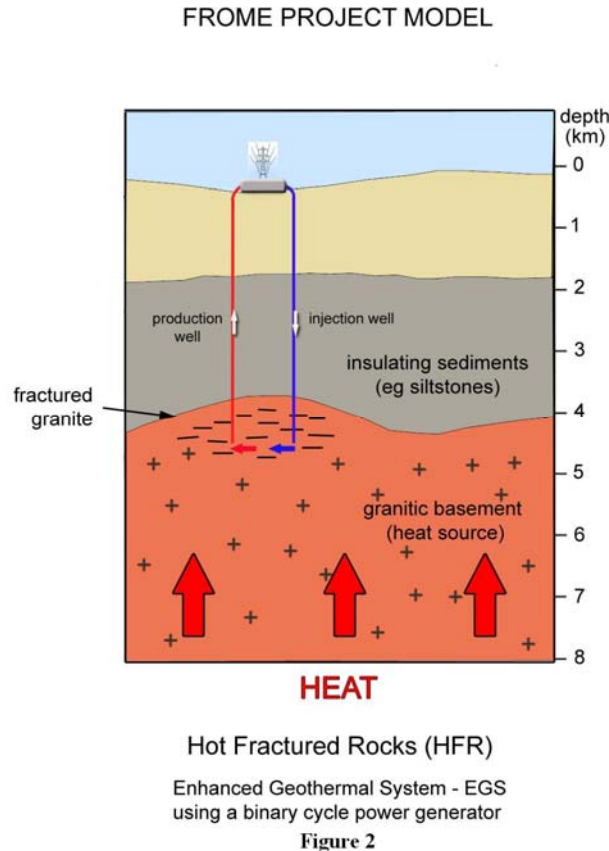


Figure 1 Location of Frome project, drillholes, GELs and resource area

The Frome project is based on the Hot Fractured Rock (HFR) geothermal model, similar to that successfully demonstrated by Geodynamics for their Cooper Basin project (Figure 2). In this model the heat source is radiogenic granitic rock that is buried deep beneath a thick pile of insulating sediments. The extensive amounts of trapped heat are exploited by setting up a heat exchanger hot water circulation system in the granite, whose natural fracturing is stimulated by hydrofracturing.



The purpose of this report is to present a geothermal resource estimate for the Frome project that is in accordance with the Geothermal Reporting Code 2008. It has been prepared by Dr Chris Giles whose qualifications include a PhD thesis and several scientific papers relating to the geology and geochemistry of granitic and volcanic basement terrains in SA of the type lying beneath the Frome project area. He is very familiar with the geology of the basement rocks of the region through his involvement with successful mineral exploration of the area over the last decade.

The report should only be quoted in full. Neither Geothermal Resources nor Dr Giles takes any responsibility for selective quotation of the report or if quotations are not made in their correct context.

Geological Setting

The Frome project area covers an unexposed portion of the Precambrian age Curnamona Province that is blanketed by a locally thick sequence of Neoproterozoic and Cambrian sediments of the Moorowie Sub-basin, with a thinner cover of Mesozoic and Tertiary sediments in places.

The Precambrian granitic basement rocks outcrop to the south of the Frome project area. These rocks are abnormally enriched in primary uranium, evidenced by numerous historic uranium mines and prospects. They are characterised by strong radiometric responses, as a result their high content of radiogenic elements, namely uranium, thorium and potassium. As a consequence, their heat

producing capacity due to natural radioactive decay is abnormally high by world standards.

Gravity data for the region shows a marked gravity low associated with these granites, which extends northwards under the Moorowie Sub-basin, covering an area of more than 4000 km². According to PIRSA depth to basement interpretations compiled from seismic, gravity and borehole data, the Moorowie Sub-basin thickens rapidly northwards from the outcropping basement rocks, reaching depths of more than 5 km in the central portion of the basin (Figure 3).

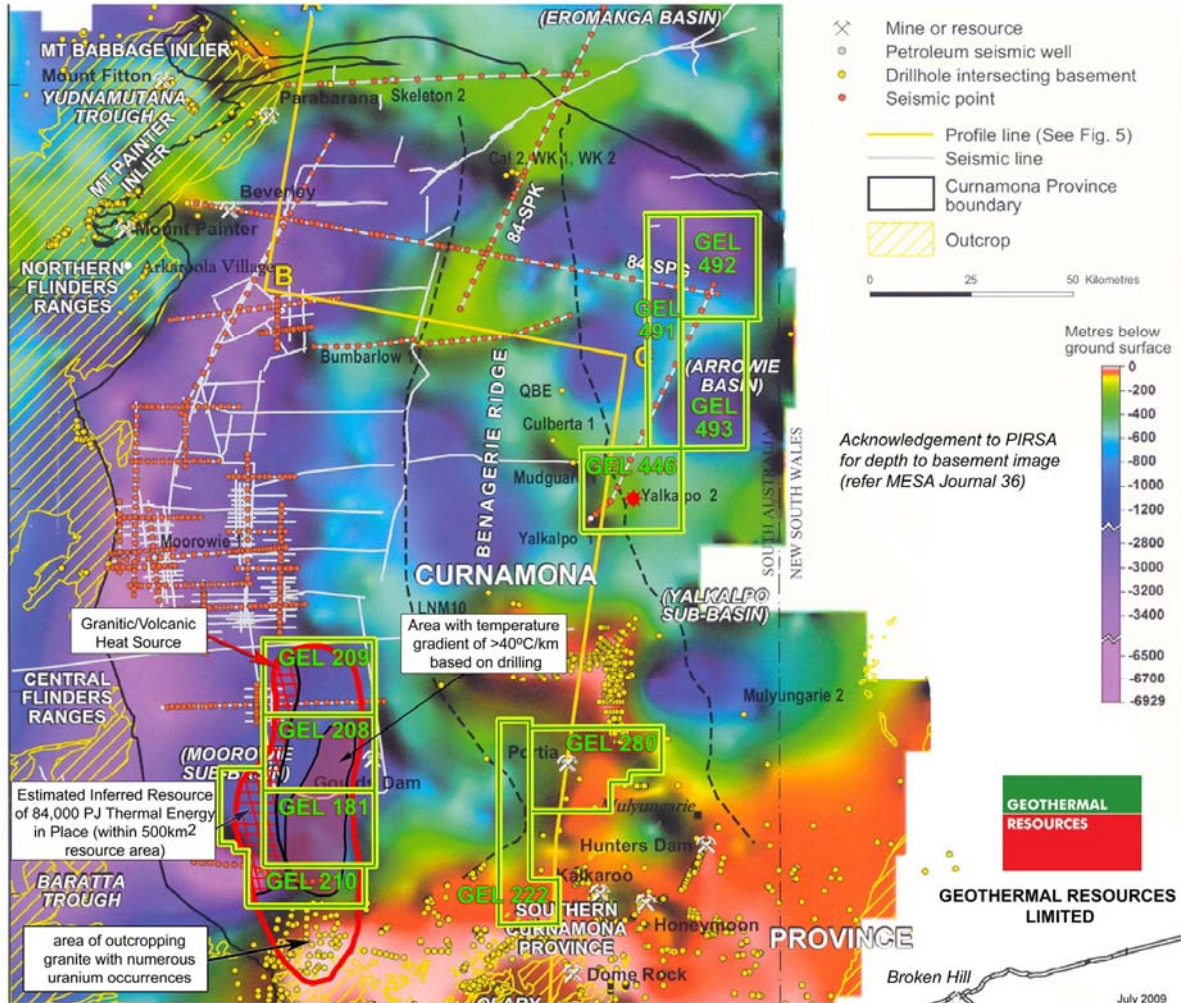


Figure 3 Depth to basement map compiled by PIRSA showing GELs and resource area

Geothermal Resources’ GELs were pegged to cover the area of the gravity low and interpreted granite in the subsurface beneath the Moorowie Sub-basin. In this regard the general geological setting appears very analogous to the Cooper Basin HFR geothermal field. The results of a 2003-2004 Government sponsored seismic traverse line through the area supports the view that the gravity low is caused by a large body of granite at depth. Assuming a depth extent of 4 km, the total volume of granitic rocks is estimated to exceed 5,000 km³ within the Frome project area. The granite is covered by a sedimentary pile that is interpreted to range from 1-4 km in thickness within the project area.

Drilling and Temperature Measurements

Since commencement of exploration of the Frome project three years ago, Geothermal Resources has completed 8 exploration wells, with all but one located within an area of approximately 1000 km² above the interpreted granite body (Figure 1). These wells have been drilled by various methods to varying depths, the deepest wells to date being Frome 12 and Frome 13 (to 1761 and 1809 metres depth, respectively). Systematic down-hole temperature logging has been completed

for each well, allowing an accurate geothermal gradient to be calculated in each case, as summarized in the following table.

Well	Total depth of well (m)	Well temperature [@ depth (m)] (°C)	Overall well temperature gradient (°C/km)	Temperature at top of granite (°C)	Projected temperature at 4,000 m (°C)
Frome 2	500	42.5 [@ 496 m]	38.6	Not intersected	
Frome 3	500	44.9 [@ 443 m]	46.8	Not intersected	
Frome 9	505	42.5 [@ 492 m]	37.2	Not intersected	
Frome 10	261	35.5 [@ 244 m]	44.3	Not intersected	
Frome 11	255	35.9 [@ 255 m]	44.0	Not intersected	
Frome 12	1,761	93.5 [@ 1761 m]	41.1	84.5 [@ 1471 m]	190
Frome 13	1,809	96.0 [@ 1809 m]	40.5	92.9 [@ 1703 m]	187

This drilling has confirmed several important points :

1. The geological concept of a buried granitic heat source in the Frome project area is proven by the intersection of granite at 1471 metres depth in Frome 12, some 50 km from the nearest basement granite outcrop. Interpreted comagmatic volcanic rocks of similar geochemical character to the granitic rocks were intersected in Frome 13 at 1703 metres depth.
2. In drill core the granite in Frome 12 shows clear evidence of frequent and regular subhorizontal fracturing. Such natural fracturing can potentially be stimulated by hydrofracturing to enhance permeability in the granite.
3. Temperatures measured in all drillholes above the granite body clearly indicate above average temperature gradients capable of generating temperatures of around 185 to 190°C at 4 km depth.
4. The drilling conditions are comparatively straightforward and would appear to present no particular difficulties drilling to greater depths.

Assumptions and uncertainties in resource estimation

The present resource estimate relates to an area of 500 km² (referred to as the “resource area”) lying within the gravity low and where available seismic data indicates that the top of the granite is around 3 km depth, (Figure 1). Assuming the granite is 4 km thick in this area, then the potential volume of the granitic heat energy reservoir is at least 2,000 km³.

Temperature data from Geothermal Resources drilling cited above indicates a uniformly high average geothermal gradient of > 40°C/km within the area encompassing drillholes Frome 2, 3, 9,10,11,12 and 13 (Figure 1 and above table). This accords with the expected similarity in chemical composition of the granitic and comagmatic volcanic rocks with respect to heat producing elements across the entire region, and also the uniform thickness and composition of the blanketing sediments. Based on these observations, and the assumption of uniform thermal conductivity of the granite and a relatively small heat flow variation across the granite body, this geothermal gradient is extrapolated to the resource area. Geodynamics made similar assumptions when estimating thermal energy resources for their Habenero and Jolokia well sites.

A temperature gradient of 31°C/km within the granite has been measured in Frome 12, which penetrated 290 metres into the granite. Again, based on the above assumptions, this within granite temperature gradient may also be extrapolated to the resource area for the purpose of this resource estimate.

At this stage of exploration, in the absence of production tests to measure water flow rates through the granite heat exchanger, heat recovery factors are unknown. Based on observation of drillcore in Frome 12, it is evident that the granite does have abundant natural sub-horizontal fractures and there are reasonable expectations that hydrofracture stimulation will enhance the permeability. Whether this will be sufficient to produce adequate water flow rates through the granite geothermal heat exchanger can only be determined by production testing in the future.

Estimated resource of thermal energy in place

Estimation of the thermal energy in place within the granite body is based on the following key data inputs that are largely derived from Geothermal Resources drilling:

1. An average regional temperature gradient of 40°C/km (with a surface temperature of 25°C) and an average temperature gradient within the granite of 31°C/km, implying temperatures of 145°C at the top of the granite at 3 km depth and 207°C at 5 km depth.
2. The average temperature in the granite between 3 and 5 km ie. ~ 175°C.
3. A cut-off temperature for an Organic Rankine Cycle binary power plant of 135°C. This cut-off temperature reflects a considered balance of the many factors that affect it. Some of these factors include:
 - the efficiency of the selected Organic Rankine Cycle unit which in turn relates to the selected organic liquid,
 - the flow rate of the primary liquid/brine,
 - the water quality (eg. silica, carbon dioxide, chloride, calcium and magnesium contents),
 - the proximity of the resource to an end user (eg. mining company),
 - the proximity of the resource to the transmission network,
 - the 'feed-in' voltage, and
 - the available 'feed-in' price.
4. The difference between the average granite temperature (175°C) and the cut-off temperature for an Organic Rankine Cycle Heat Exchanger (135°C) ie. 40°C.
5. The specific heat capacity of the granite. Literature values for granites range between 0.69 and 0.80; a typical value of 0.79 J/g/°C is used [The Engineering Tool Box ¹].
6. The density of the granite. Literature values range from 2.64 to 2.76 g/cm³; a typical value of 2.7 g/cm³ is used [Handbook of Chemistry and Physics (2004) ²].
7. The thermal capacity of the granite of 2.1 PJ/km³/°C (obtained from the data in points 5 and 6 above).
8. The estimated volume of the heat energy reservoir from the top of the granite at 3 km to a depth of 5km over the 500 km² area specified, amounting to 1,000 km³.

Using these parameters an **Inferred Resource estimate for the thermal energy in place for the defined resource area is 84,000 PJ**. The Inferred Resource status reflects the uncertainty concerning how much of this in place thermal energy will ultimately prove to be recoverable.

If a conservative heat recovery factor of 20% is applied [based on Tester et al. (2006) ³] then the potentially recoverable thermal energy based on the above Inferred Resource estimate is 16,800 PJ. If the conversion efficiency to electricity is assumed to be 10% [based on Tester et al. (2006) ³] then this amount of recoverable thermal energy has an estimated generating potential of 460,000 GWh.

Resource Area	Estimated thermal energy in place PJ	Potential recoverable thermal energy PJ	Electricity generating potential GWh
500 km ²	84,000	16,800	460,000

Determination of the heat recovery and reservoir parameters, so that the thermal energy in place estimate can be assigned a measured resource status, which implies a high level of confidence in the recoverability, is an ongoing objective of the project. This will involve drilling two deep wells (>3km), subsequent fracturing of the granite between the two wells, followed by open and then closed loop testing of water flow and heat energy extraction rates.

Acknowledgement

Estimation of thermal energy resources in HFR systems is a fledgling scientific endeavour, with few examples or precedents to follow. In producing the current resource estimate, Dr Giles acknowledges that he has adopted the conservative and scientifically logical resource estimation methodology first reported by Geodynamics for their very similar Cooper Basin HFR geothermal system.

Dr K R Johnson
CHAIRMAN

This geothermal resource estimate has been compiled by Dr Chris Giles in accordance with the guidelines defined in Edition 1 (2008) of the “Geothermal Reporting Code, 2008”.

Dr Giles is a member of The Australian Institute of Geoscientists and is employed by the Company on a consulting contract. He has sufficient experience which is relevant to the style of geothermal play under consideration to qualify as a Competent Person as defined in Edition 1 (2008) of the “Geothermal Reporting Code, 2008”.

Dr Giles consents to the release of the information compiled in this report in the form and context in which it appears.

Enquiries should be directed to Dr Bob Johnson, Chairman, on (08) 83389292

References Cited

¹ http://www.engineeringtoolbox.com/specific-heat-capacity-d_391.html

² *CRC Handbook of Chemistry and Physics: A Ready-reference Book of Chemical and Physical Data*, 85th edition. Edited by David R. Lide. (CRC Press, 2004).

³ TESTER, J. W. et al. 2006. *The Future of Geothermal Energy: Impact of Enhanced Geothermal Systems (EGS) on the United States in the 21st Century* (Cambridge, MA: Massachusetts Institute of Technology).