HDR Geothermal Exploration

Go To
Australia
↓
Drill a Deep Well
↓
Bingo
↓
Sorted

I CAN'T HELP FEELING YOU MAY HAVE OVER SIMPLIFIED OUR OBJECTIVES SOMewhat...
Hot Dry Rock Geothermal Exploration in Australia

Richard Hillis  
Scott Mildren  
Peter Reid

Martin Hand  
John Morton  
Scott Reynolds

Australian School of Petroleum Research  
Primary Industries and Resources SA  
Petra Therm  
Australian School of Petroleum Research
Hot Dry Rock Geothermal Exploration in Australia

- hot rock geothermal energy
- greenhouse driver
- hot rock exploration philosophy
  - thermally anomalous granites (TAGs)
  - radiogenic iron oxides (RIOs)
  - enhanced natural thermal systems (ENTs)
Hot Rock Geothermal Energy

- Fenton Hill (USA)
- Soultz-sous-Forêts (France)
- Rosemanowes (UK)
- Hijori & Ogachi (Japan)
- Basel (Switzerland)
- Bad Uhrach (Germany)
- El Salvador
- Cooper Basin (Australia)
Hot Rock Geothermal Energy

- ‘hot rock’
- ‘hot dry rock’ (HDR)
- ‘hot wet rock’ (HWR)
- ‘hot fractured rock’ (HFR)
Hot Dry Rock Geothermal Exploration in Australia

- hot rock geothermal energy
- greenhouse driver
- hot rock exploration philosophy
  - thermally anomalous granites (TAGs)
  - radiogenic iron oxides (RIOs)
  - enhanced natural thermal systems (ENTs)
Greenhouse Driver

Year 2000 Levels > 360 ppm
Greenhouse Driver

- Renewable Energy Act 2000
- Clayton’s Kyoto
- mandatory renewable energy target
- electricity generation from renewables
- reduce greenhouse emissions

Renewable Energy Certificates (RECs) ~$40/MWh: economic driver for hot rock geothermal energy
South Australian GEL Explosion

Geothermal exploration licence (GEL)

Geothermal exploration licence application (GELA)

National parks and reserves

South Australian Hot Flow Anomaly
Hot Dry Rock Geothermal Exploration in Australia

- hot rock geothermal energy
- greenhouse driver
- hot rock exploration philosophy
  - thermally anomalous granites (TAGs)
  - radiogenic iron oxides (RIOs)
  - enhanced natural thermal systems (ENTs)
Hot Rock Exploration Philosophy: Hot Rock Electricity Cost Pillars

- temperature
- drilling cost (i.e. depth)
- proximity to market
- flow rate
- above ground plant

\[
\{ \text{exploration for highest geothermal gradient, closest to market} \}
\{ \text{fractures & in situ stress} \}
\{ \text{‘off the shelf’} \}
Hot Rock Exploration Philosophy: Thermal Modelling

\[ Q = -k \frac{dT}{dz} \]

- high heat flow
- insulating cover sediments (low thermal conductivity)
Hot Rock Exploration Philosophy

- previously HR utilise known ‘hot spots’
- Petratherm has initially targeted the South Australian Heat Flow Anomaly
- TAGs
- RIOs
- ENTs

Neumann et al. (2000)
Philosophy:

- Geothermal exploration licence (GEL)
- Geothermal exploration licence application (GELA)
- National parks and reserves

South Australian Hot Flow Anomaly

Hot Rock Exploration

Electricity Grid

Petratherm

GELs &
Hot Dry Rock Geothermal Exploration in Australia

• hot rock geothermal energy
• greenhouse driver
• hot rock exploration philosophy
  ➢ thermally anomalous granites (TAGs)
  ➢ radiogenic iron oxides (RIOs)
  ➢ enhanced natural thermal systems (ENTs)
Thermally Anomalous Granites

‘Typical’ granite heat production: 2.65 $\mu$Wm$^{-3}$

UK HHP (High Heat Production) Granites:
- Cornubian granites: 3.7-5.3 $\mu$Wm$^{-3}$
- Grampians granites: 4.7-7.8 $\mu$Wm$^{-3}$
- Lake District granites: 3.5-4.9 $\mu$Wm$^{-3}$

Big Lake Suite
- Cooper Basin
- Carboniferous
- 11 $\mu$Wm$^{-3}$

Box Bore Granite
- Mt Painter Area
- Mesoproterozoic
- 22 $\mu$Wm$^{-3}$

Yerila Granite
- Mt Painter Area
- Mesoproterozoic
- 62 $\mu$Wm$^{-3}$
Thermally Anomalous Granites: Callabonna and Paralana
Thermally Anomalous Granites: Modelling Callabonna Gravity
Hot Dry Rock Geothermal Exploration in Australia

- hot rock geothermal energy
- greenhouse driver
- hot rock exploration philosophy
  - thermally anomalous granites (TAGs)
  - radiogenic iron oxides (RIOs)
  - enhanced natural thermal systems (ENTs)
Radiogenic Iron Oxides: Ferguson Hill

- RIOs smaller than TAGs, but up to 50x more heat-producing
- eg. OD U-only heat production:
  - 7 assays
  - 64-250 $\mu$Wm$^{-3}$
  - mean 141, sd 52
  - (Houseman et al., 1989)
- Minotaur expertise in seeking Olympic Dam/Prominent Hill under 3 km cover
Radiogenic Iron Oxides: 
Ferguson Hill 1VD Gravity Image

- Prominent Hill
- Ferguson Hill
- Olympic Dam

1VD Gravity Image
Mt Woods/Olympic Sub-domain

100km
Radiogenic Iron Oxides: Modelling Ferguson Hill Aeromagnetics
Hot Dry Rock Geothermal Exploration in Australia

• hot rock geothermal energy
• greenhouse driver
• hot rock exploration philosophy
  ➢ thermally anomalous granites (TAGs)
  ➢ radiogenic iron oxides (RIOs)
  ➢ enhanced natural thermal systems (ENTs)
Enhanced Natural Thermal Systems: Paralana
Resources Triangles: Petroleum & Geothermal

PETROLEUM

- Low permeability oil
- Heavy oil
- Coalbed methane
- Oil shale
- Gas shales
- Gas hydrates
- High-Medium Quality

GEOTHERMAL

- Shallow, high permeability, hot aquifers
- Deeper, tighter hot aquifers
- Hot wet rocks/fractured basement
- Hot dry rocks

- Small volumes that are technologically easy to develop
- Large volumes that are technologically difficult to develop

Conventional Reservoirs

Unconventional

Improved Technology
Petratherm’s Forward Programme

Stage I: Target Definition
- geophysics (gravity, MT and seismic)
- temperature data in old wells
- heat production and conductivity data (core)

Stage II: Shallow Test Wells (~750 m)

Stage III: Thermal Reservoir Evaluation Well (~3.5 km)

Stage IV: Resource Circulation Test
Summary

• HR geothermal offers the potential of emissions-free, renewable energy
• SA is global focus of HR activity due to its unique geological endowment of hot rocks
• Petratherm will test a portfolio of hot rock plays with a staged, risk-reducing exploration strategy
• can Geodynamics, Petratherm et al. turn HR from technical success to commercial success?
Acknowledgements

• John Hart & Barry van der Stelt, Minotaur Resources
• Hillis, Mildren & Hand are consultants to Petratherm
• Hillis is a non-executive director of Petratherm