Status of the Paralana 2 Hydraulic Stimulation Program

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The Paralana Engineered Geothermal Project is located 600km north of the city of Adelaide in South Australia (Figure 1). The project is testing for viable geothermal resources, within a sedimentary basin that lies immediately east of known high heat producing Mesoproterozoic basement rocks of the Mt Painter Region. In this area, 2D reflection seismic survey data and potential field geophysical (aeromagnetic, magneto-telluric and gravity) data delineate a major half graben informally termed the Poontana basin. Based on the interpreted geophysical data, Petratherm postulates that the high heat producing basement rocks observed in outcrop, continue under the insulating cover material, with the maximum thickness of the sedimentary cover in sections of the Poontana Sub-basin being modeled at greater than five kilometres. This favourable arrangement of thick sediments overlying anomalously radiogenic basement suggests that the Paralana area is an ideal location to test the development of an Engineered Geothermal System.

Petratherm Limited in joint venture with a major oil and gas (Beach Energy) and power industry energy utilities (TRUenergy) are initially seeking to build a 7.5 MWe commercial power development to supply a local mine. In the second half of 2009 a deep geothermal well (Paralana 2) was drilled to 4012m. The well was designed as an injector, the first of an initial two well program to prove circulation between wells. An innovative strategy for development of the EGS reservoir is planned, involving massive hydraulic stimulation of multiple target zones within the sedimentary overburden. Multiple zone stimulation increases the chance of achieving a commercial flow rate which is the key commercial barrier for EGS developments around the world.

Keywords: EGS, Drilling, Fracture Stimulation

Paralana 2 Well Completion

The planned multizone stimulation of Paralana 2 involved the well being fully cased and cemented to allow better control on what intervals in the well would be stimulated in a cost effective manner. In the past, open hole hydraulic stimulations resulted in the main frac developing at the zone of least resistance which is usually at the base of the casing shoe (lowest pressure point) or a locations where large natural fractures already occur. This in effect leaves much of the open hole unaffected by the stimulation program. Being the first well, Paralana 2 was designed as an injector with the advantage of simplifying the well design and allowing learning from this well to be incorporated into the well design and planning of the production well (Paralana 3) to maximize the chances of achieving a commercial flow rate.

During drilling of the lower 8 ½” section several fractures were encountered below 3400 m. High torques, drilling breaks, an increase in well-bore deviation followed by inflow of geothermal over pressurized brines provide strong indications for the presence of a natural and permeable fracture system between depths of about 3690 m and 3864 m. Increased rates of penetration during drilling through the fractured zones indicate a change in rock strength possibly related to open fractures. Shut in pressures indicated an overpressure of approximately 3,300 psi and the mud system required weighting up to 13.2 ppg to stop the inflow, and allow drilling to continue safely.

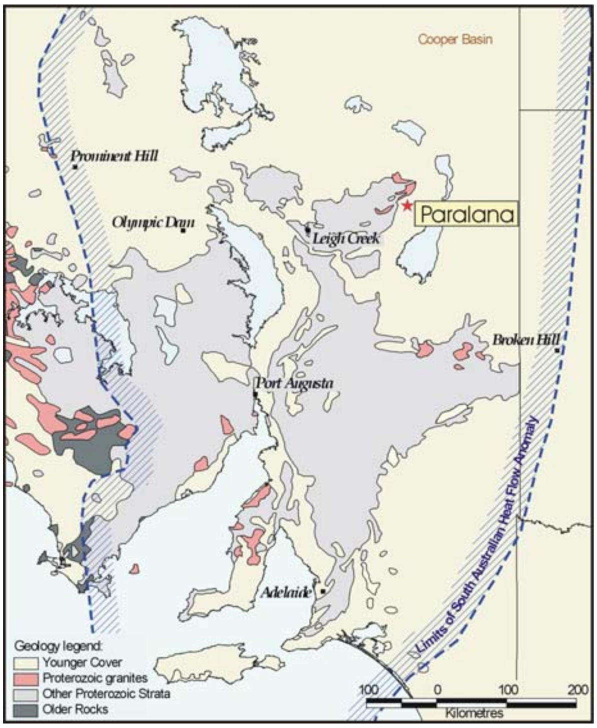

Figure 1: Regional Locality Map and extent of SAHFA (SAHFA modified from Neumann *et. al* . 2000)

Due to wellbore stability problems the characterization of this zone was limited to logging while drilling measurements down to 3740 m depth. The final 7” casing string was run to a depth of 3725 m as below this depth the well was too unstable to be able to set casing and cement in place (Figure 2).

Paralana 2 Geology

The litho- stratigraphic and structural environment of the Paralana Project area is complex and weakly constrained. The interpretation of the stratigraphic succession and lithology of the overlying Phanerozoic sequences and their contact with the underlying Adelaidean strata at Paralana-2 is based on the results of drilling Paralana-1B, drilled 1.5km to west of Paralana-2. The Cambrian-Adelaidean unconformity is interpreted at 1115m and the sequence begins with the Amberoona Fm. The Tapley Hill Formation was entered at 1612m in Paralana2 and its contact with the underlying Sturtian Glacials has been interpreted at about 1803m. At 2855m, a 500meters thick haematic metaquartzose with siliceous cement underlies the tillite and grades to a litharenite with depth. Its age is ambiguous, but the metasediment is still considered as Adelaidean, within the Sturtian Tillite or the Callanna Beds.

At 3397m, a major change of lithology was observed during the drilling, associated with a key unconformity. It is related to a strong reflector observed on the seismic. Below the contact, the lithologies are mainly composed of dolomitic siltstones and sandstones, interbedded with numerous intervals of felsic tuffs. Several dolerite horizons are intercalated in the package, from a depth of 3450m to the bottom of the hole. Zircons extracted from the volcanic tuff returned a $^{207}Pb/^{208}Pb$ age of 1585±11Ma using a LA-ICPMS technique at the University of Adelaide. At 3910m, Paralana 2 entered a felsic intrusive, confirming high heat production rate of the basement of approximately 10 to 12µWm^{-3}, and showing a similar Mesoproterozoic age of 1580±10Ma.

Numerous intervals of fractures were encountered in the lower zone of the well based on interpretation of the logs and experienced during the drilling operation. A more complex tectonic history and the presence of dolerite in the sequence are indicated by a chaotic seismic signature below 3400m. The thick homogenous quartzite overlying the basal sequence is highly competent with rock strengths ranging between 16,000 (110MPa) and 29,000 psi (200MPa) as calculated from the sonic logs. This unit may be considered to act as a top seal to the fractured, overpressured unit below.

MEQ array

The Paralana Micro-seismic monitoring array has been operational since April 2008, recording the background seismicity at the Paralana Geothermal Project site. The array has recently be up-graded to a real-time monitoring network to enable Petratherm and the joint venture partners to actively record, analyse and locate microseismic events during the stimulation of the geothermal reservoir. The growth of the fracture network during fracture stimulation will be monitored by seismologists from the Institute of Earth Science and Engineering, Auckland, New Zealand. The array combines sensitive downhole sondes with surface seismometers to enable the interpretation of a wide spectrum of seismic events. All events will be analysed, with auto-picking software, MIMO, developed by the Norwegian Seismic Array (NORSAR), providing data on the event location and magnitude.

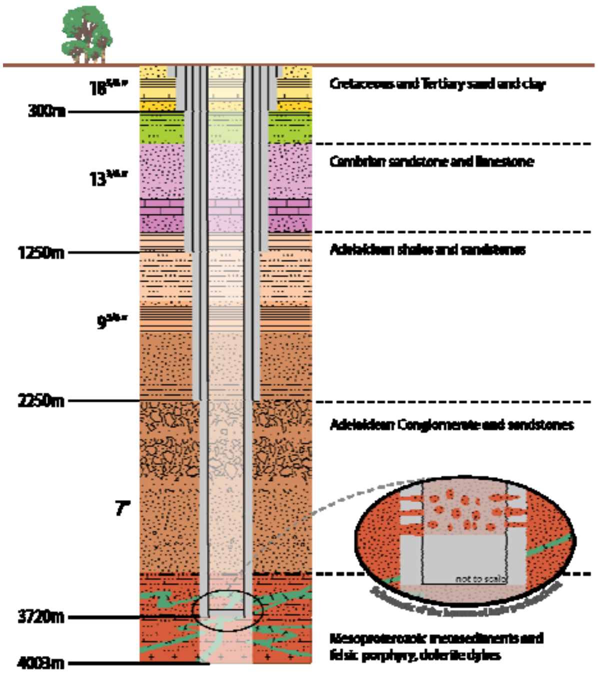

Figure 2: Paralana Well Completion and Geological log.

Stimulation Program

The initial stimulation program is to be undertaken in two stages. The Stage 1 Injectivity test involves perforation of the steel casing near the bottom of the Paralana 2 well and injection of a small volume of water to confirm fracture initiation and propagation. The test aims to derive information of the insitu stress regime, reservoir properties and determine if the well is already connected to fractures of the natural overpressured zone encountered during drilling.

The Stage 2 fracture stimulation involves injection of larger volume of water at higher rates. The stimulation aims to create a fracture network and connect to and enhance the existing natural fracture network intersected lower in the well. The stimulation also aims to generate significant micro seismic events, measured by the MEQ array, greater than 500 metres from the well bore. The volume and rate of the stimulation will be dependent on the micro-seismic response and adjusted to meet the objectives. A series of stepped injection rate tests are planned during the stimulation to observe the development of the fracture network. Post the main water stimulation, tests will be performed to determine the injectivity flow rates. This will be followed by production testing if the well allows, to understand longer term reservoir performance. Acidizing and use of proppant with gel in the fracture stimulation is contingent on data obtained from the injectivity test. A second interval may be stimulated dependent on the results of the initial stimulation.

References

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