



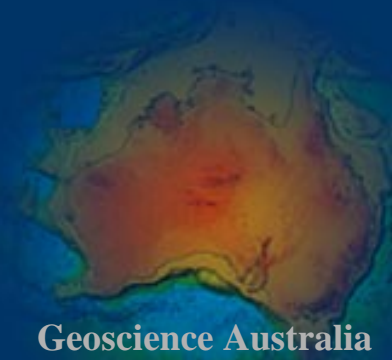
Australian Government

Geoscience Australia

GEOHERMAL ENERGY PROJECT

Mapping Heat Across the Australian Continent

Dr Anthony Budd



Introduction

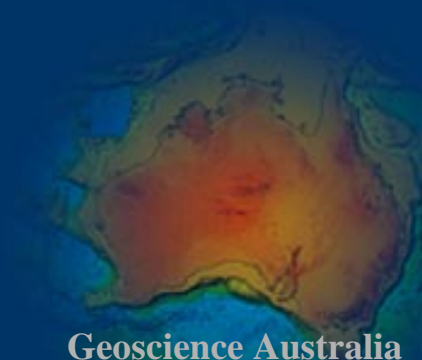
The Onshore Energy Security Program – what is it?

Scoping the Geothermal Project:

- What types of geothermal systems?
- Consultation
- Impediments

Project structure & activities

Progress to date



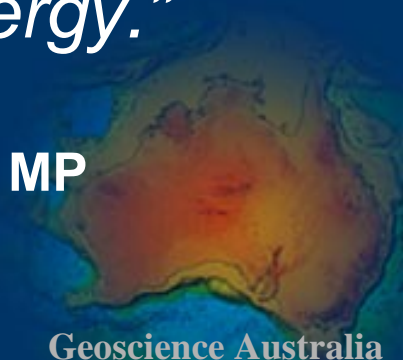
Ministerial Statement to Parliament on Energy Initiatives

14 August, 2006



“The Government will also commit an additional \$58.9 million over five years to identify onshore energy sources such as petroleum and geothermal energy.”

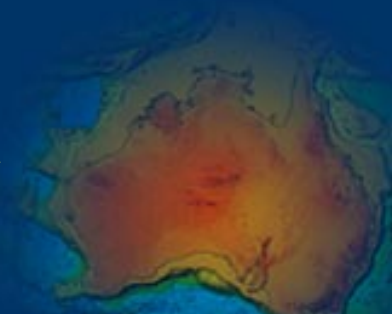
The Hon John Howard MP



Onshore Energy Security Program – Budget and Principles

06/07	07/08	08/09	09/10	10/11
\$7.4M	\$14.8M	\$14.8M	\$12.7M	\$9.3M

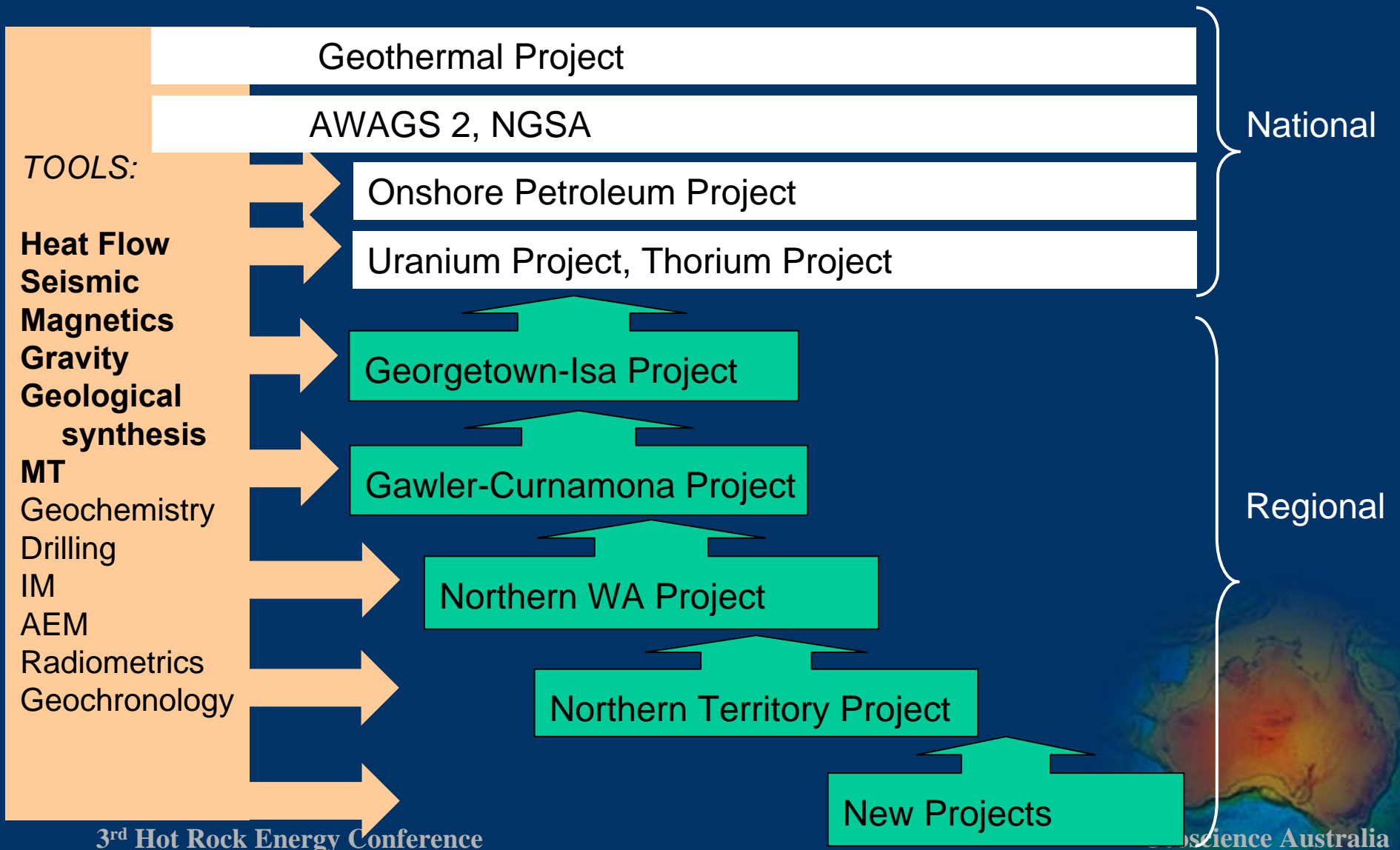
- Promoting exploration for energy-related resources, especially in greenfields areas;
- Improving discovery rates for energy-related resources;
- Projects of national and/or strategic importance;
- Data acquisition driven by science; and
- Collaboration with States/Territory under National Geoscience Agreement.



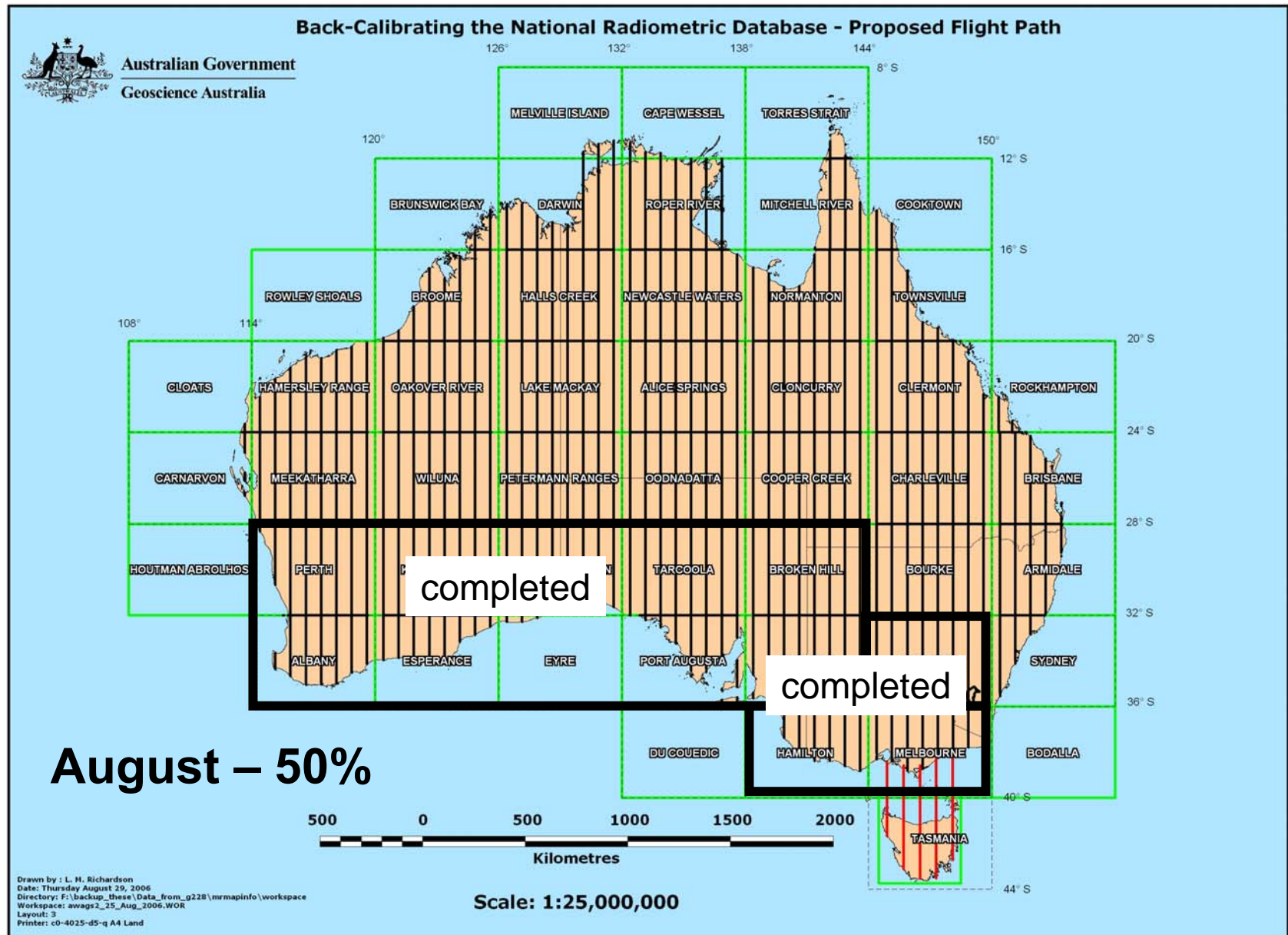
Plan for the Energy Initiative

Aug 2006 now

June 2011

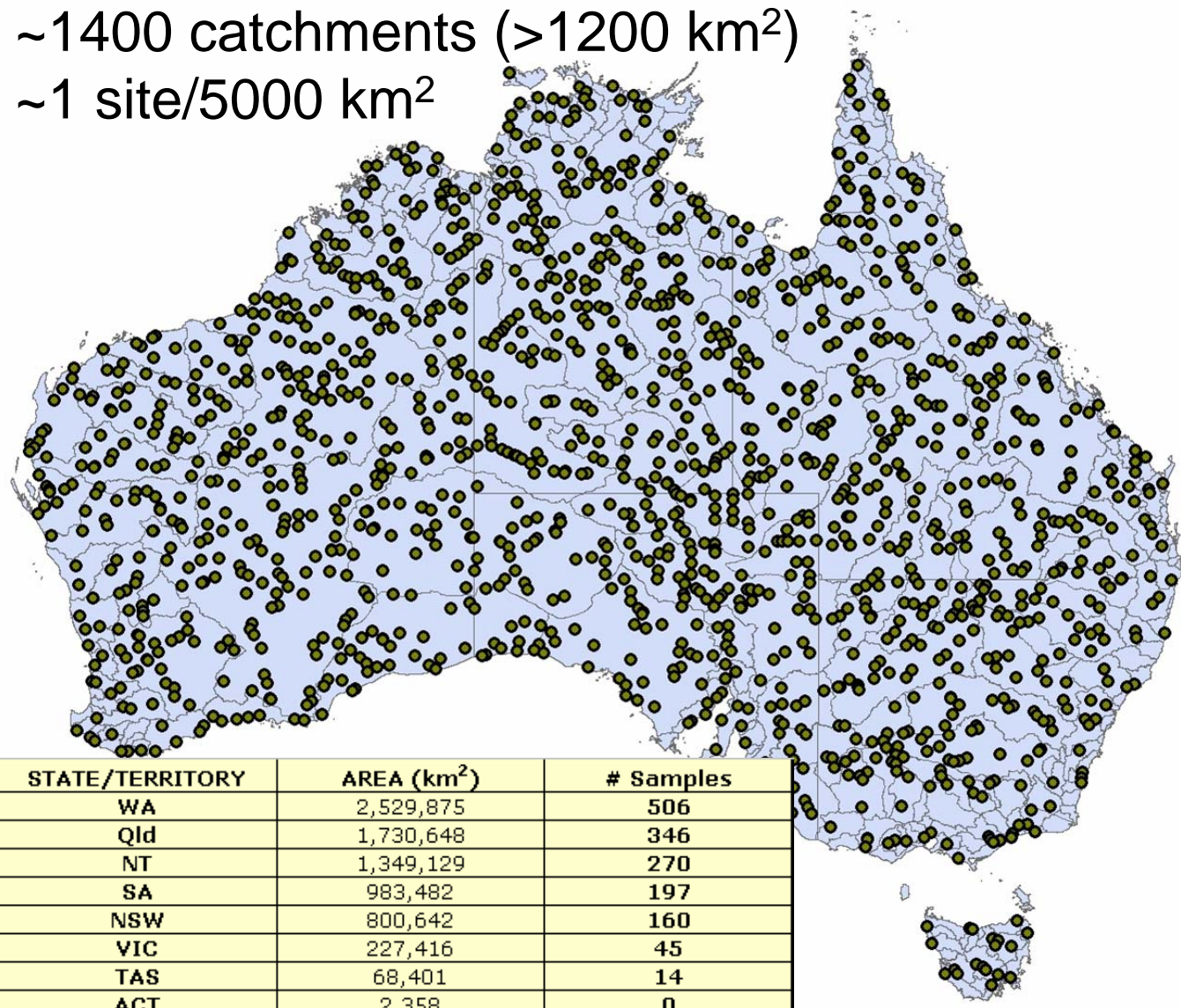


Australia-Wide Airborne Geophysical Survey 2



Heat Flow measurements

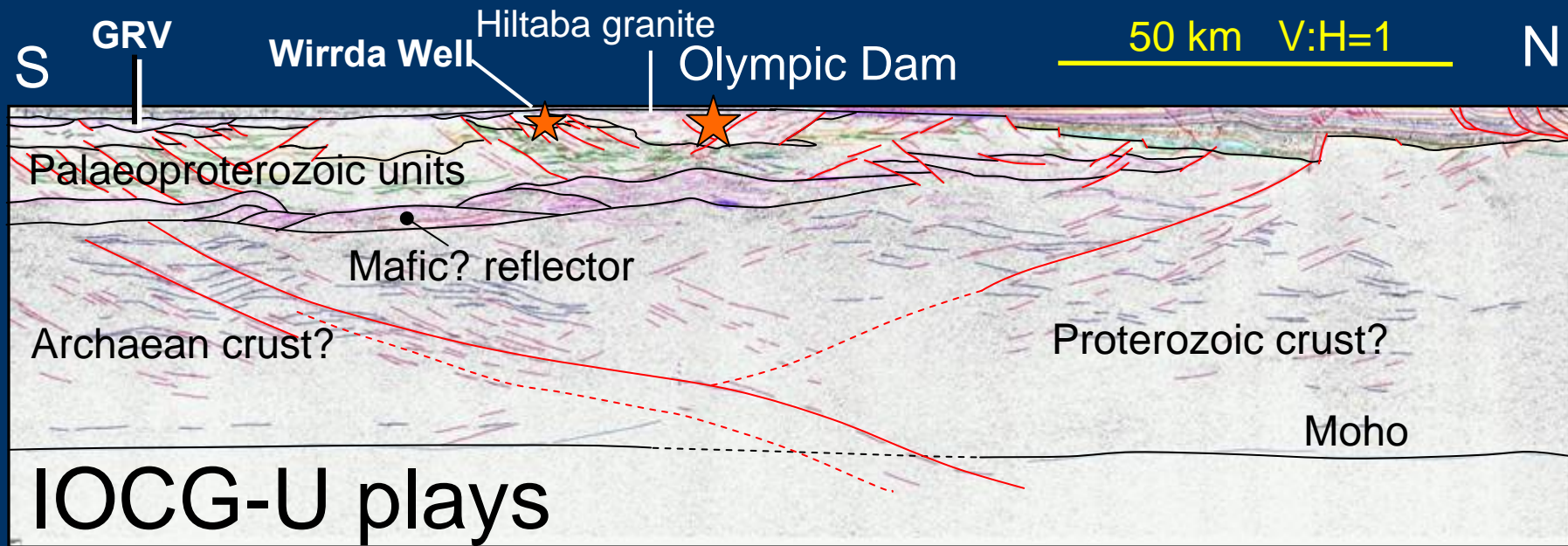
~1400 catchments ($>1200 \text{ km}^2$)
~1 site/5000 km^2



- Sampling of transported regolith at outlets of ~1400 catchments
- Average density 1 site/~5000 km^2
- Samples at 2 depths (surface and ~80 cm)
- Whole rock analyses U-Th-K + >60 other elements

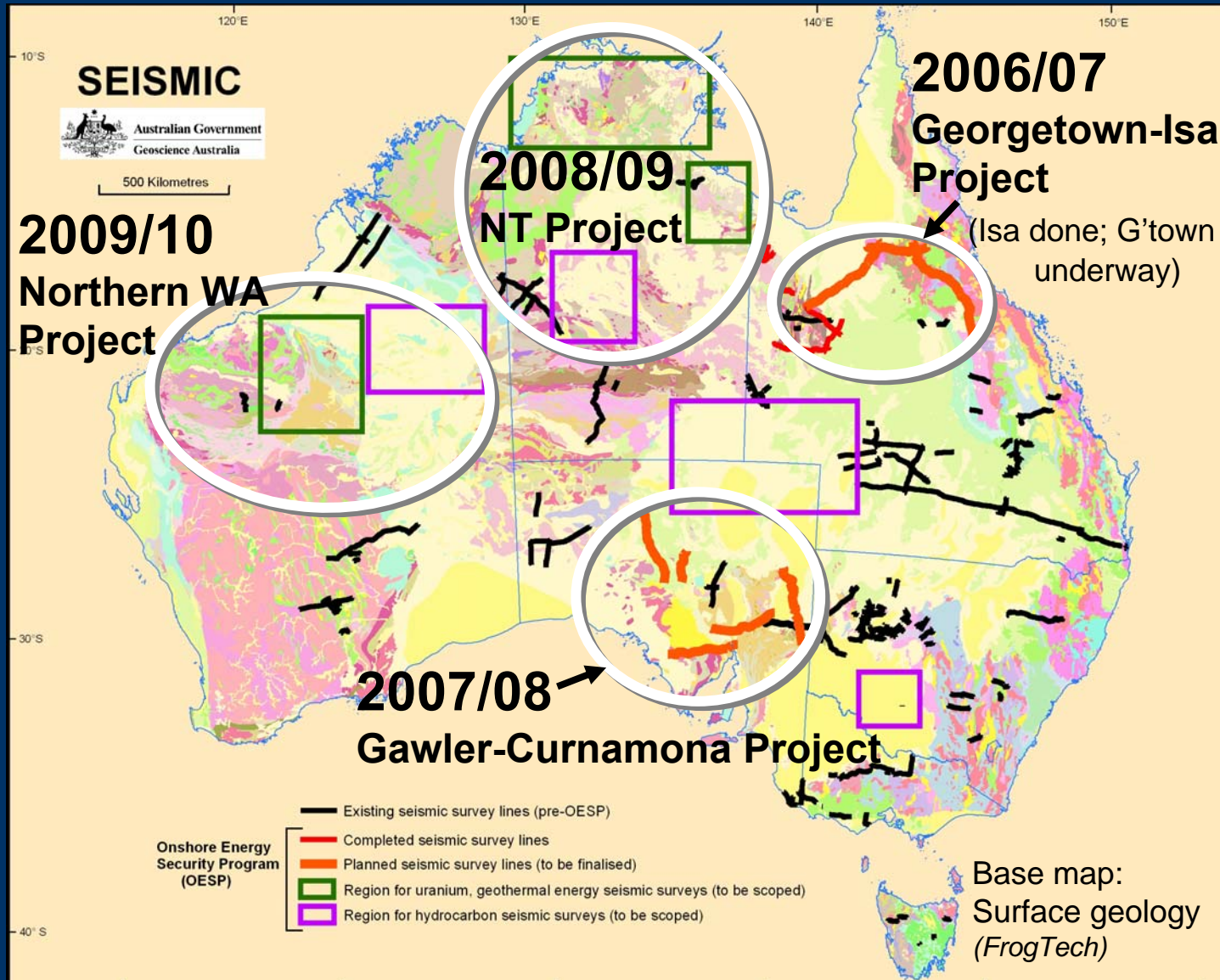
Seismic Imaging of Crustal Architecture

- controls on mineralising systems
- depth and structure of sediments
- depth and extent of granites

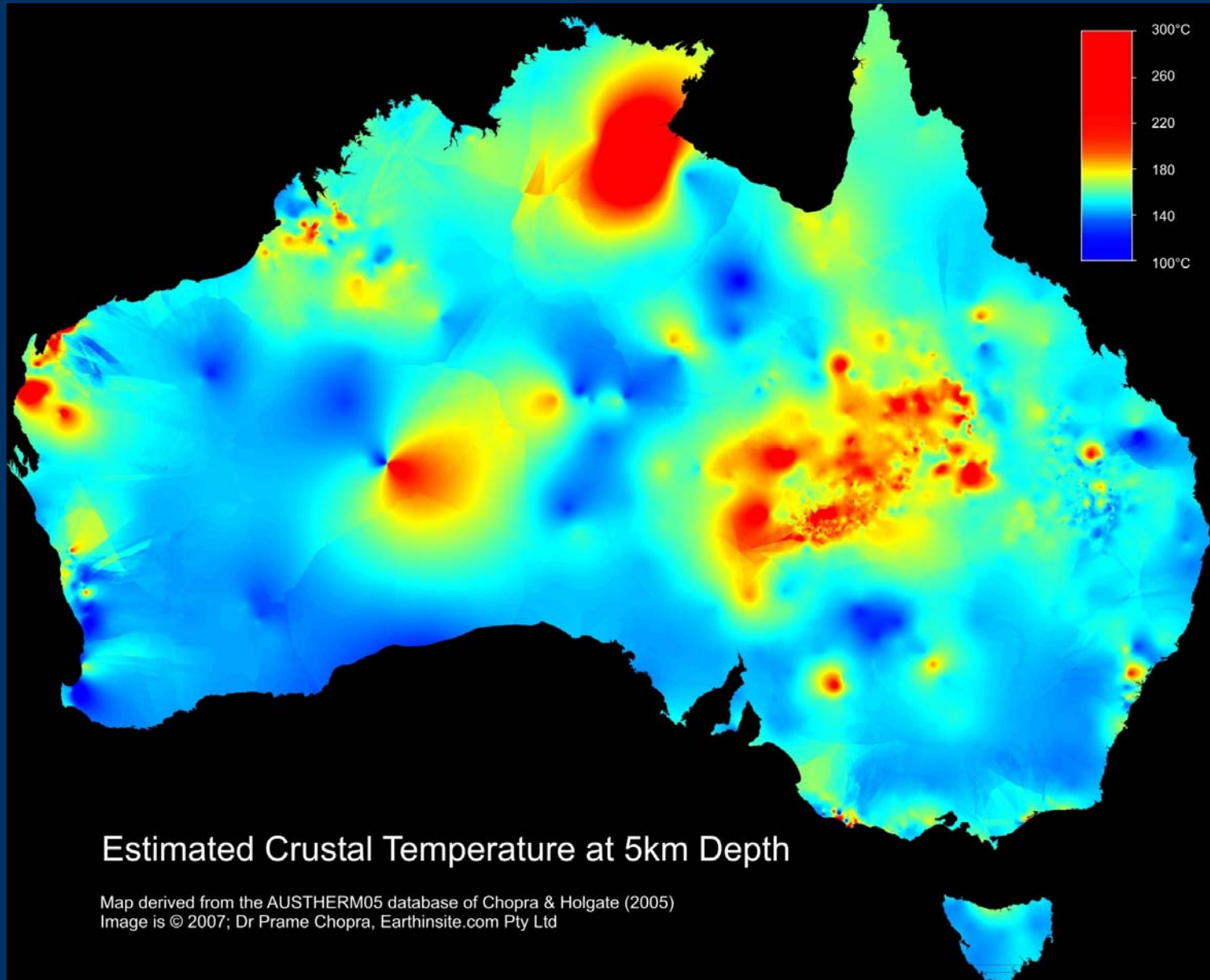


Olympic Dam above suture

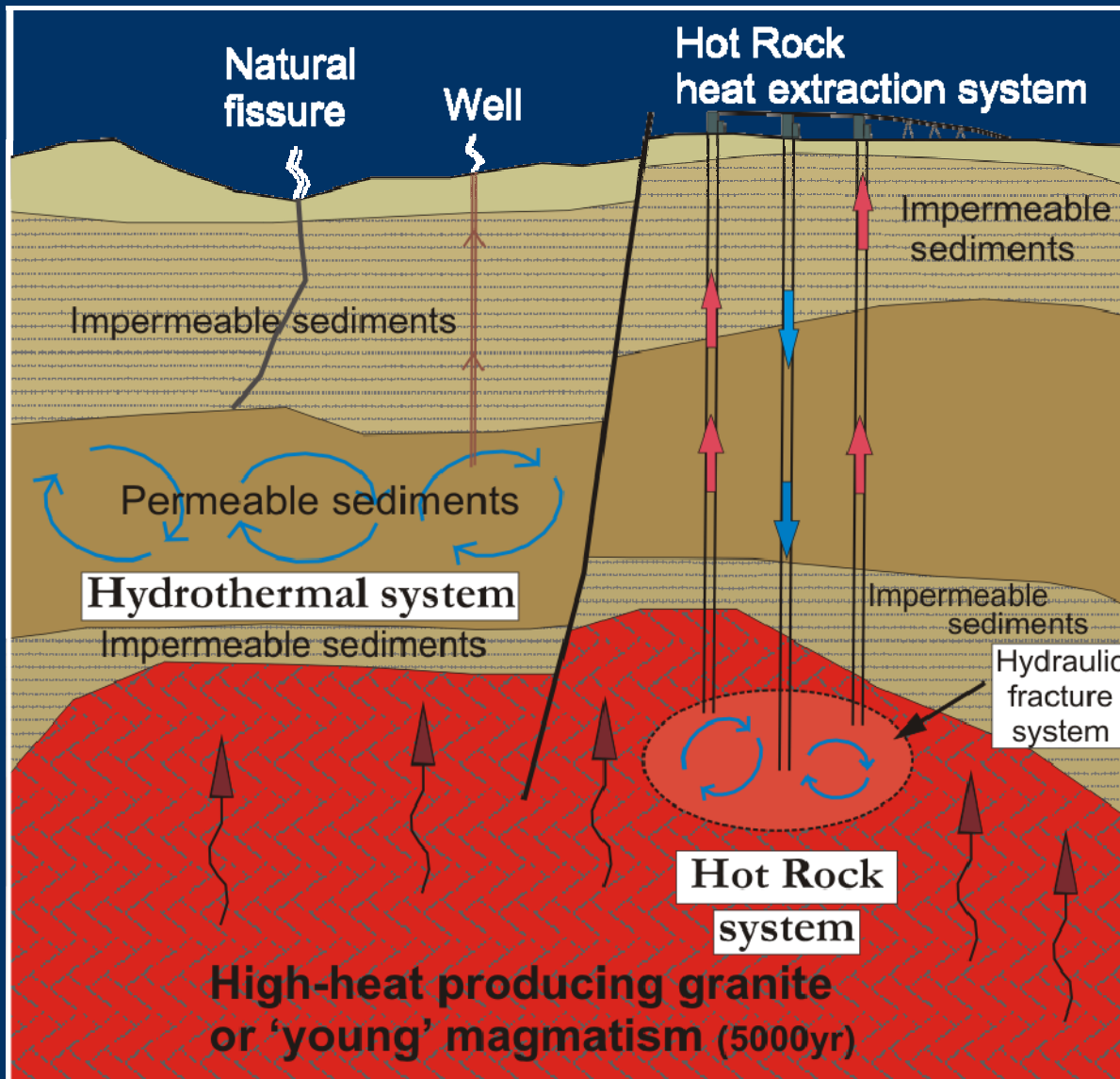
Regional Projects - seismic



Where's the next Hot Rock play?



Electricity generating geothermal systems



Hydrothermal system:

Heated by radiogenic high-heat producing granite (HHPG), or 'recent' magmatism

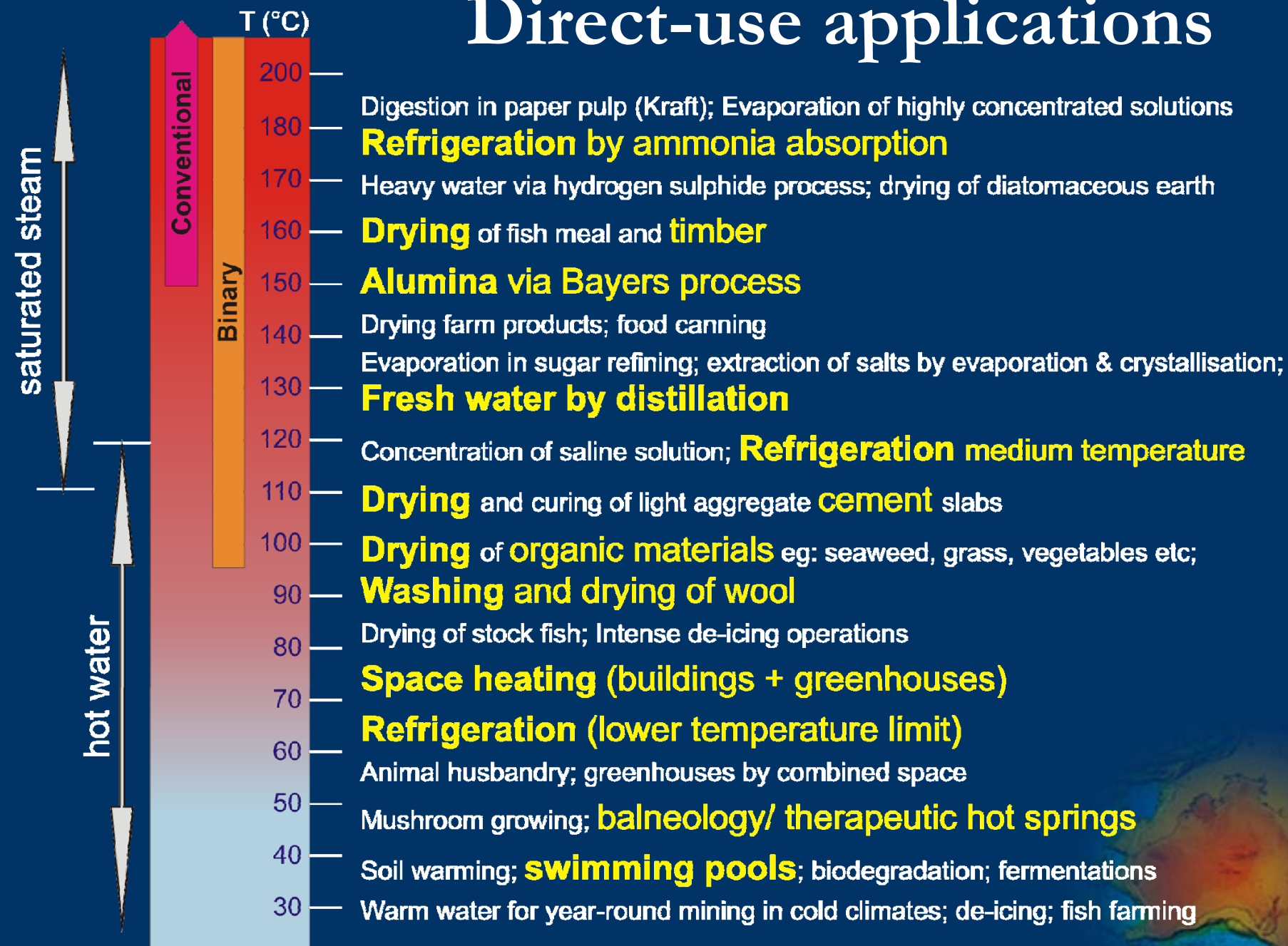
Artesian waters e.g. GAB

Hot Rock system:

HHPG, overlain by low thermal conductivity sediments

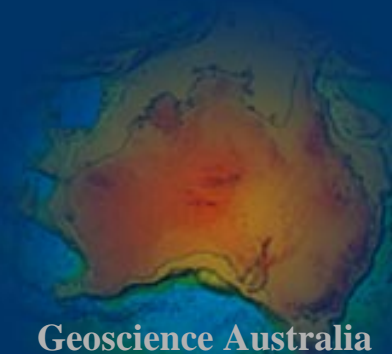
Heat exchange reservoir needs to be artificially enhanced

Direct-use applications

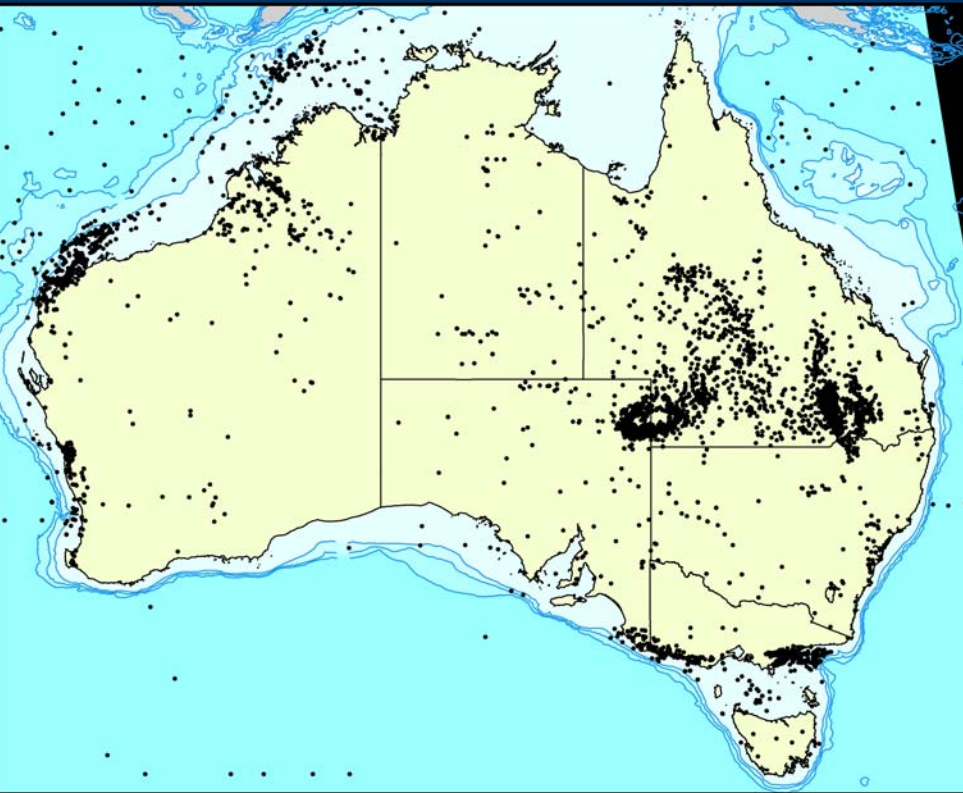


Geological impediments to uptake

- Australian situation has little potential for 'traditional' geothermal usage from active volcanism (c.f. New Zealand, Iceland, western USA)
- Hot Rock model is novel: no-one has succeeded in making the entire system work commercially – Australia is leading the world in development
- Remoteness of Hot Rock resources increases costs of transmission
- Paucity of appropriate geothermal data

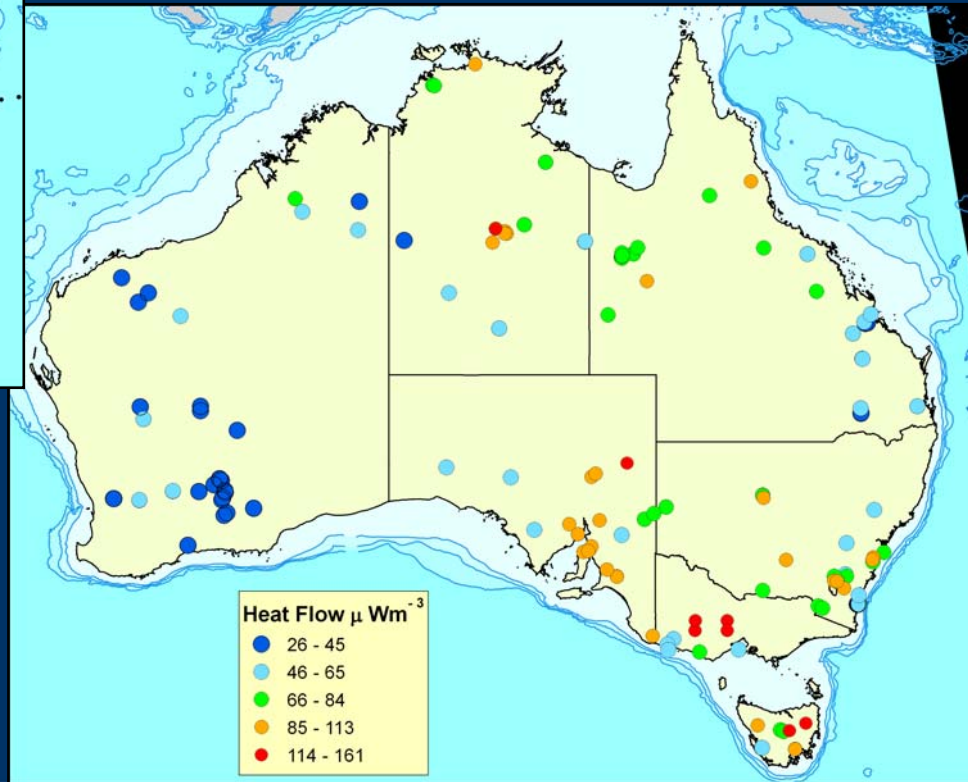


Data Gaps



Bottom-of-hole temperatures

Heat Flow measurements –
Global Heat Flow database



Geothermal Energy Project

Three ways to map heat:

1. Heat flow

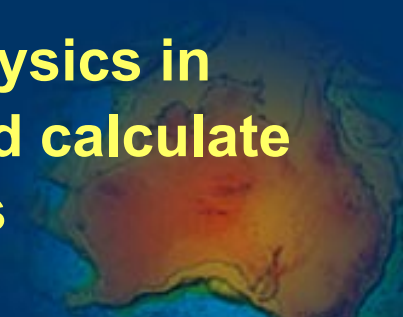
→ Make new heat flow measurements in conjunction with State / Territory geological surveys

2. Temperature at depth

→ Create a geothermal database and information system, including methods for calculating temperature at depth

3. Modelling based on source & trap

→ Map buried hot granites in 3D using geophysics in conjunction with other OESP activities, and calculate heat resource using geological constraints



Geothermal Project Summary

National Scale Compilation

Gap analysis, area selection & acquisition prioritisation

Play Map: heat source and insulator (Budd & Meixner)

Regional
Project

Geothermal for Cities (Ayling & Meixner)

Heat Flow capability & mapping (Gerner)

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Project

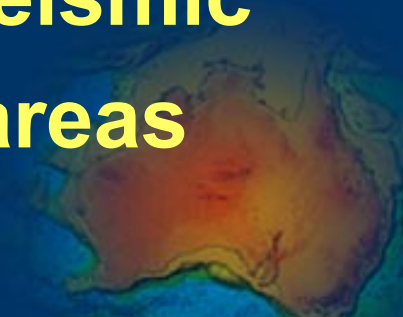
Geothermal database system & Resource estimation (Holgate)

Remote sensing, seismicity, hydrogeology, Outreach (various)

Regional
Project

Hot Rock Play Map

- **Model: granite heat source, sediment heat trap**
- **Use granite geochemistry, group into suites to be *predictive***
- **Sediment chemistry, conductivity**
- **3D volumes of granites + sediments from potential field inversion + seismic**
- **Heat flow modelling in selected areas**



New Products

AUSTRALIAN RADIOGENIC GRANITE AND SEDIMENTARY BASIN GEOTHERMAL HOT ROCK POTENTIAL MAP

SCALE 1:5 000 000

Geothermal Energy Division
Geothermal Energy Project
Preliminary Edition, July 2007

Granite Heat Production
Granite Radiogenic Heat Production (kW t⁻¹)

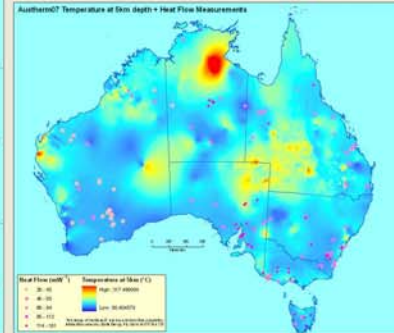
100 - 2.01	Basalt
2.01 - 3.75	Basalt
3.75 - 4.41	Basalt
4.41 - 12.23	Basalt
12.23 - 35.36	Basalt

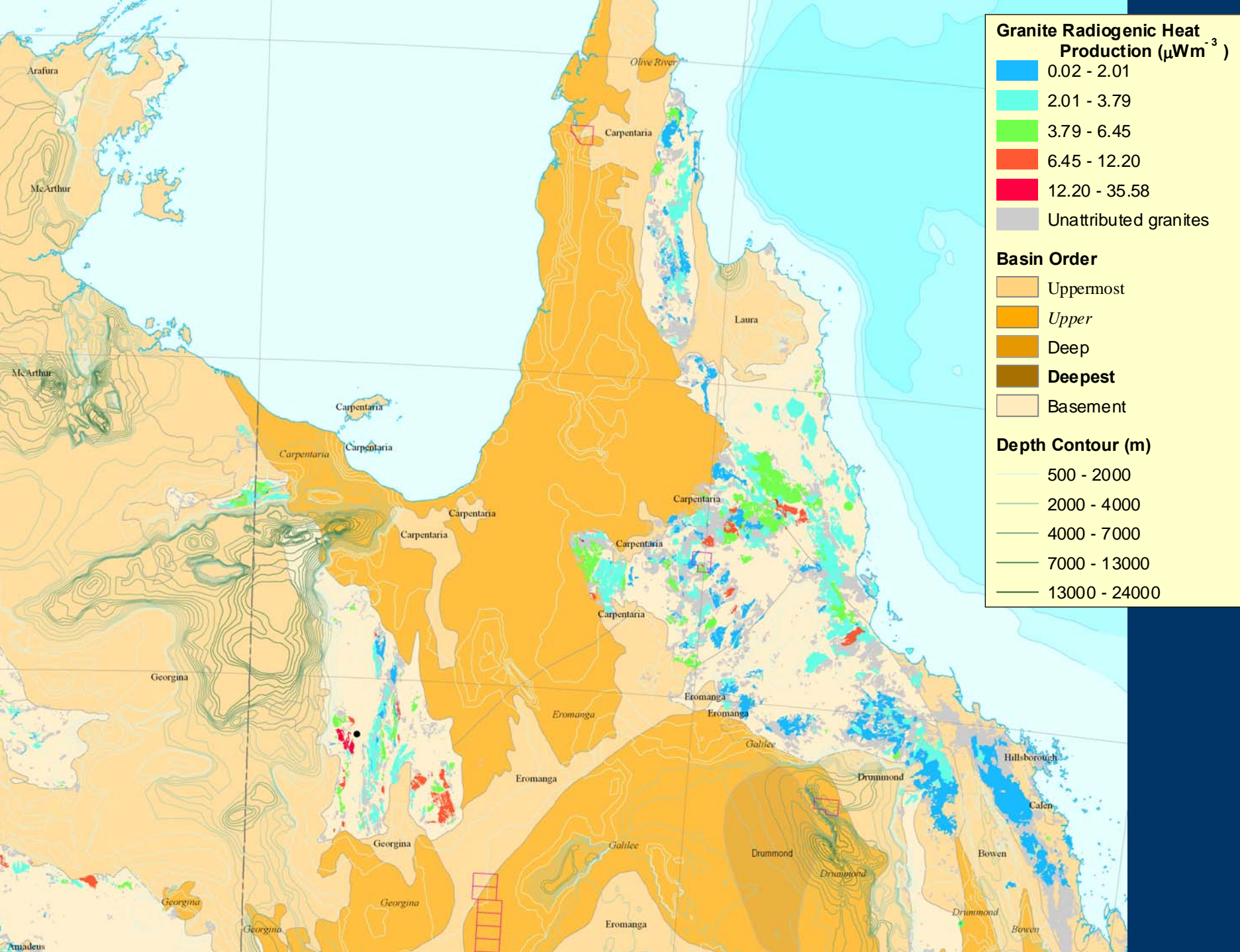
Basalt
Basalt
Basalt
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Basalt

Living
Geothermal Exploration Licences and Agreements

Onshore Energy and Minerals Division
Onshore Energy Security Project
Geothermal Energy Project
Preliminary Edition, July 2007

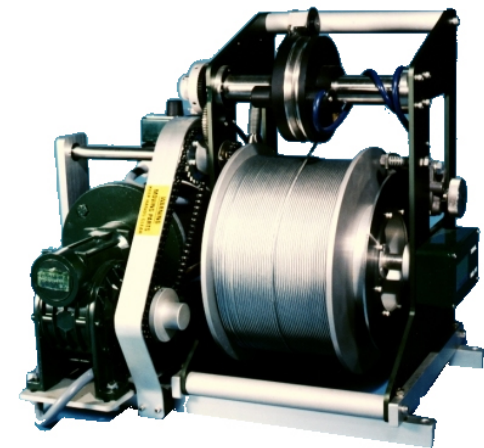
This map is a preliminary product of the Geothermal Energy Division, Onshore Energy Security Project, Geothermal Energy Project, Preliminary Edition, July 2007. It is based on data from the Geothermal Energy Division, Onshore Energy Security Project, Geothermal Energy Project, Preliminary Edition, July 2007. The map is a preliminary product of the Geothermal Energy Division, Onshore Energy Security Project, Geothermal Energy Project, Preliminary Edition, July 2007. It is based on data from the Geothermal Energy Division, Onshore Energy Security Project, Geothermal Energy Project, Preliminary Edition, July 2007.





Heat Flow Measurements

- **Purchasing a thermal conductivity meter with ability to measure at temperatures between 0°C and 300°C**
- **Purchasing downhole logging gear, taking a long-term lease on a vehicle, and hiring personnel to run a full-time facility**
- **Use existing holes where possible, and collaborate on logging new holes**



Data System

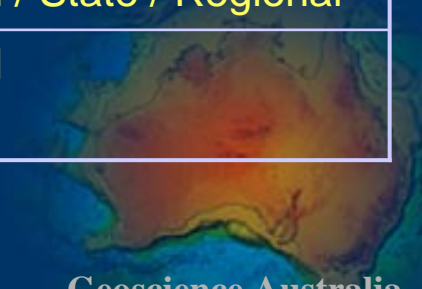
- **AGEG Technical Interest Group**
- **Thermal conductivities, temperatures, heat production etc**
- **Will be made available in Access or Excel database \pm tables**
- **Have started collating data from literature**
- **Any companies willing to share data??**
- **Ultimate aim is for a web interoperable system**



Data compilation

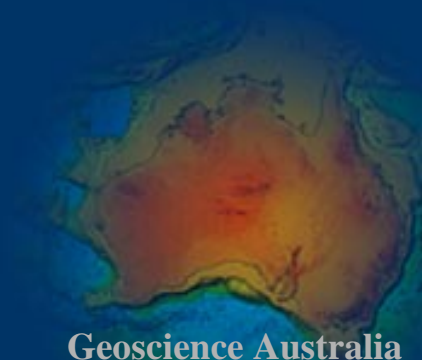
Data	Scales
Point datasets	
Geochem	National / State
Drilling	National / State
Gravity locations	National
Topo (settlements)	National
Other	
Topo & Infrastructure	National
Digital Elevation Model	National
Thermal IR	Regional
Mean Average Surface Temperature	National
Water?	Regional

Data	Scales
Geophysics	
Gravity	National / Regional
Magnetics	National / Regional
Radiometrics	National / Regional
Gamma	National / Regional
Geology	
Solid	National / State / Regional
Granite / Sediment	National / State / Regional
Outcrop	National / State / Regional
Faults	National / State / Regional
Stress / Neotectonics	National

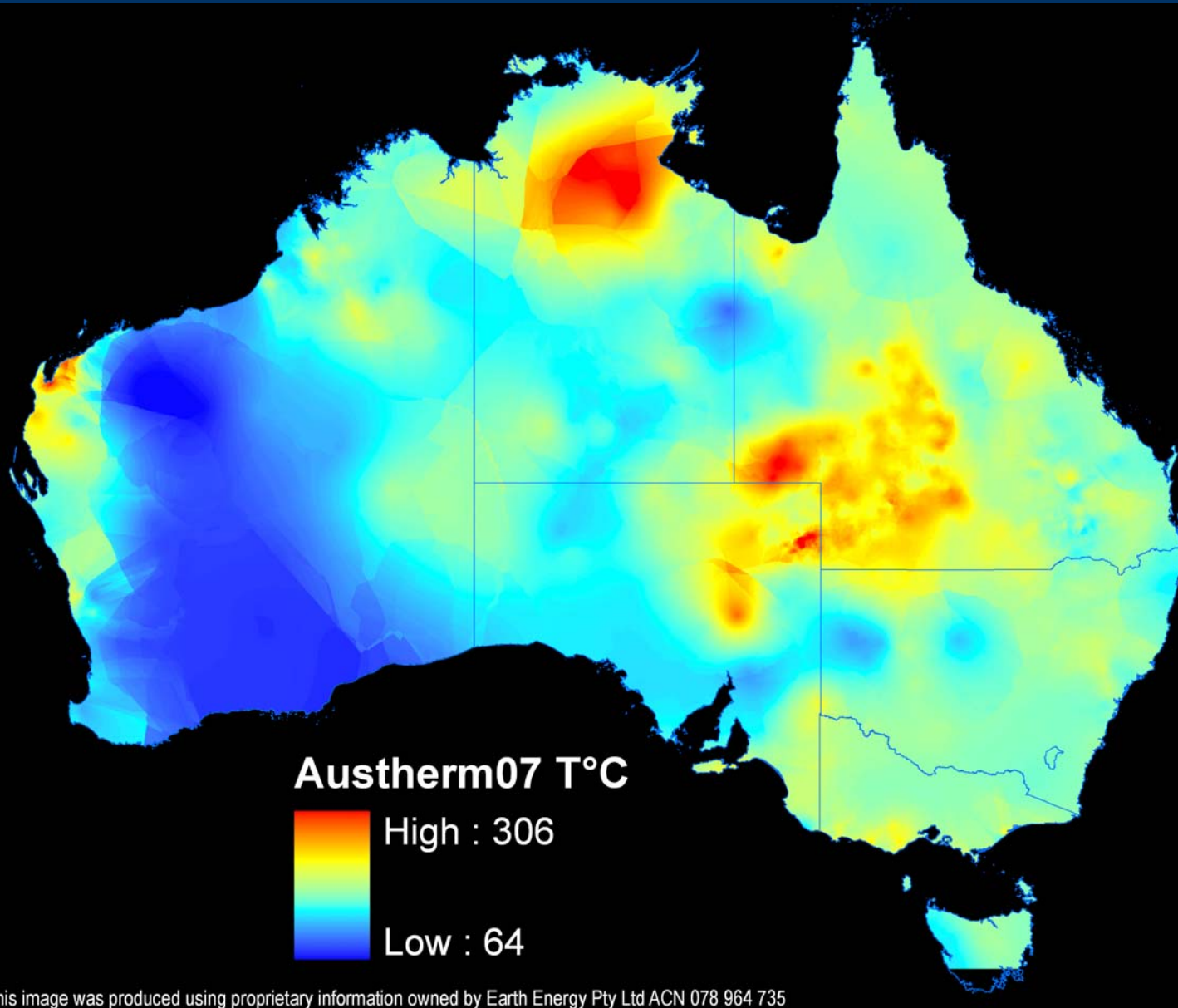


Resource Activities

- Purchase of *Austherm07* database
- Combine *Austherm07* with other databases to provide better constraints to make improvements
- Reserves & Resources definition scheme – AGEG Technical Interest Group



New Work

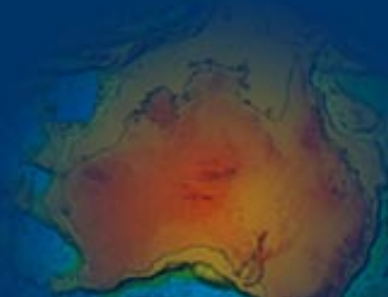


Austherm07

OzSEEBase™

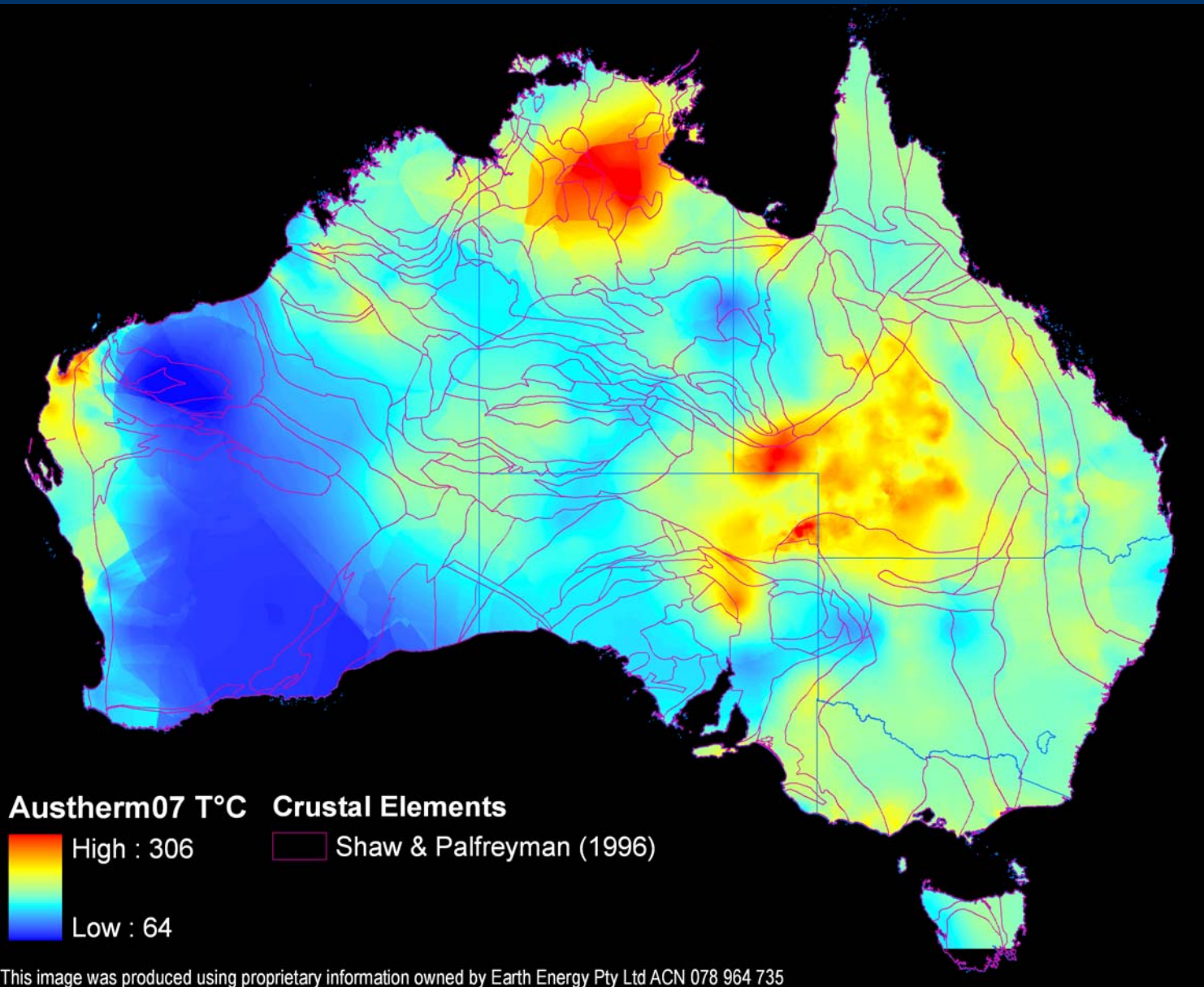
Heat Flow
province map
(after Sass &
Lachenbruch
1979)

Requires
refined kriging



This image was produced using proprietary information owned by Earth Energy Pty Ltd ACN 078 964 735

New Work

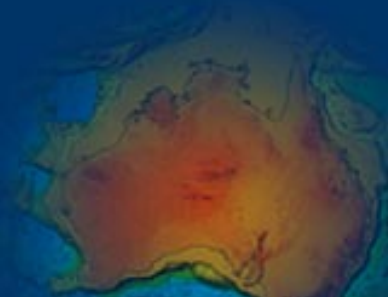


Austherm07

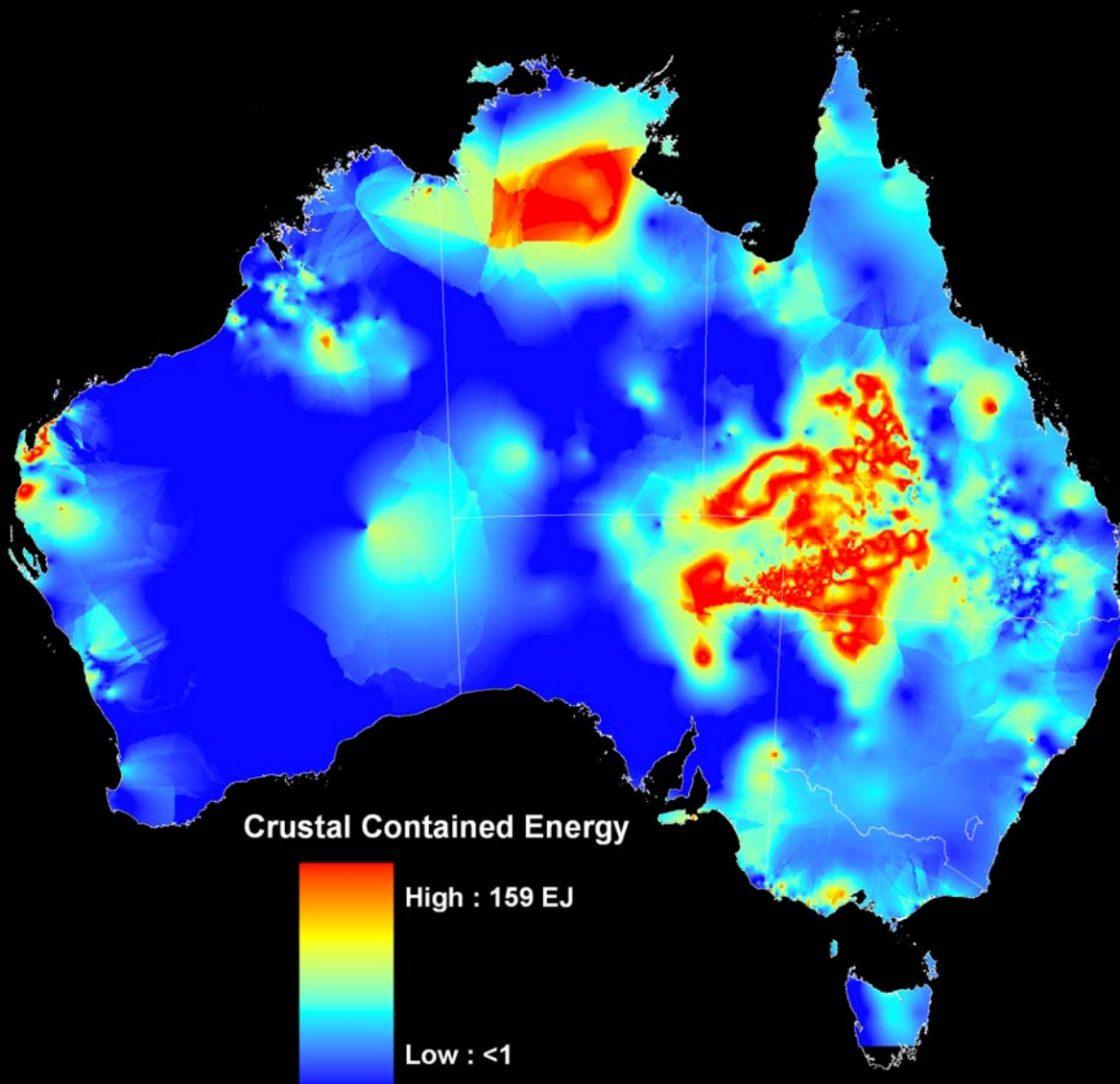
OzSEEBase™

Heat Flow
province map
(after Sass &
Lachenbruch
1979)

Requires
refined kriging



Volumetric Resource Calculation



Calculated between 5 km (lower) and 150°C isotherm (upper)

Resource calculated on a 5x5 km grid

OZ SEEBase™ depth to basement

Heat Flow provinces

Contained energy
 1.9×10^{25} Joules
(1% extractable = 25,000 years at 2004-2005 total energy consumption levels)

Geothermal for Cities



From existing data – geothermal resources near population centres are low temperature – *true?*

Work in conjunction with State and Territory governments (surveys) to investigate heat flow close to market

Raise public awareness of geothermal resources, for direct use applications and power generation

→ **Compile geology, drill hole information, temperature data, target drilling – requires hydrogeology**

Australian Geothermal Energy Group

	AGEG Technical Interest Group (TIG)	Purpose–Share Information to Learn-While-Doing with Maximum Effect and Efficiency	TIG Leaders / Members
1	Data management	Database design, contents and ongoing enhancements	TIG Leader: Anthony Budd, Geoscience Australia
2	Reserves and Resource (Definitions)	Align with similar International forums Bankable feasibility Venture capital is leading geothermal development for first time	TIG Leader: Adrian Williams, Geodynamics
3	Outreach (including website)	Create informed public through accessible information. Provide educational kits for media, K-12 and university education	TIG Leader: Tony Hill, PIRSA
4	Land Access Protocols (seismicity , native title emissions , etc)	Mirrors IEA Geothermal Research Annex 1. management of environmental concerns and potential impacts of geothermal energy and devises protocols to avoid or minimise impacts	TIG Co-leaders: Mike Malavazos / Barry Goldstein, PIRSA
5	Direct Use of Geothermal Energy (including geothermal heat pumps)	Mirrors IEA Geothermal Research Annex VIII. This annex addresses all aspects of the technology related to geothermal energy being used directly as heat, with emphasis on improving implementation, reducing costs and enhancing use	TIG Leader: Russel D'Arcy, Qld DME



Geothermal Energy Project

Geoscience Australia: Projects: Geothermal Project - Microsoft Internet Explorer provided by Geoscience Australia

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Address <http://www.ga.gov.au/minerals/research/national/geothermal/index.jsp>



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Updated: 04 July 2007

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- ▶ Australian Mineral Systems
- ▶ Felsic and Intermediate Igneous Rocks of Australia
- ▶ Geothermal Energy
- ▶ Mineral Exploration Promotion
- ▶ Mineral Potential of Australia
- ▶ National Geological Maps
- ▶ Proterozoic Synthesis Project
- ▶ Regolith and Land Use

Related Links

- ▶ Publications and presentations
- ▶ Regional scale projects
- ▶ Cooperative Research Centres
- ▶ Methodology & standards
- ▶ Archived projects

Some of the documents on this webpage may be in PDF Format. Please download the Free PDF reader from Adobe to view these files.

Geothermal Energy

- ▶ Project description
- ▶ Project technical notes
 - ▶ Rationale
 - ▶ Project objectives
- ▶ Project outputs
- ▶ Project outcomes
- ▶ Presentations
- ▶ References
- ▶ Related geothermal links

<http://www.ga.gov.au/minerals/research/national/geothermal/index.jsp>

<http://www.ga.gov.au/minerals/research/oesp/index.jsp>

Project description

Following the announcement of the Australian Government's Onshore Energy Security Initiative in August 2006, Geoscience Australia has established a geothermal energy project. The project aims to improve our knowledge of the type and location of geothermal resources in Australia on a national scale, and encourage investment, exploration & exploitation of this energy source through provision of pre-competitive geoscience datasets relevant to geothermal energy.

To achieve these aims, the objectives of the geothermal project are to:

- ▶ collect new heat flow data across Australia to better define and locate our geothermal resources;
- ▶ complete source and trap modelling to identify potential Hot Rock systems;
- ▶ compile national datasets that may be useful to the geothermal industry, such as groundwater temperatures, borehole temperatures, rock thermal conductivities, locations of recent volcanic activity and hot springs, granite and sediment chemistry, and thermal-IR imaging of shallow hydrothermal circulation systems;
- ▶ build a geothermal information system to effectively store new and existing heat flow data and make this data easily accessible to the public, industry and academia; and
- ▶ use these new datasets to produce a revised estimate of Australia's total contained geothermal resource.

[\[back to top\]](#)

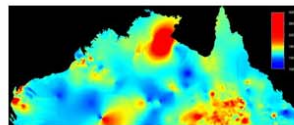
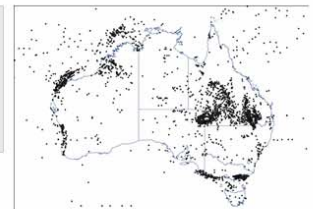
Project technical notes

Rationale

Our current understanding of Australia's geothermal resources is based on limited data. This includes temperature measurements taken in 5722 petroleum and mineral boreholes across the country (Figure 1), which were used to generate a map of estimated crustal temperatures at 5km depth (Figure 2; Chopra & Holgate, 2005).

Heat flow data (the product of geothermal gradient and thermal conductivity) are rarer, with the most recently published compilation containing less than 200 heat flow data-points for Australia (Figure 3). These temperature and heat flow measurements are unevenly distributed, and where no temperature or heat flow data exist, this data has been interpolated over large areas to generate national-scale maps.

Figure 1 Distribution of drillholes from which temperature data was acquired and used to create the AUSTHERM05 database (see Figure 2). This map has been derived from proprietary information owned by Earth Energy Pty Ltd ACN 078 964 735.



Compilations of other national-scale datasets relevant to exploration for geothermal energy are either incomplete, non-existent, or not publicly accessible. Datasets such as the 3D distribution of high-heat producing granites overlain by insulating low thermal conductivity sediments will be useful for identifying locations with potential for high temperatures. Geothermal is an emergent industry in Australia, and access to geothermally-targeted geoscience information will lower the risk to explorers and investors, and facilitate the exploitation of this low-emission energy source.

Figure 2 Map of crustal temperature across Australia at 5km depth using