



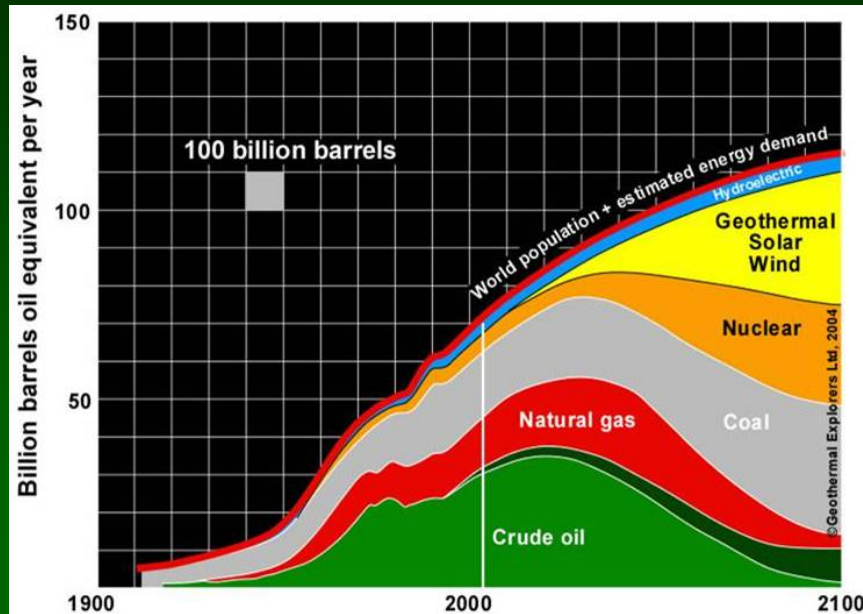
# The role of Geothermal Energy in a Diversified Clean Energy Portfolio

The 2<sup>nd</sup> Hot Rock Energy Conference

Adelaide, 17<sup>th</sup> February 2006

Presentation by Graham Jeffress outlining Eden Energy's strategy concerning the hydrogen economy & the role geothermal energy has as a potential major source of clean H<sub>2</sub>

## 21<sup>st</sup> Century Energy Demand Predictions



From Geothermal Explorers Ltd

World populations continue to expand, currently around 6 billion, with predictions around 9 billion by 2050.

- Energy demand will need to grow to support this population as well as deal with global climate change & the decrease in energy available from petroleum.
- Petroleum production will peak sometime in the next decade – Hubbard's Peak – thereafter reserves are depleting faster than replacement
- Technologies such as nuclear power, clean coal combustion & geothermal are needed to supply energy for the world's population & standards on living in developing economies.
- Most alternative energy sources – nuclear, wind, solar - will provide power but are not well suited to transport applications except via heavy battery solutions with limited range & performance.
- Transport needs a high energy density, light, low pollution & easy to manage system analogous to existing petroleum technologies.
- Hydrogen based technologies provide the answer.

Graph from the Geothermal Explorers website.

**Earth is a  
water planet  
(70% of its  
surface).**

- An energy system based on water is sustainable
- Goal is make the energy consumption part of the water cycle



- Earth is a water planet.
- An energy system based on the hydrogen in water will be sustainable
- By moving to a hydrogen based economy, rather than hydrocarbon-based, we can transfer energy consumption to the water cycle rather than the carbon cycle.
- This results in an environmentally minimal impact – both in terms of climate & pollution - as well as an effectively infinite energy supply.

## Factors Driving Transition to Hydrogen

- Concern that global oil production has peaked
- Concern over dependence on Middle East oil
- Concern over global climate change / warming
- Air pollution

In essence there are four main factors driving the need for a transition to a hydrogen economy.

1. Hubbard's Peak & the recognition that global oil production has either peaked or will do so in the near future, with other petroleum resources due to suffer the same fate in due course.
2. Continuing & possibly increasing instability in Middle East – the source of most of the world's easily extractable petroleum, e.g. the situation in Iraq & now the looming nuclear issue with Iran, as well concerns over the lack of alternatives to balance cartel pricing strategies.
3. Widespread recognition of climate change & possible anthropogenic drivers is leading to significant political & economic changes in the way power is generated & transport systems are driven.
4. Serious problems with air pollution, especially in countries such as China & India, where the rapid industrialization & growth in living standards has created the most polluted cities in the world.

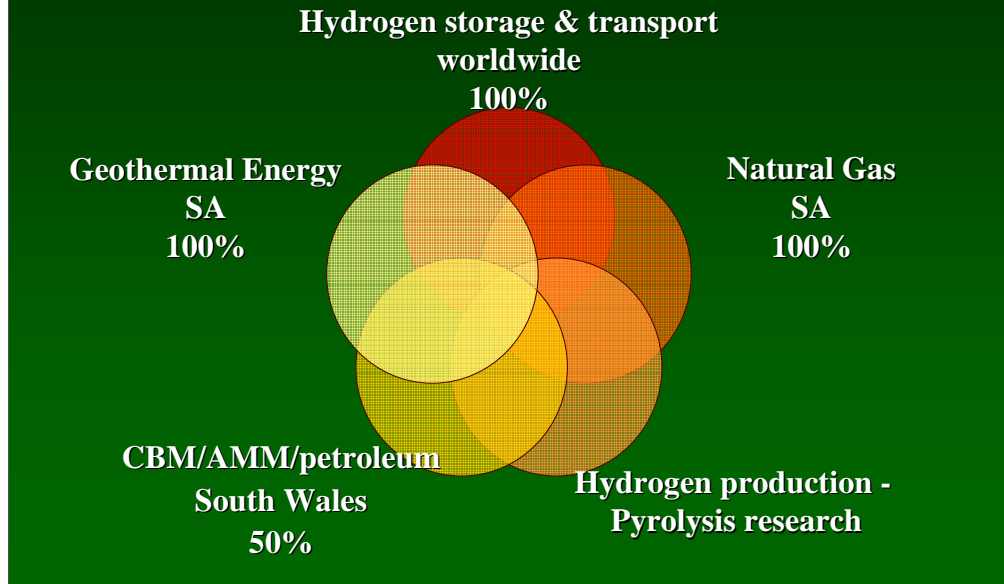
## Global Hydrogen Initiatives

- In 2003 EU budgeted €2.8 billion over 10 years
- Clean Energy States Alliance (12 US States) committed USD 3.5 billion over 10 years on alternative energy
- Germany set CO<sub>2</sub> targets for 2008 & 2012 for vehicle companies to achieve using hydrogen & other fuels; & plans 10,000 H<sub>2</sub> filling stations by 2010
- Iceland plans to phase out all hydrocarbon fuels in 50 years & use geothermal power to make hydrogen for local consumption & export
- Western Australia – AUD 10 million for hydrogen fuel cell bus trial

Just some examples of global progress on the hydrogen economy, also,

- Wales has established the Hydrogen Valley Initiative & Alternative Fuels Strategy
- Canada has initiated the Hydrogen Highway Project
- California has a program for Zero Emission Vehicles (ZEV), with hydrogen cars forming major part of planned solutions

## Eden Energy - Strategic Plan A Diversified Clean Energy Portfolio



Eden Energy Ltd is a new diversified clean energy company seeking listing on the Australian Stock Exchange in early 2006. Eden has interests in hydrogen storage & transport fuel systems, including the low emission Hythane® hydrogen-methane blend, a revolutionary cryogenic storage & superconducting magnetic electrical storage device, coal seam & abandoned mine methane, conventional gas, low temperature pyrolysis research into hydrogen production & geothermal energy production.

All these aspects of Eden's business are part of an integrated strategy to become a major global participant in the alternate energy market, particularly focussing on the clean energy transport market, producing hydrogen without any carbon emissions, transporting the hydrogen to markets & providing the engines to power hydrogen-based transport & energy solutions.

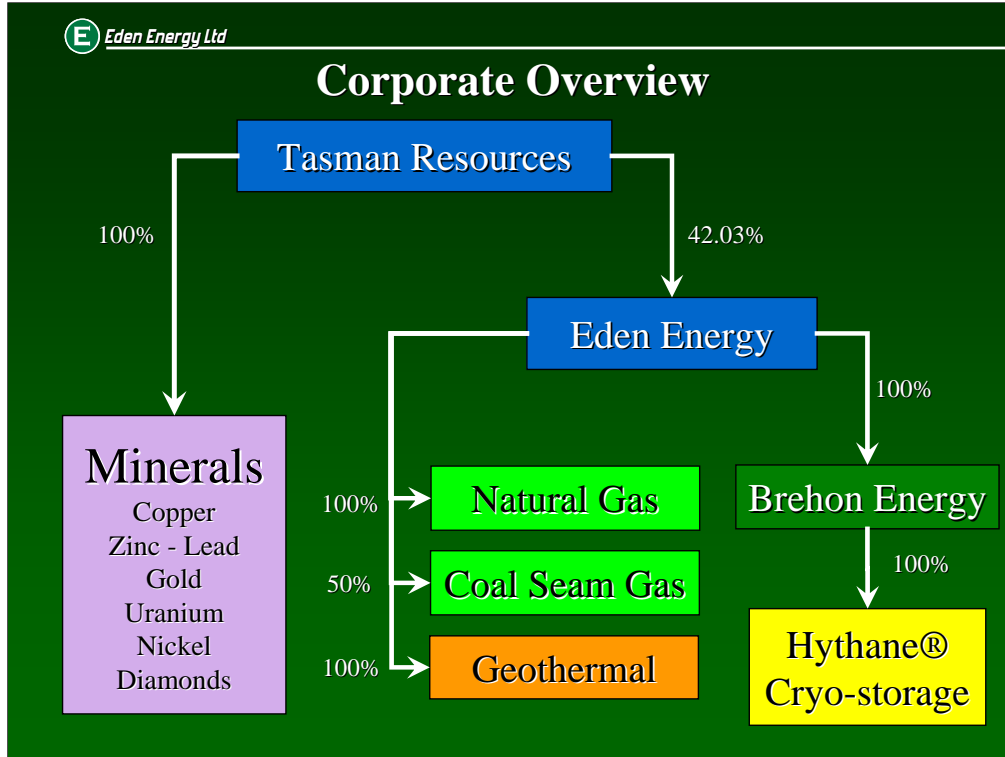
Eden is exploring for geothermal resources in a number of target areas:

- At Witchellina, northwest of Leigh Creek;
- North of Renmark, on the Murray River;
- Around Moomba in the Cooper Basin, adjacent to Geodynamics & at Bollards Lagoon; &
- At Mungeranie, in the southwest Eromanga Basin region on the Birdsville Track.

The company is pursuing a prospecting-style strategy, aiming to test a number of different geothermal target types, ranging from the deep hot fractured granite model near Moomba & at Mungeranie, relatively shallow (2-3km) heat sources associated with buried radiogenic iron oxide & granite at Witchellina & enhanced permeability zones in the Renmark Trough associated with elevated heat flows.

If successful, Eden will target electricity markets & clean hydrogen production.

For more information visit <http://www.edenenergy.com.au>



Eden Energy is a diversified energy company with direct interests in Geothermal energy & Natural gas & through it's 100% owned subsidiary, Brehon Energy, interests in hydrogen & Hythane®. Eden also has JVs in South Wales concerning CBM, AMM & petroleum exploration projects.

Eden will be seeking a listing on the ASX.

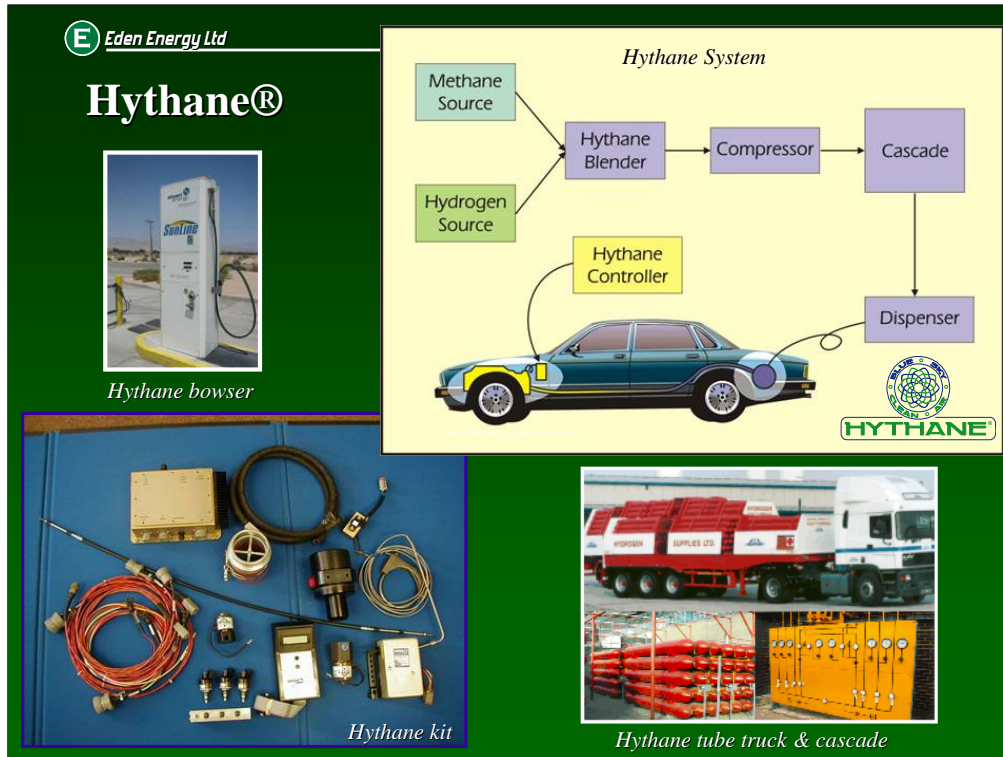
## Applications

	CNG (Methane)	<i>Hythane</i> ®	Hydrogen
<b>Application</b>	Cars, Trucks, Buses, Rail, Ships	Cars, Trucks, Buses	Cars initially
Fuel		<i>Hythane</i> ®	
Tank	Methane, CNG, LNG, light weight tanks	<i>Hythane</i> ® tanks cryogenic Liquid Compressed gas	Hydrogen Tanks cryogenic Liquid Compressed gas
Fuel Systems	Refueling Pumps Conversion kits	Refueling Pumps Conversion kits Reliquefaction	Refueling Pumps Reliquefaction On-boards systems
R&D	Light weight tanks	Advanced <i>Hythane</i> ®	Advanced hydrogen tanks, Power distribution

A significant proportion of Eden’s strategy is based on the hydrogen technologies it controls through it’s subsidiary Brehon Energy.

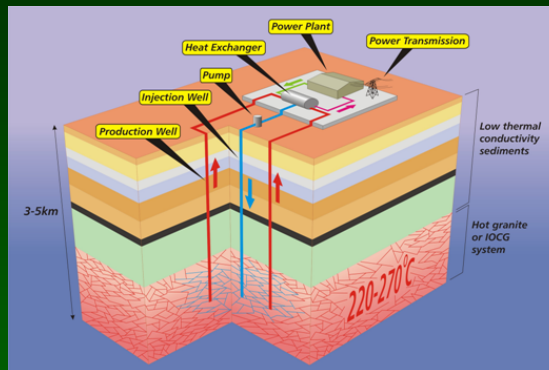
- Brehon Energy’s objective is to make hydrogen the future alternative fuel of choice.
- Brehon proprietary processes include cryogenic hydrogen & liquid hydrogen storage tanks & systems.
- Brehon owns the registered trademark & patents for *Hythane*®.
- Brehon offers a range of flexible alternative fuel systems to meet customer demand.





- Hythane® is a combination of cryogenic hydrogen & natural gas. It utilizes the existing CNG infrastructure to facilitate the transition to hydrogen.
- 5-7% by energy H<sub>2</sub>/Natural gas blend
- Major reductions in CO<sub>2</sub>/NO<sub>x</sub> emissions (at least Euro5), recent conversion of Yuchai engine achieve Euro 4 at first attempt
- H<sub>2</sub> burns the fuel more efficiently & thereby produces significantly fewer pollutants
- Proven technology based on 15 years experience, real world trials in Montreal & California
- Uses existing CNG infrastructure
- Can use waste H<sub>2</sub> streams (>90% H<sub>2</sub>) – such as steel works, chemical plants, glass float works
- Immediately marketable transition fuel

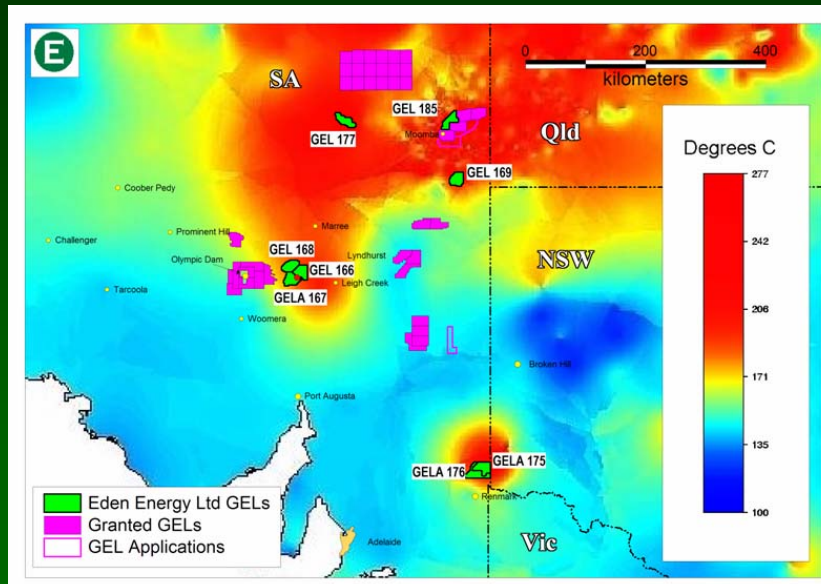
## Reasons for Eden's Geothermal Interests



- Large amounts of clean, green, power available
- Direct retail of electricity
- Use of power to produce 'clean' hydrogen to power hydrogen based transport fuels & hydrogen economy

- Large amounts of clean, green, power available
- Direct retail of electricity
- Use of power to produce 'clean' hydrogen to power hydrogen based transport fuels & hydrogen economy
- Hydrogen production - either, electrolysis, pyrolysis or reformation

## Eden's SA Geothermal Exploration Tenements



Eden has GELs over 5 project areas in SA

- GEL 166,167,168 – Witchelina, between Leigh Creek & Olympic Dam
- GEL 175,176 – Renmark, immediately north of the Murray R. on the NSW/SA border
- GEL 169 – Bollards Lagoon, South of Moomba
- GEL 177 – Mungeranie, on the Birdsville Track
- GEL 185 – Moomba North, adjacent to Geodynamics tenements

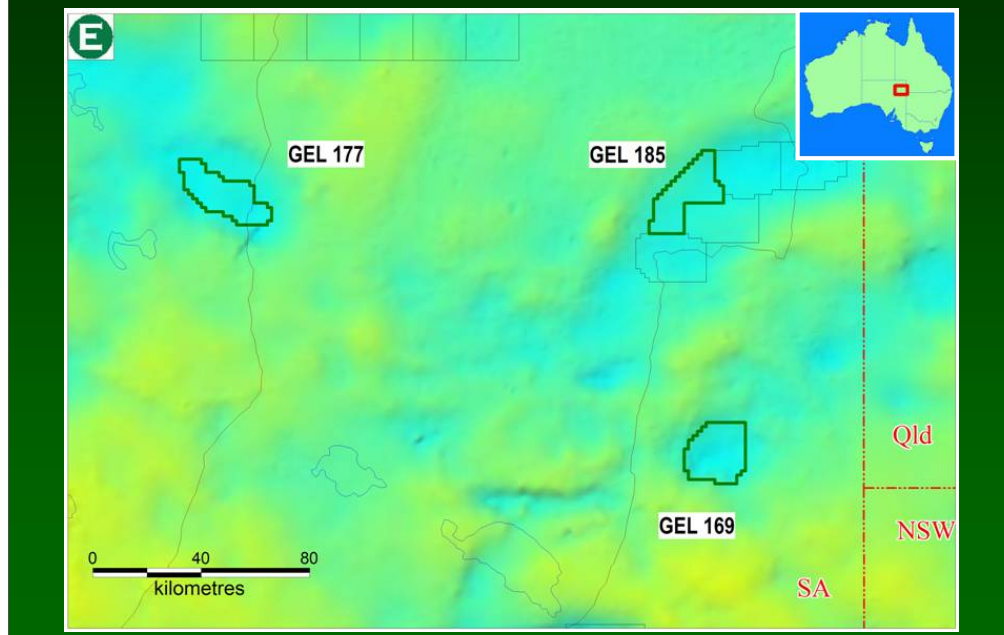
ANU image showing estimated temperature at 5km depth

## Eden Geothermal Exploration Strategy

- Prospecting approach
- Multiple target types
- Staged approach
  - Target characterization → geophysics, open file data
  - Geothermal gradient – 300-600m slim hole
  - Heat flow estimates – conductivity - modelling
  - Target ranking
  - Deep test hole – temperature confirmation, stress regime

AIM: Find the hottest shallowest geothermal resource close to infrastructure

## Eromanga Projects on gravity image



### Moomba North

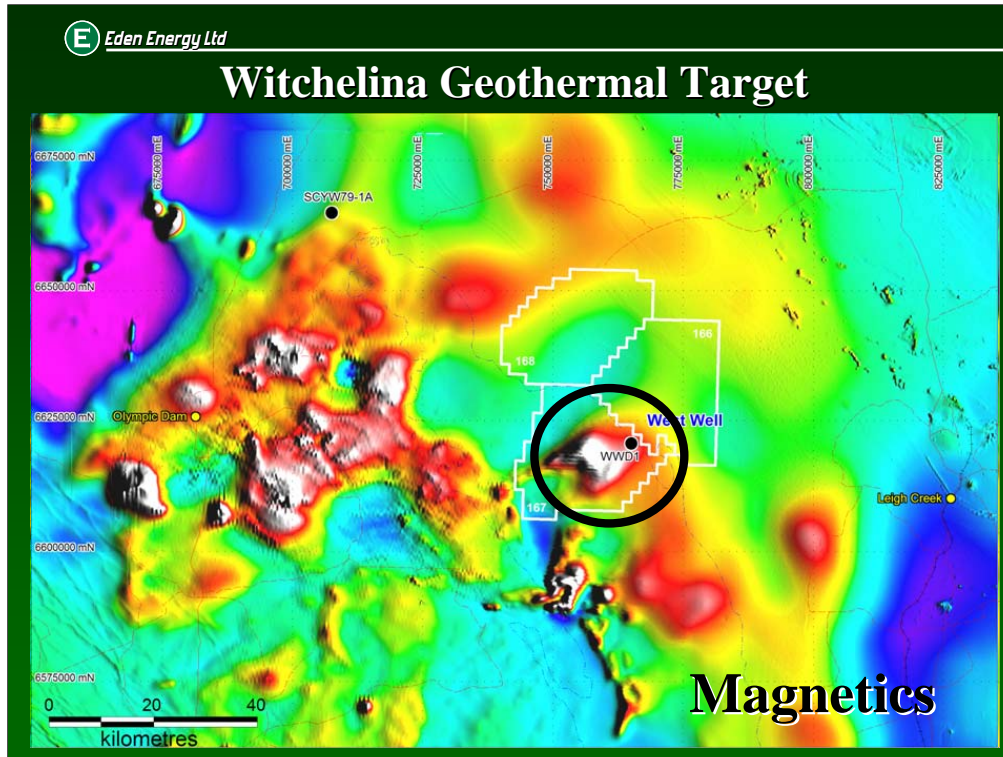
- GEL185 is located near Moomba in the Eromanga Basin in close proximity to the advanced operations of Geodynamics Pty Ltd. There are strong regional trends with continuity of structural elements between the two tenements resulting in similar geothermal conditions. Consequently the Geodynamics program provides a close analogue for future operations on GEL185, but with attention to permeability at shallower depths either in porous sediments or in natural fracture systems associated with major structures

### Bollards Lagoon

- GEL169 is located south of Moomba, around Beach Petroleum's **tenements**, in the Eromanga Basin on structures related to the Cooper Basin model developed by Geodynamics Pty Ltd. Although it is outside the Cooper Basin depo-centre there are significant sediment sections in the Tennapera Trough providing good thermal insulation for basement granites. In addition there is some evidence for regional lineaments providing a focus for fracturing & aquifer development in basement sections.

### Mungeranie

- On Birdsville Track north of Lake Eyre
- GEL177 is located in the Eromanga Basin on the southern margins of the Simpson Basin. Basement granites resemble those of the Moomba area in terms of heat production but cover appears more limited. Temperature data from holes the area however suggest that interesting temperatures are likely to occur at depths greater than 4km.



Located between Leigh Creek & Olympic Dam/Roxby Downs

Large magnetic & gravity anomaly under Lake Torrens

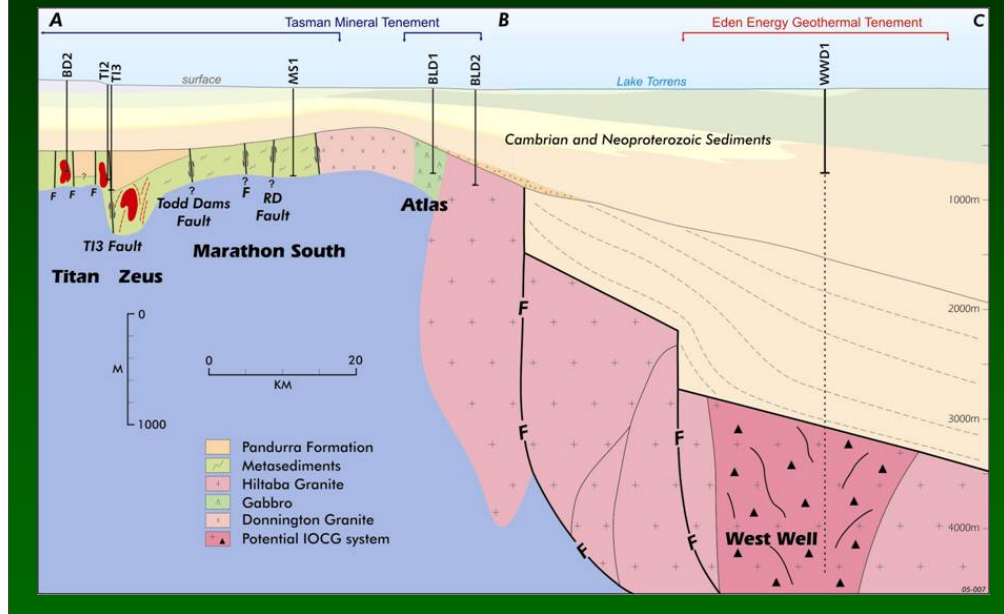
Recognized by WMC & test attempted in 1979 – they concluded that it was too deep to be of interest as IOCG

Petratherm's RIO concept – but in a location we feel has a better chance of a large iron oxide system with adequate insulation to have trapped a geothermal resource

Targets comprise two concepts either individually or in combination as a heat source:

1. A radiogenic iron oxide system; &
2. A uranium enriched Hiltaba granite

## West Well Geothermal Target Cross Section



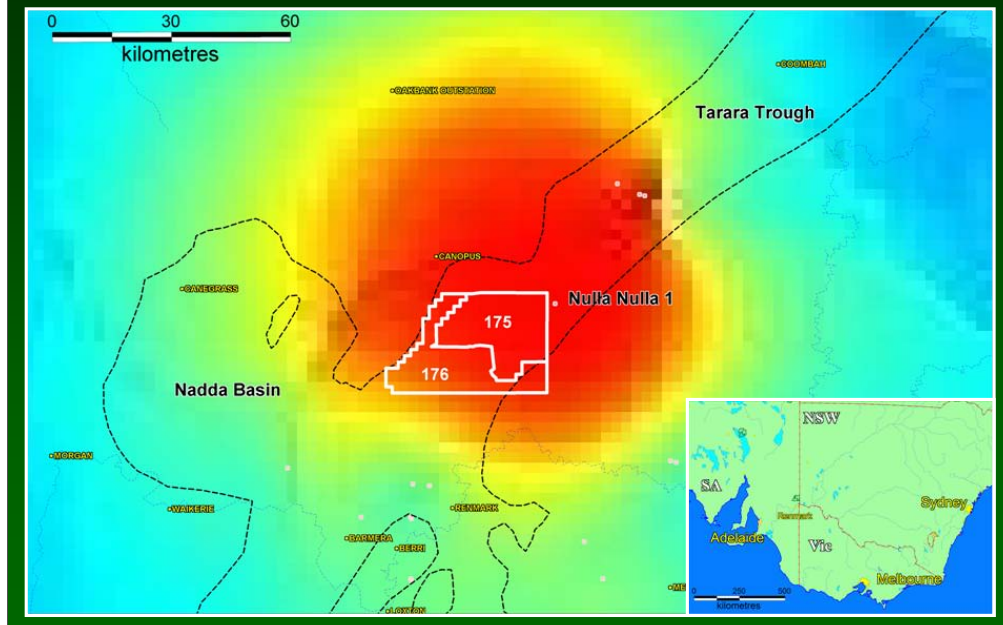
- Eden interprets the West Well geophysical anomaly to be due to a deeply buried iron oxide system, potentially radiogenic & anomalously hot
- Geophysical modelling & stratigraphic considerations suggest deep of iron oxide system to be around 3km depth
- There are also features suggestive of Hiltaba granite intrusions, which are commonly also radiogenically anomalous
- Substantial structures associated with the development of the Adelaide Geosyncline are likely to present, & contribute significant natural permeability if re-activated during subsequent tectonic activity
- The iron oxide complex itself is likely to be substantially brecciated
- The results of the recent Geoscience Australia seismic imaging around Olympic Dam support the proposed architecture of the interpretation

Plans:

Re-entry WWD1 and/or drill test hole

Estimate temp. gradient & model Heat flow

## Renmark Geothermal Target

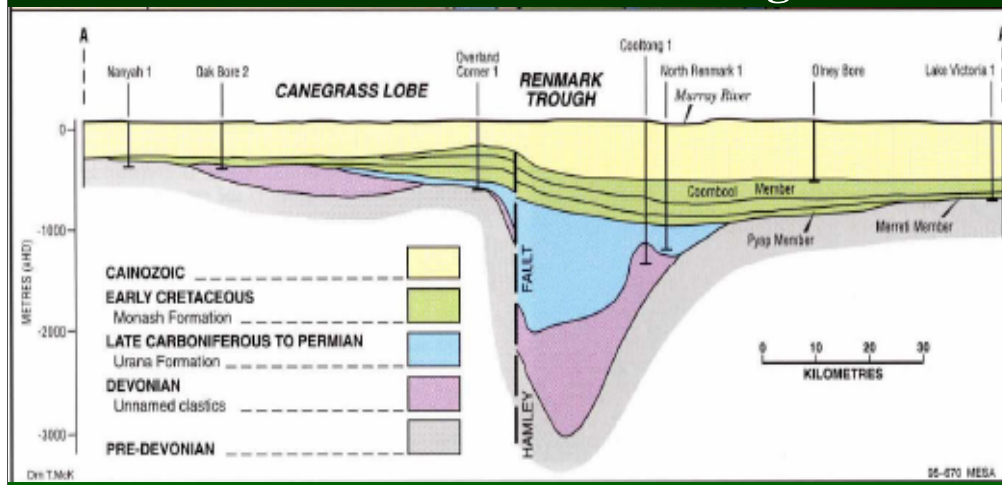


### Renmark Project

- Hot spot from ANU 5km depth temp. estimate image
- Hot spot lies within the Renmark-Tarara Trough – part of the Nadda Basin which underlies the Berri & Murray Basins
- Located north of the Murray River near Renmark on the NSW/SA border



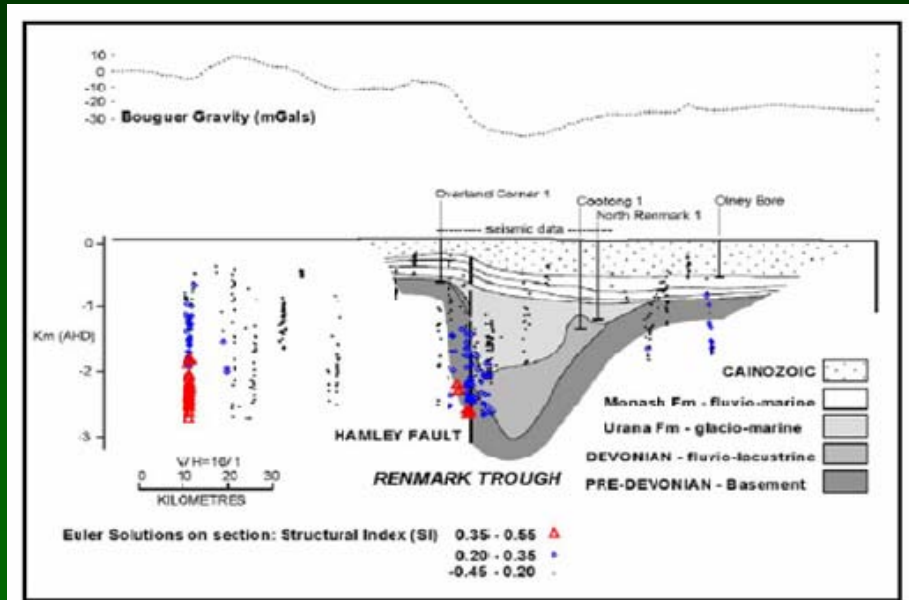
## Renmark Geothermal Target



- Murray, Berri & Nadda Basins
- Geothermal Gradient at bottom of NullaNulla1 was 60°C/km
- Coaly sediments in Monash Formation & Murray Basin
- Dimensions of basins poorly known

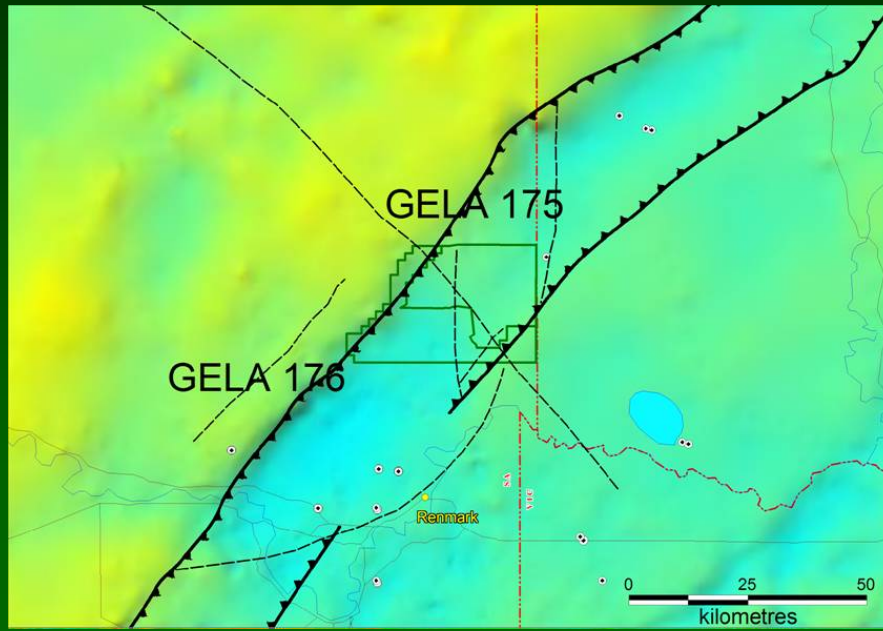
- Cross section of the Renmark Area taken from Geology of SA Vol2
- Limited understanding of geology of the region – only poor seismic refraction data from 60s/70s oil exploration & relatively few exploration wells
- Coaly sediments & coal known in the basins – excellent insulators

## Euler Solutions on section thru Renmark Trough



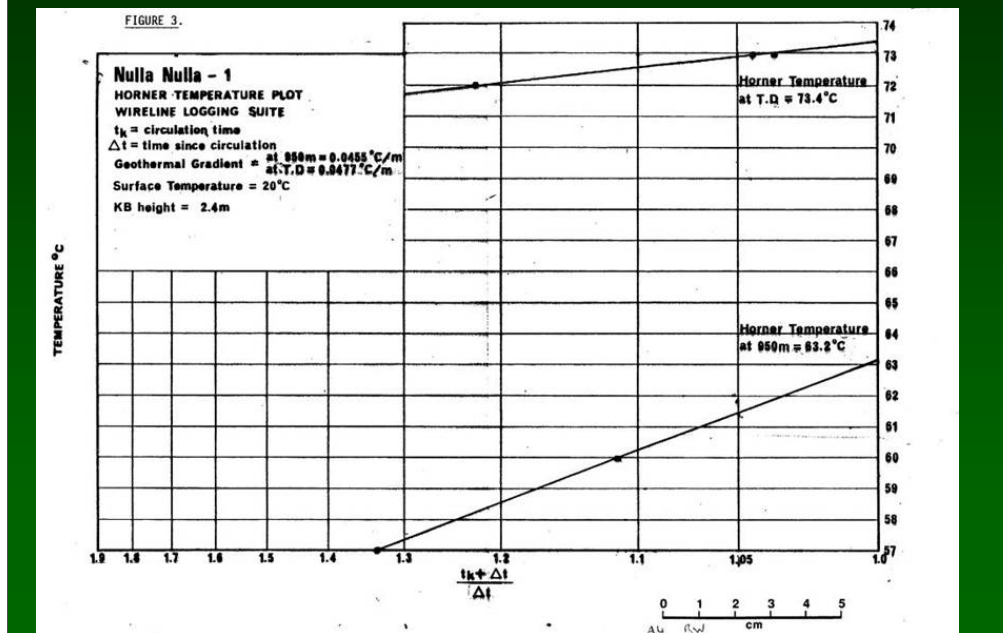
- Euler depth deconvolution of potential field data (gravity & magnetics) supports sediment depths greater than 2-2.5km
- Enough to provide a good insulating blanket to trap heat

## Renmark Project regional geophysics



- Regional geophysics showing interpreted major structures
- Structures → enhanced permeability zones
- Coaly sediments in Murray Basin & underlying basins (e.g. Monash Formation) provide low conductivity blanket to trap heat
- Regional heat flow 100-120mW/m<sup>2</sup>

## Nulla Nulla 1 Temp Data



- Horner plot suggests gradient of actual deep gradient of 61 °C/km from 950-1118m rather than hole average of 46 °C/km.

- Hole average indicates heat flow >120 mW/m<sup>2</sup>

- In conclusion, there is evidence that are:

- elevated heat flows;
- anomalous temp gradients in an area;
- with a deep trough of sediments, including coal; &
- naturally enhanced permeability from basin controlling structures;
- which, comprise an attractive geothermal target.

- Combined with favourable location of the site with respect to ADL, SYD & MEL, these factors make Renmark a high priority project for Eden.

## Summary

- Eden Energy is pursuing a diverse portfolio of clean energy projects
- Hydrogen technology, especially in transport applications, is a key component
- Geothermal power has the potential to provide power for direct retail & H<sub>2</sub> production
- Eden is pursuing a prospecting style strategy assessing multiple target types to locate the hottest, shallowest, geothermal resource near to infrastructure

[gjeffress@edenenergy.com.au](mailto:gjeffress@edenenergy.com.au)

Regardless of which groups succeed in developing viable geothermal projects in Australia Eden Energy will be seeking to produce clean green hydrogen using geothermal energy.