

Geothermal Power-Green Power for the 21st Century

Bright Horizons Cruise #6

December 6, 2009

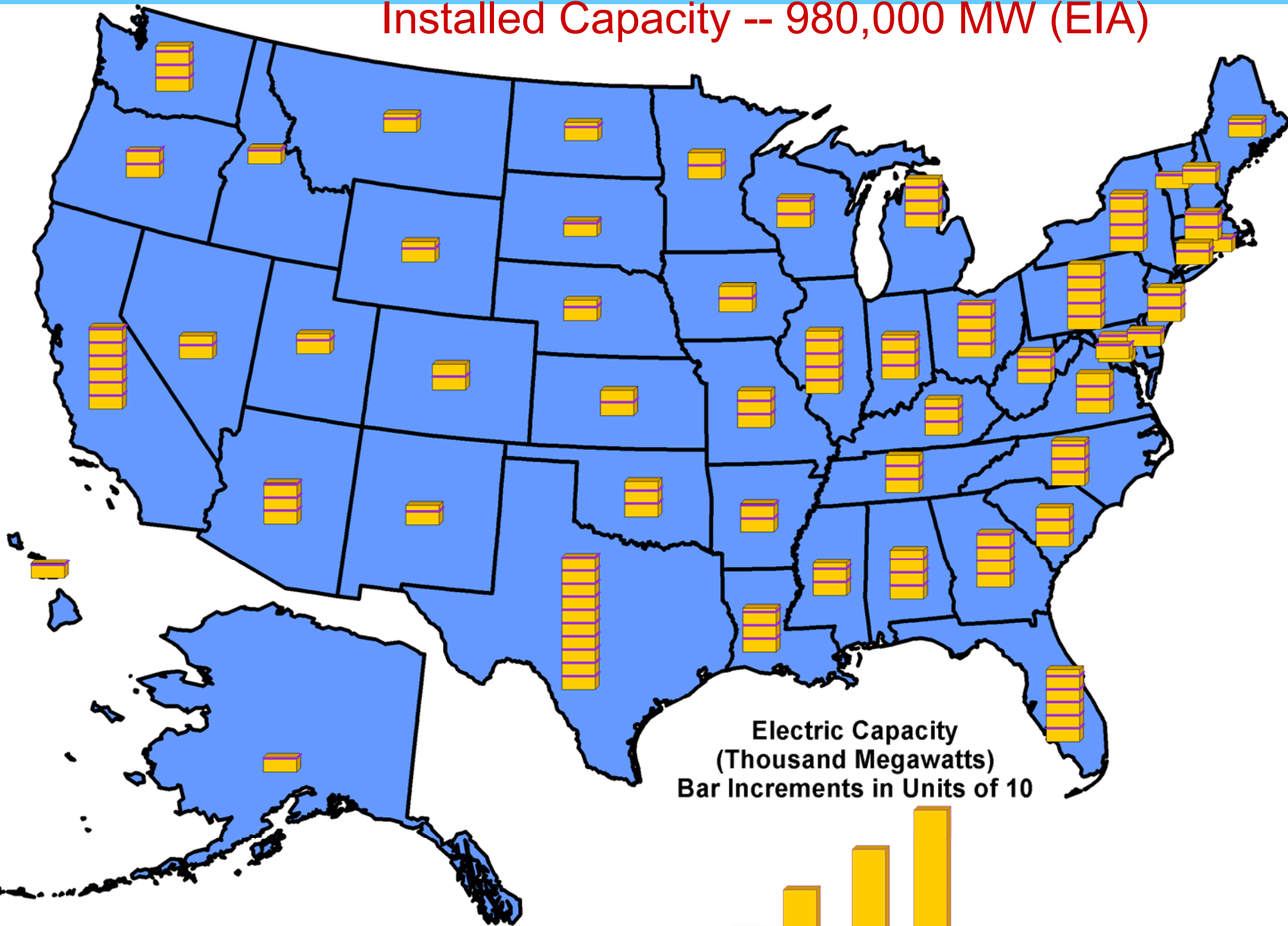
David Blackwell

SMU Geothermal Laboratory

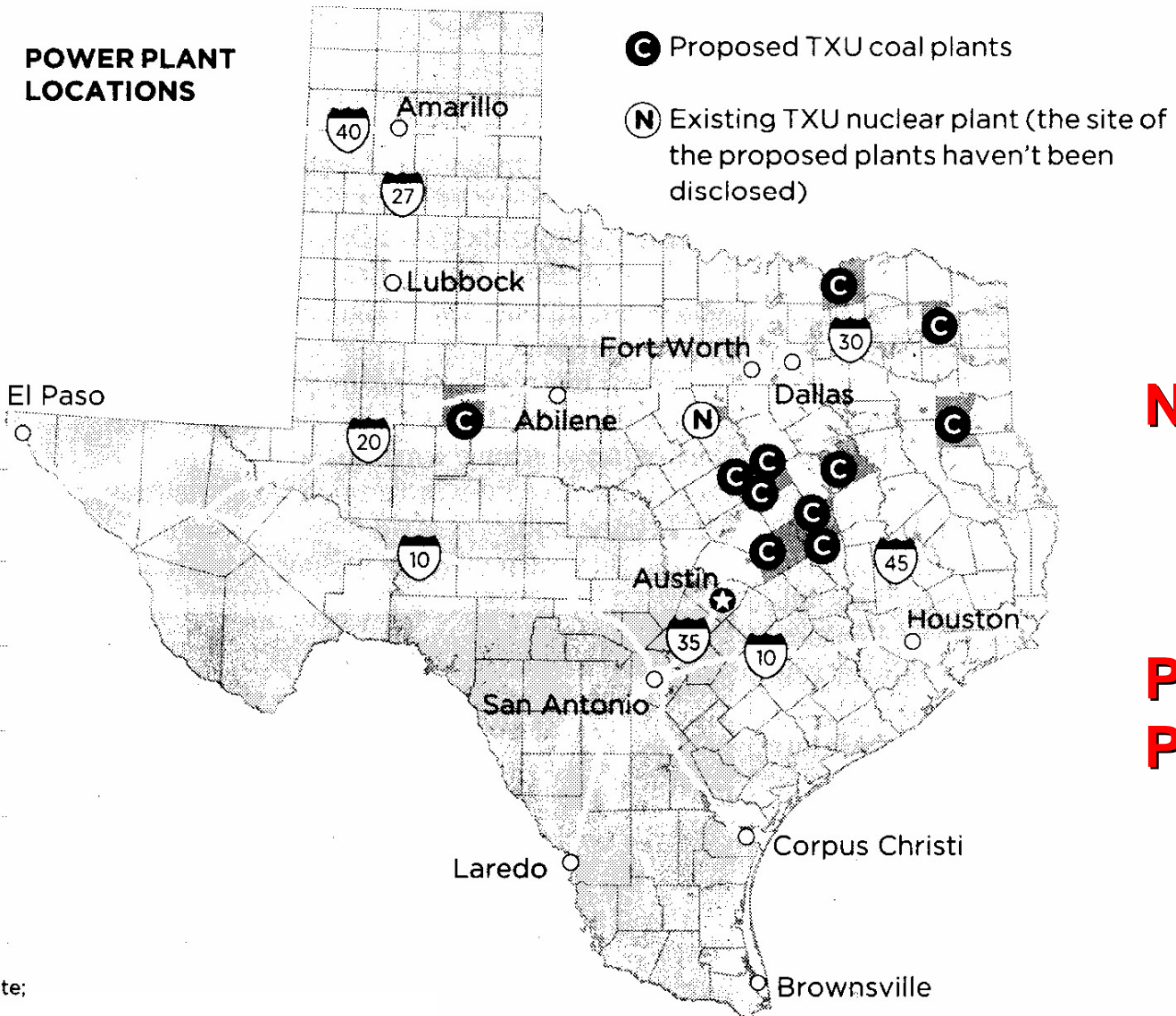
Energy Forms

- **Gas-too expensive, too valuable**
- **Coal-”cheapest”**
- **Nuclear-expensive, most dangerous**
- **Wind-nonbase load, 40% max**
- **Solar-solar-thermal**
- **Geothermal-hydrothermal (conventional)**
 - **Enhanced (Engineered) GS**
 - **Geopressure**
 - **Coproduced**

Installed Capacity -- 980,000 MW (EIA)



Texas has 10% of installed capacity!



**Coal
NonAttainment
Areas**

**Nuclear
Pollution
Proliferation**

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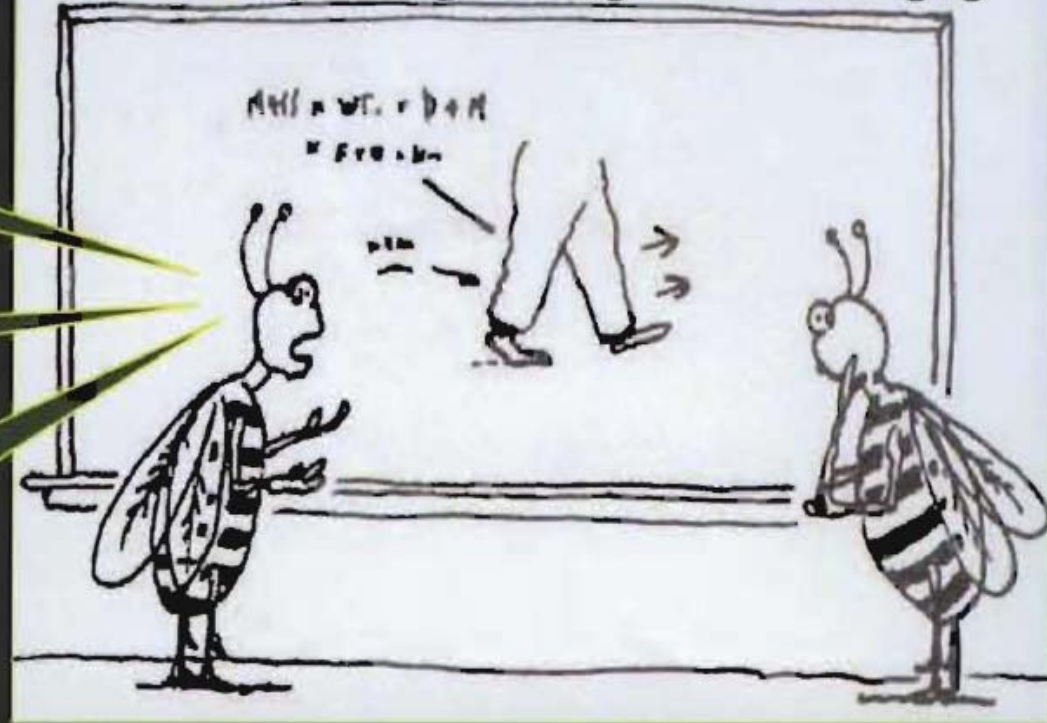
Hot Rocks Downunder – Evolution of a New Energy Industry

Visit: www.pir.sa.gov.au/geothermal/ageg

Stage 1:
This design
makes walking
impossible

Stage 2:
Yeah, possible
but impractical

Stage 3:
Told you this
would work!

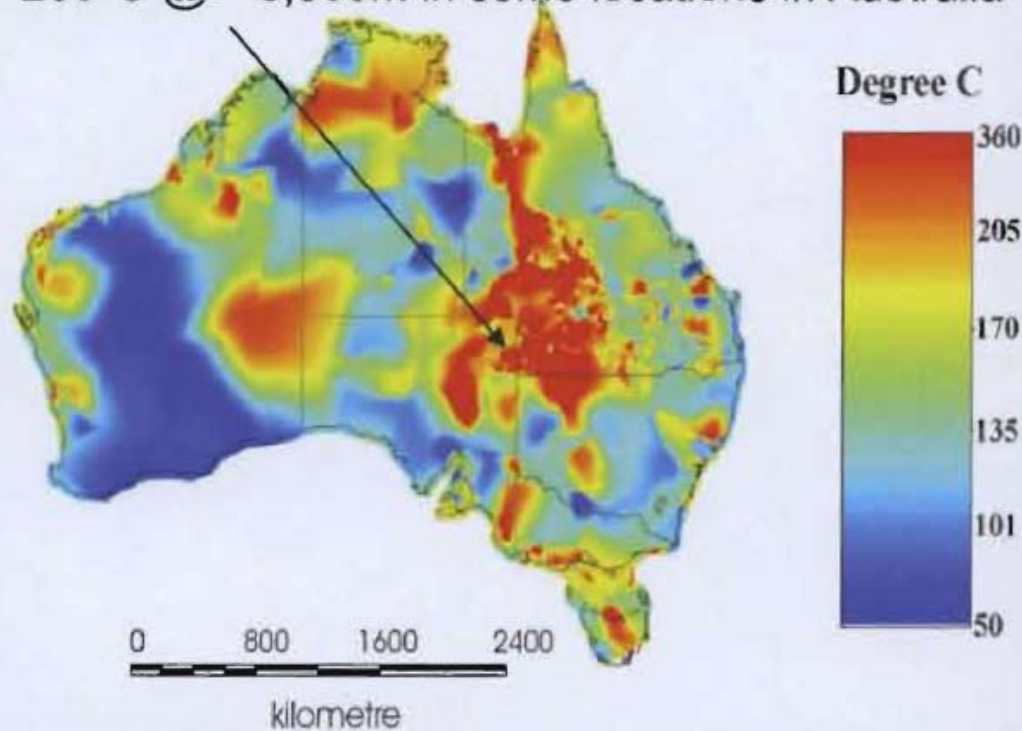


Barry Goldstein¹, Tony Hill¹, Alexandra Long¹, Mike Malavazos¹
Dr Anthony Budd² and Dr Bridget Ayling²

1. South Australian Government (PIRSA) & AGEG Secretariat
2. Geoscience Australia (Federal Government)

Why Hot Rocks in

>200°C @ < 3,500m in some locations in Australia

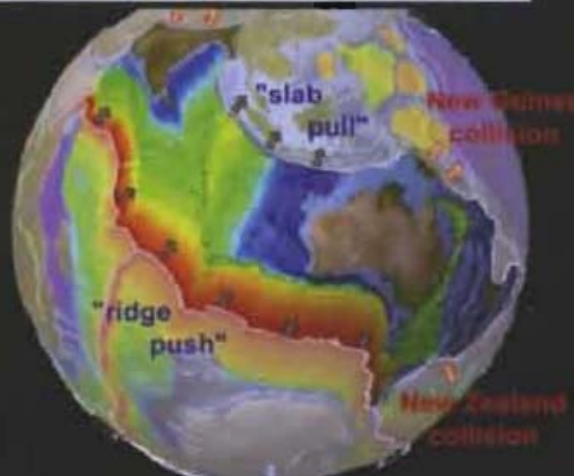


Below Ground Factors

- Extensive radiogenic basement at modest depths (heat source)
- Australia converging with New Guinea – giving rise to horizontal compression and common naturally occurring horizontal fractures (reservoir)
- Sedimentary cover (insulators) for hot sedimentary aquifer & hot rock EGS targets

Above Ground Factors

- Land access and title to resources
- Government stimulus for low emissions and renewable energy R, D, D & D
- Market recognition of comparative advantages – extensive, exploitable hot rocks
- Political will to attain energy security & mitigate risks of climate change
- Investors perceptions of risk: reward
- Growth in energy demand



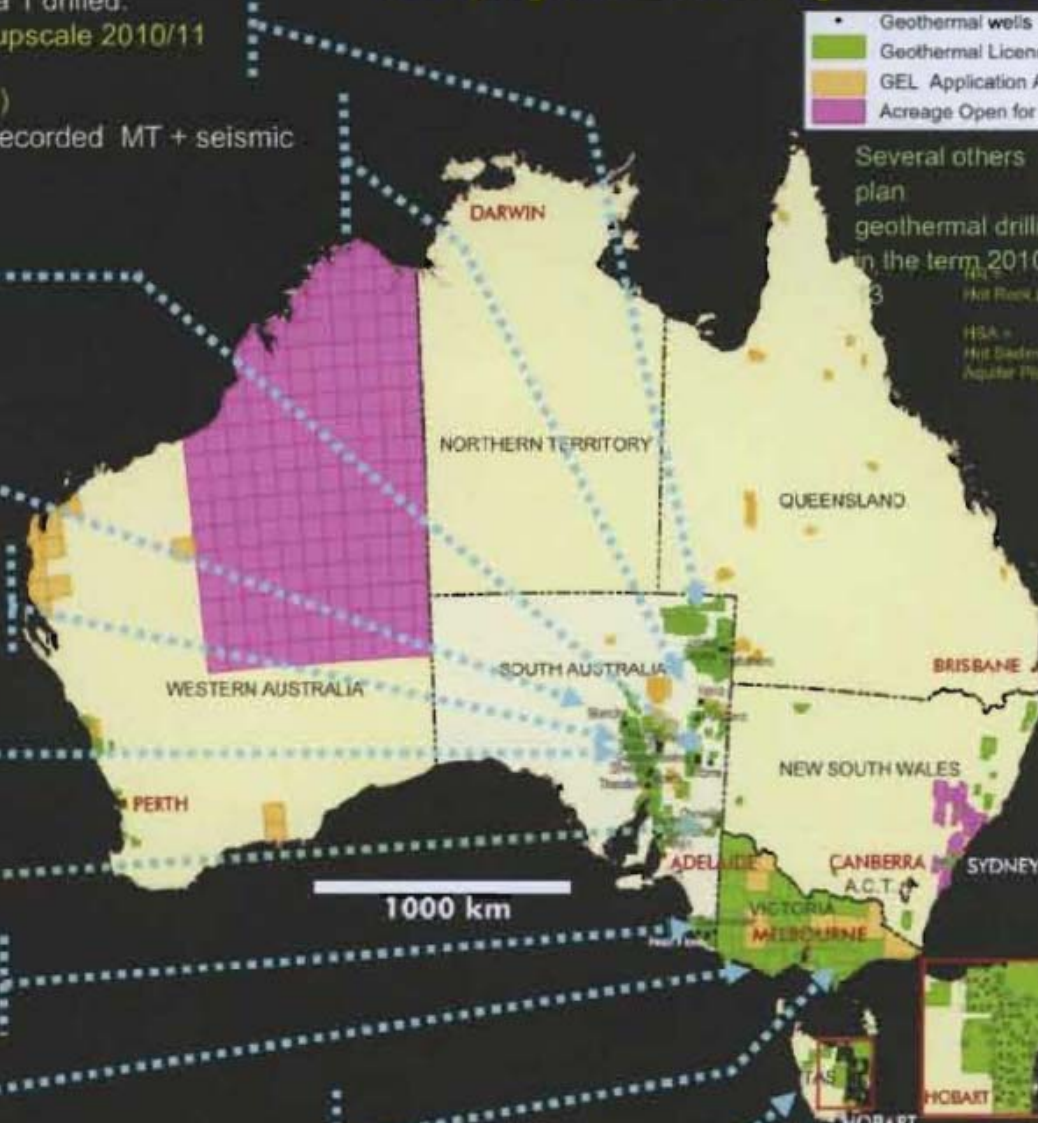
Geothermal Drilling & Geophysical Surveys to YE 09

- Geothermal wells
- Geothermal Licences
- GEL Application Area
- Acreage Open for Bids

Several others plan geothermal drilling in the term 2010-13

HSA = Hot Rock play

HSA = Hot Bedrock Aquifer Play



Geodynamics/Origin/Tata Power/Sentient-SunSuper (HR)

- 2003-5: Proved flow of geothermal energy with Habanero 1 & 2
- 2007-9: Habanero 1 - 3 closed loop flow, Jolokia 1 & Savina 1 drilled.
- Next: Two more deep wells, 1 MW deployment. Decision to upscale 2010/11

Petratherm/Beach Petroleum/TRUenergy (HR)

- 2005-7: Drilled Yerila and Paralana, deepened Paralana & recorded MT + seismic
- Next: Now drilling Paralana 2 to 4000m. Then Paralana 3

Geothermal Resources (HR)

- 2007-9: drilled 8 Frome area wells up to 1809m depth
- Next: Drill deep wells in the Frome area

Green Rock Energy (HR)

- Drilled and Mini-Frac'd - Blanche 1 to 1935m
- Next: Optimise plans for a deep well

Torrens Energy/AGL (HR)

- 2007-9: 20 wells north of Adelaide and Port Augusta. Parachilna holes to 1807m. Pt Augusta seismic survey
- Next: Drill deep Parachilna wells & Pt Augusta expl. holes

Inferus Resources (Southern Gold) (HR)

- 2008: Measured temperatures to 1 Km
- Next: Drill two deep wells in the Roxby project area

Eden Energy (HR)

- Drilled Chowilla 1 in Renmark region
- Now assessing options

Panax Geothermal (HSA)

- 2006 - 3 wells to 500m depth and an MT survey in SE SA
- Next - Drill deep, 4000m well (Salamander 1) in 2009

Hot Rock Ltd (HSA)

- Target defined
- Next: Drill 2 deep Koroit wells in 2010

Greeneath Energy Ltd (HSA)

- Target defined
- Next - Drill 2 deep wells in Geelong area in 2010

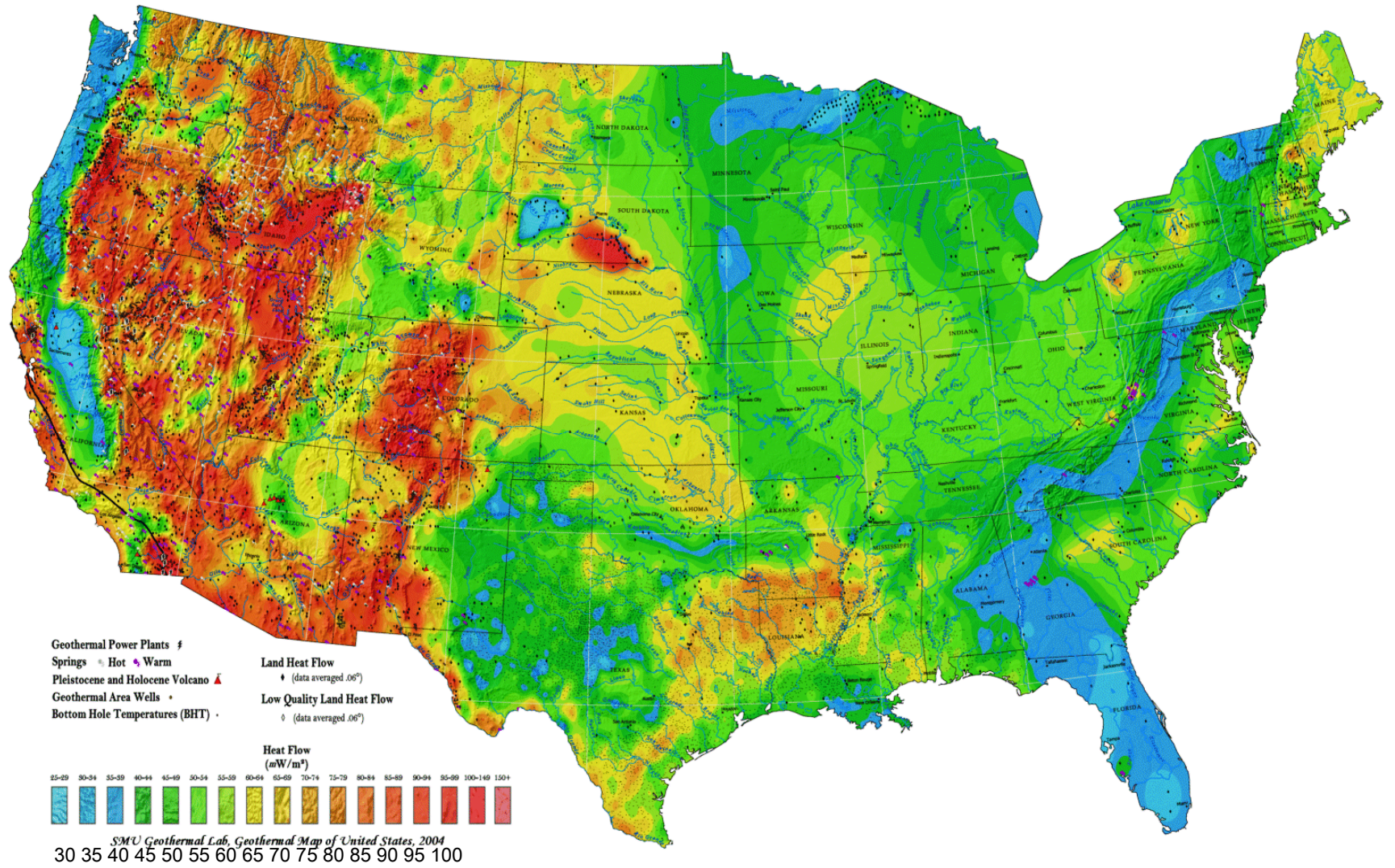
KUTH Energy Ltd (HR)

- 36 shallow holes + MT + aeromag.
- Next: Deep drilling in 2010

Progress is Measurable

Metrics	December 2007	September 2009	
Geothermal Licences	232 in Australia (198,000 km ²) 190 in SA (110,000 km ²)	391 in Australia (362,000 km ²) 279 in South Australia (130,000 km ²)	69% ↑ 47% ↑
Companies	31 Australia-wide 21 in South Australia	48 Australia-wide 28 in South Australia	55% ↑ 33% ↑
Geothermal Licence holders listed on ASX	9 Australia-wide 6 with equity in SA Licences	17 Australia-wide 12 have equity in SA Projects	89% ↑ 100% ↑
\$ Invested	Aus\$209 million in Australia (YE 07) Aus\$207 million (99%) in SA (YE 07)	Aus\$325 million in Australia (YE 08) Aus\$316 million (97%) in SA (YE 08)	55% ↑ 53% ↑
Forecast \$ 2002-12	Aus\$811 million Australia-wide Aus\$651 million in South Australia	Aus\$1,528 million Australia-wide Aus\$883 million in South Australia	88% ↑ 36% ↑
Government Grants	Aus\$48.2 million Australia-wide ^{Note 1} Aus\$29.4 million in SA (61% n SA) ^{Note 1} Qld's \$15 million grant for a geothermal research centre was part of the Australia-wide tally	Aus\$114 million Australia-wide ^{Note 2} Aus\$56.1 million in SA (73% of grants offered to 5 Aug 2009) ^{Note 2} Aus\$35 million of GDP yet to be awarded and this tally excludes \$435 REDP open for all forms of renewables bar solar	136% ↑ 91% ↑

Download AGEG-AGEA Geothermal Reserve & Resource Code:



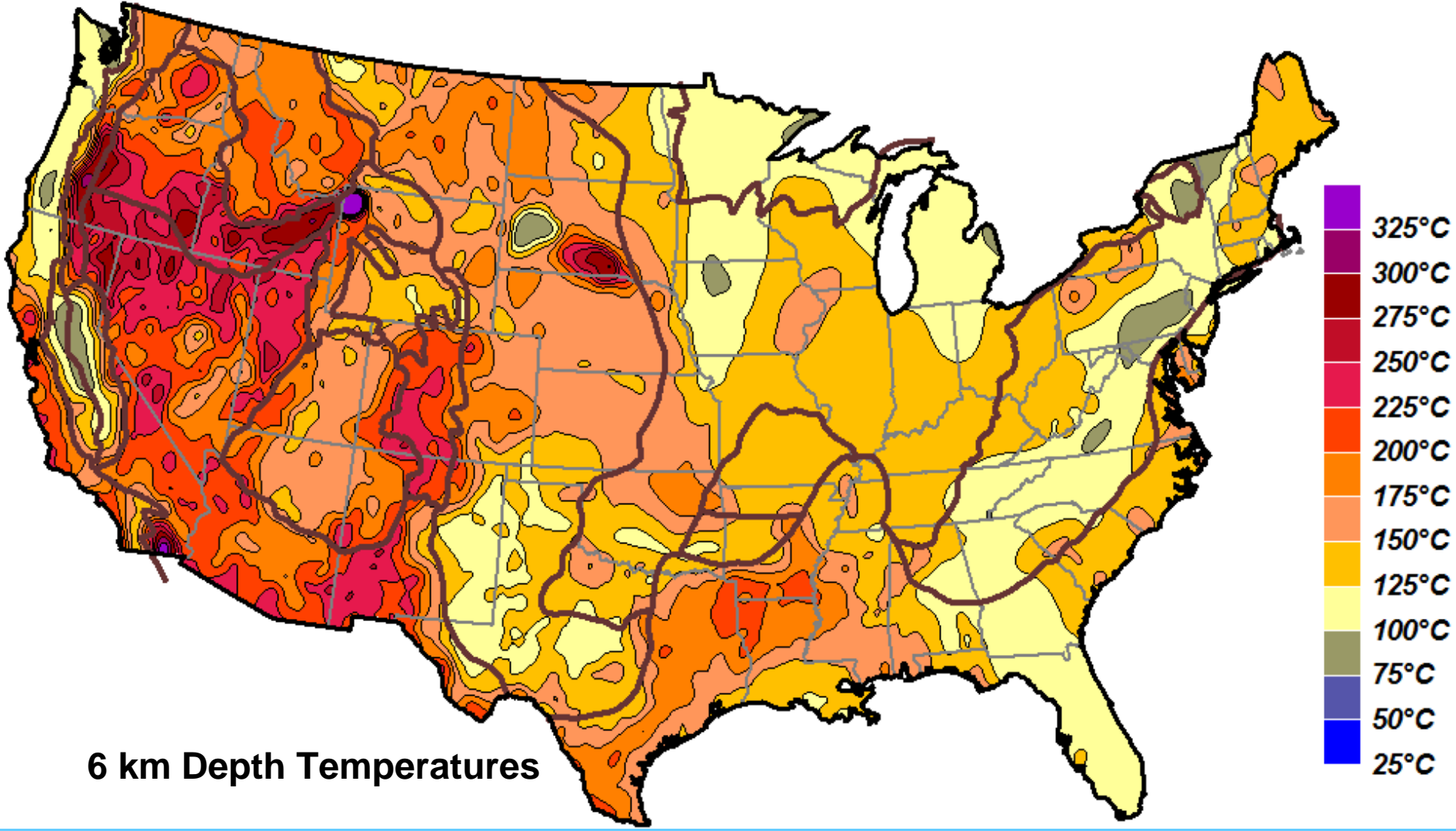
2004 Geothermal Map of North America (Blackwell & Richards)

The Future of Geothermal Energy

Impact of Enhanced Geothermal Systems (EGS) on the United States in the 21st Century

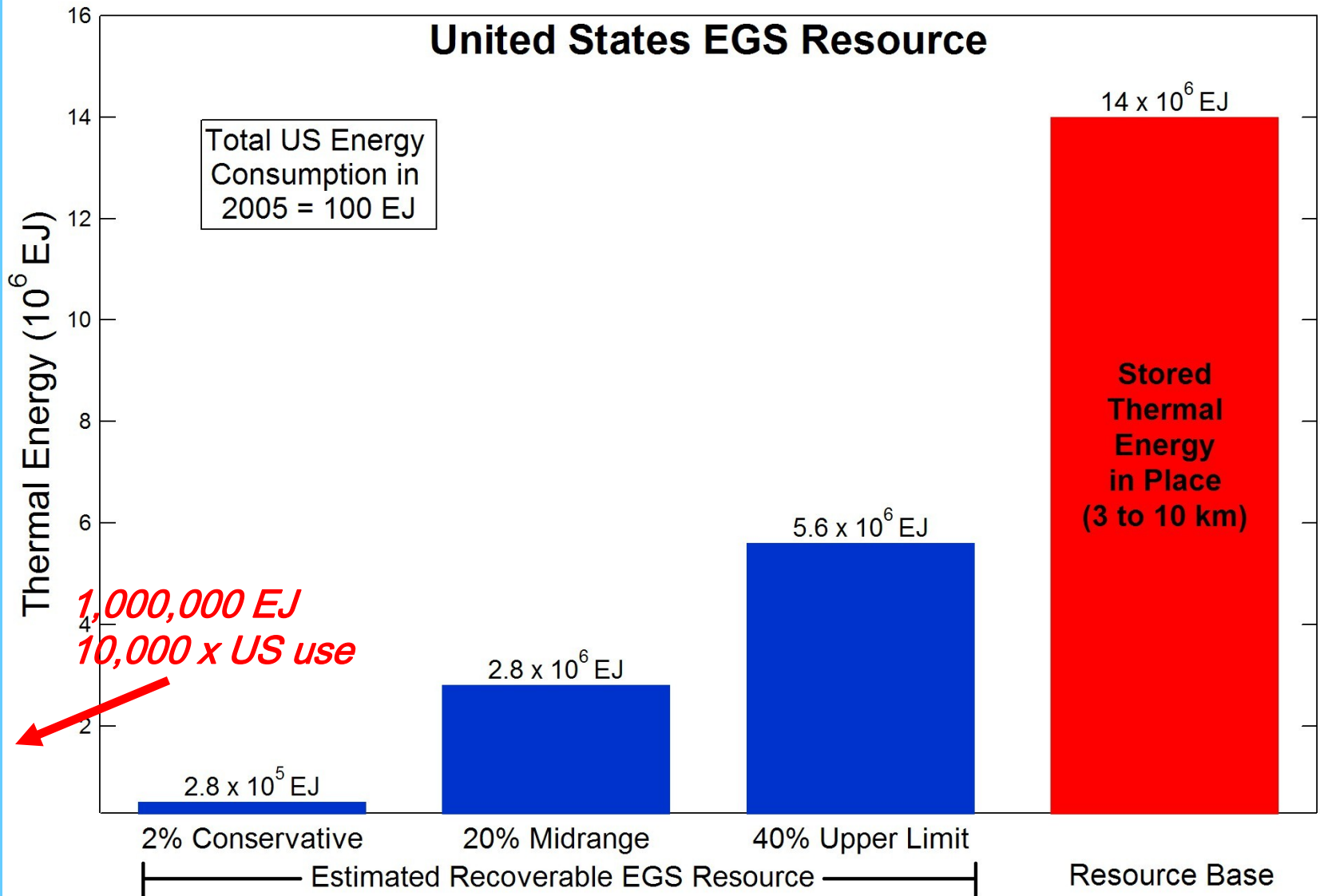
THE EGS SYSTEM
Introduction of water into rock of limited permeability (either tight sediment or basement) in a controlled fracture setting so that this water can be withdrawn in other wells for heat extraction, *i.e. heat mining*

Temperatures at 18,000 ft



6 km Depth Temperatures

United States EGS Resource



Estimated total geothermal resource base and recoverable resource given in EJ or 10^{18} Joules.



DOT EARTH

Nine billion people. One planet.

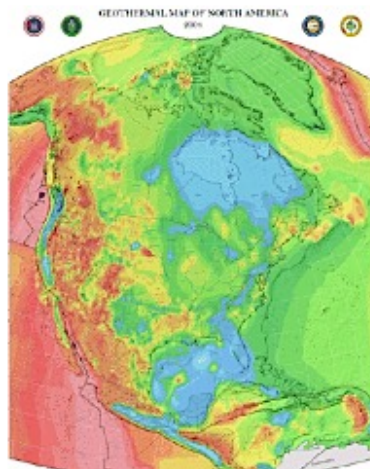
August 19, 2008, 2:04 PM

Google to Invest in Geothermal

By TOM ZELLER JR.

Google.org, the public-spirited division of Google.com, charged with addressing “climate change, poverty and emerging disease,” is using the backdrop of the National Clean Energy Summit here in Las Vegas to announce a new round of clean energy financing.

In a nutshell, the company is investing an arguably modest sum — a little over \$10 million — in the development of Enhanced Geothermal Systems, or EGS. The technology differs from “traditional” geothermal in that rather than exploiting existing wells of earthbound steam and hot water, EGS drills deep — miles down — to access layers of heated granite that exist underfoot everywhere on the planet. Water can be circulated downward for heating, and then upward to drive turbines and generate electricity.



[Efforts at mapping geothermal potential in North America at Southern Methodist University are receiving financial support from Google. \(Photo: Southern Methodist University\)](#)

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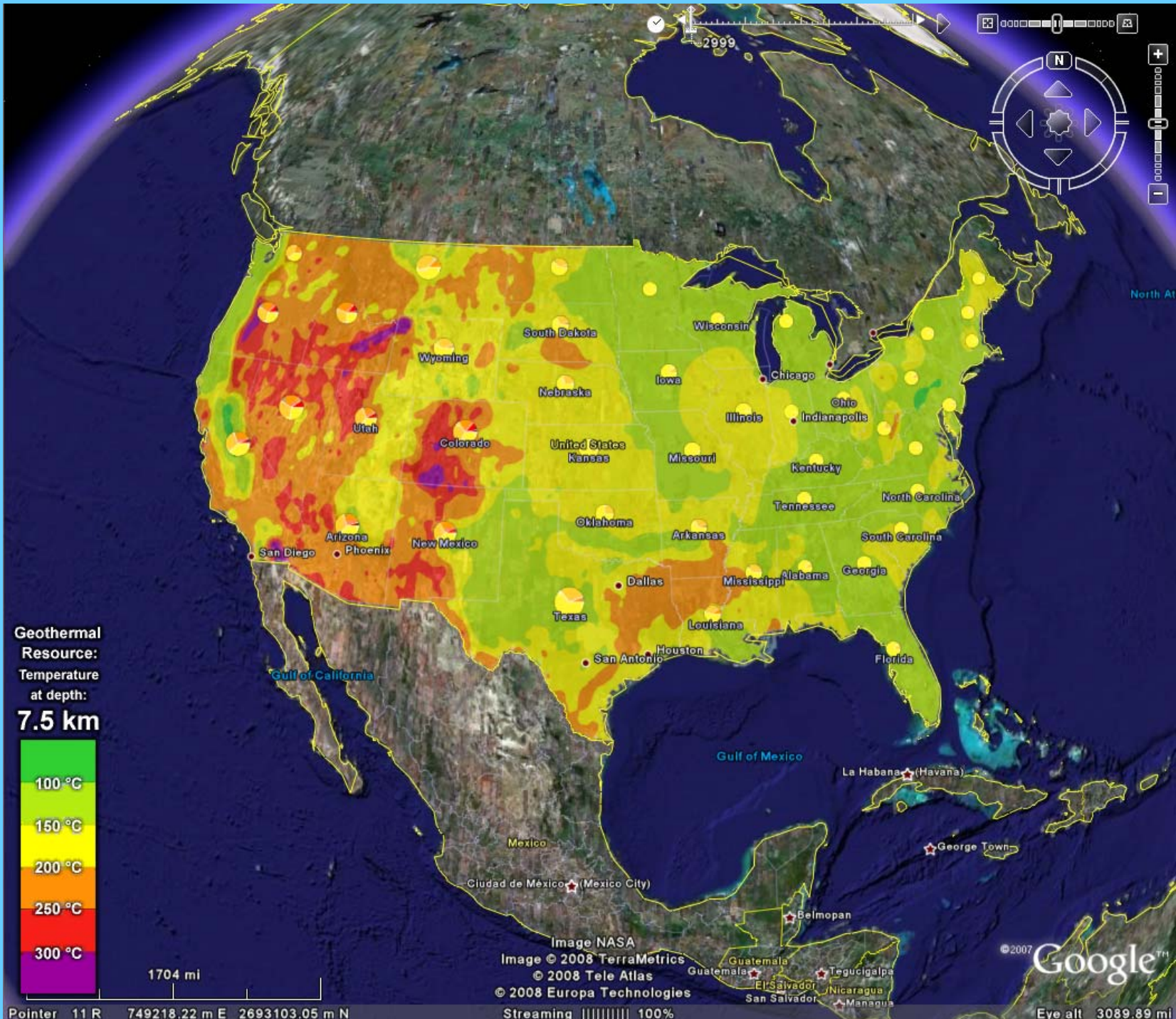
[Denuded Islands, 'Planetary Emergencies'](#) ▶

About Dot Earth

By 2050 or so, the world population is expected to reach nine billion, essentially adding two Chinas to the number of people alive today. Those billions will be seeking food, water and other resources on a planet where, scientists say, humans are already shaping climate and the web of life. In Dot Earth, reporter Andrew C. Revkin examines efforts to balance human affairs with the planet's limits. Supported in part by a John Simon Guggenheim Fellowship, Mr. Revkin tracks relevant news from suburbia to Siberia, and conducts an interactive exploration of trends and ideas with readers and experts.



FIND OUT MORE
ABOUT THE PROGRESS
CATERPILLAR IS



Geothermal Resource:
 Temperature at depth:
 7.5 km



1704 mi

Pointer 11 R 749218.22 m E 2693103.05 m N

Image NASA
 Image © 2008 TerraMetrics
 © 2008 Tele Atlas
 © 2008 Europa Technologies
 Streaming 100%

© 2007 Google™

Eye alt 3089.89 mi

The EGS system

Introduction of water into rock of limited permeability (either tight sediment or basement) in a controlled fracture setting so that this water can be withdrawn in other wells for heat extraction.

An area that is very favorable is in east Texas and northern Louisiana where the low permeability tight formations of the Jurassic with temperatures over 350 °F are being exploited as tight gas systems.

Other examples include the Cooper Basin, Australia, Gross Schoenbeck Germany

Untertage Teil der HDR-Anlage in []tz



Beobachtungsbohrung

Geophon

GPK4
(2003)

GPK2
(1999)

GPK3
(2002)

1450
m

5000 m

200°

stimulation 2000

stimulation 2005

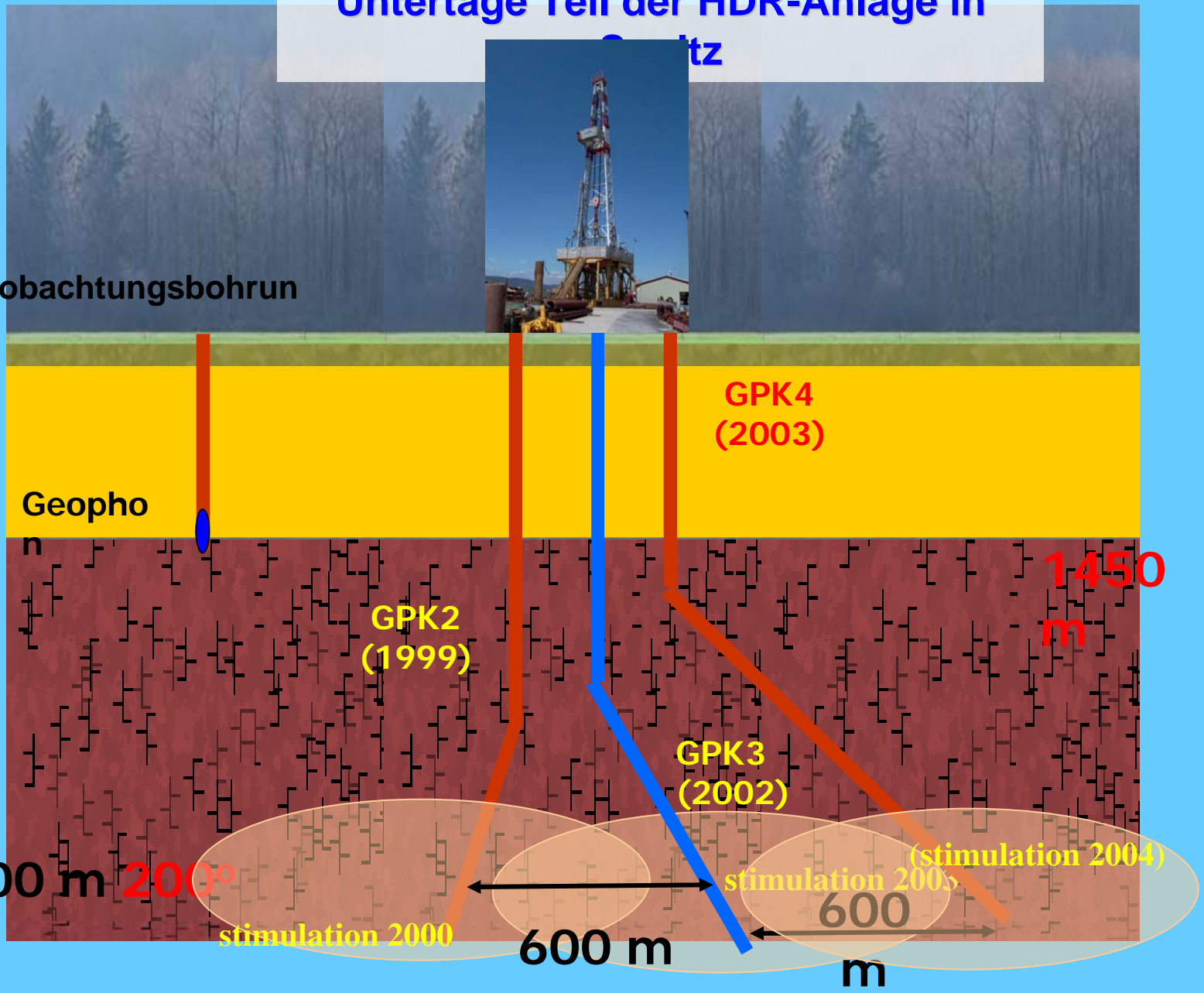
(stimulation 2004)

600 m

600

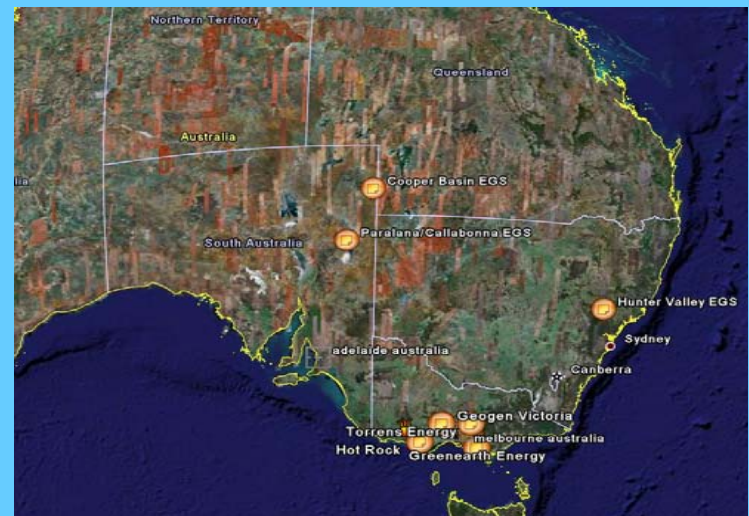
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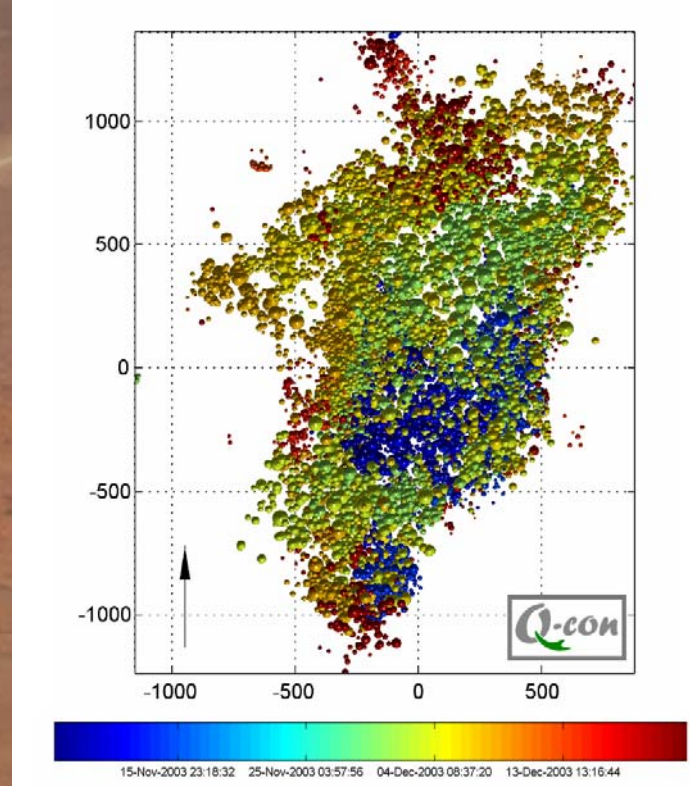
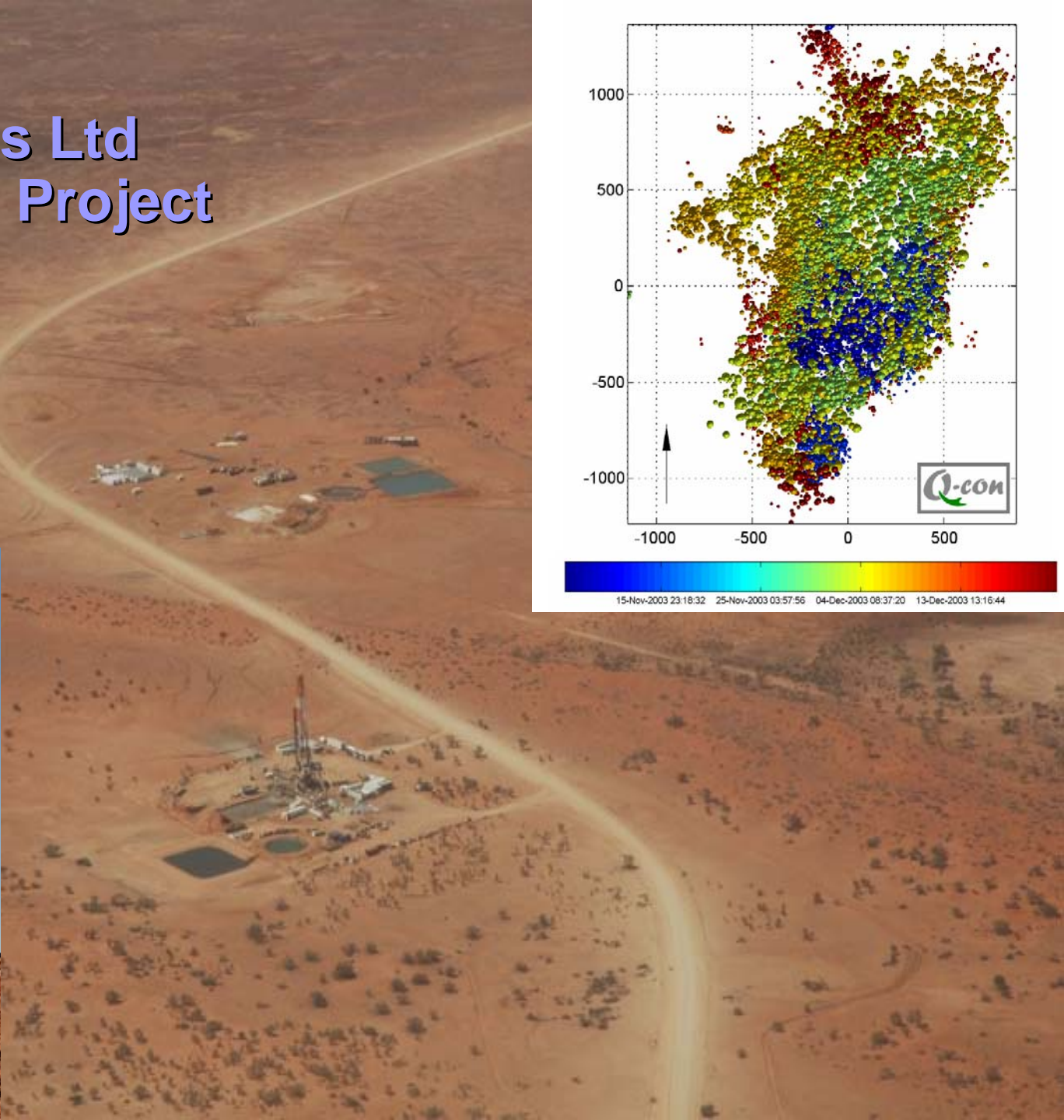


EGS Projects

- Europe
 - Soultz
 - Landau
 - Grosse Schönebeck
 - Unterhaching
- Australia
 - Cooper Basin-GEODYNAMICS
 - Paralana GreenEarth Energy
 - Hot Rock Ltd
 - Geogen VictoriaT
 - Torrens Energy Ltd
 - Granite Power



GeoDynamics Ltd South Australia Project





Habenaro #1



Newberry Volcano, Oregon

From Hot Water to Hydrogen

Bringing Geothermal Power to Alaska



Presented by: Bernie Karl

SMU Geothermal Conference June 12th, 2007

Geothermal Energy







Keeping ice
cold with
hot water



Carrier

UTC Power

Chiller...

Cap logo

Documents

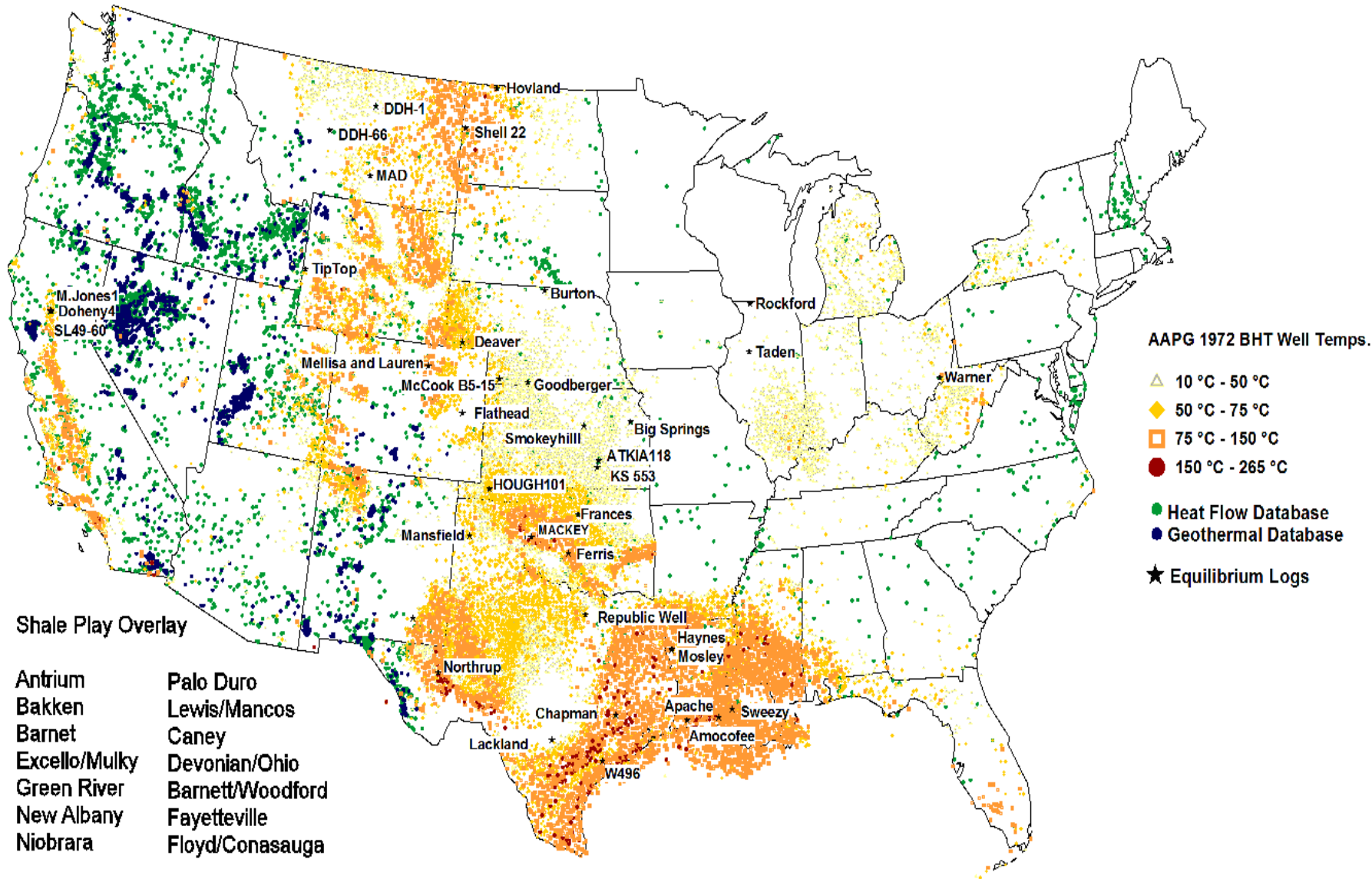
Scenarios for development

Coproduced fluids

Geopressure fluids

Sedimentary EGS

These are briefly described, Resource based discussed, and examples of development given for each category







RMOTC, Wyoming, Oct 7, 2005





NPR #3
U.S. DEPT. OF ENERGY
75-TPX-10
2469' FSL, 1383' FEL
ELEV. 5188' G.L.
SEC. 10, T 38 N, R 78 W

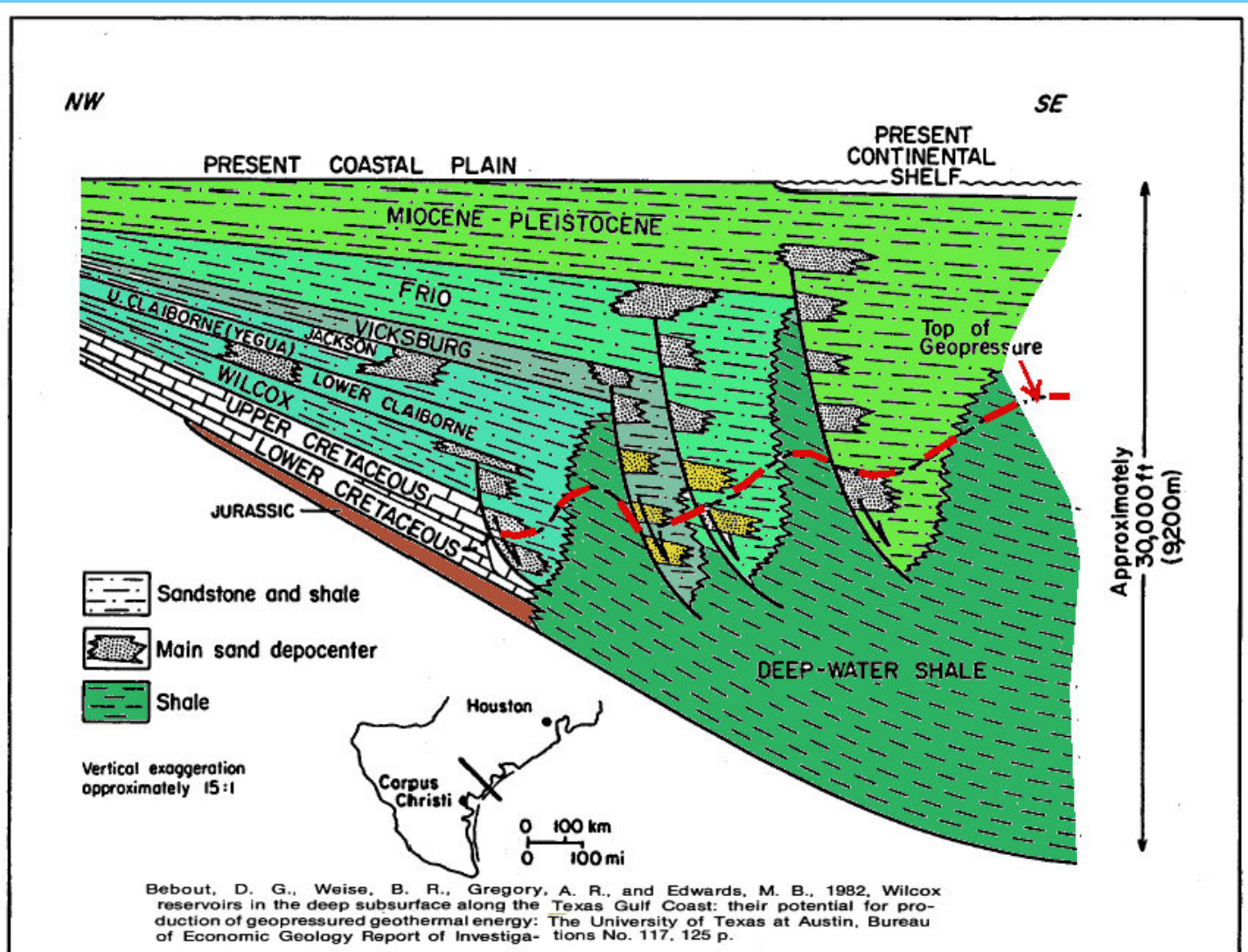
U.S. DEPT. OF ENERGY
NPR #3
75-TPX-10
2469' FSL, 1383' FEL
ELEV. 5188' G.L.
SEC. 10, T 38 N, R 78 W

Ormat Power Plant, October 18, 2008

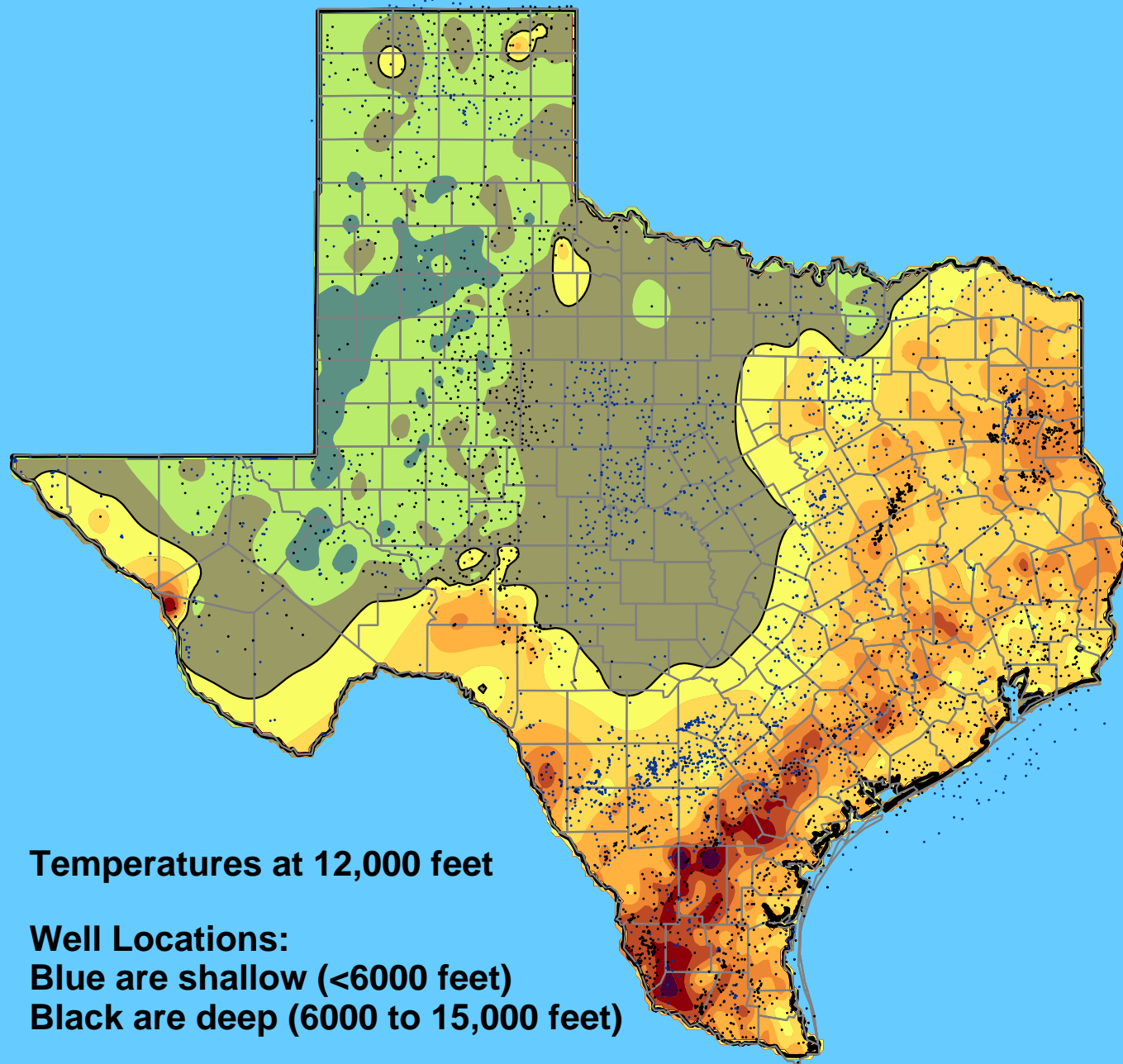
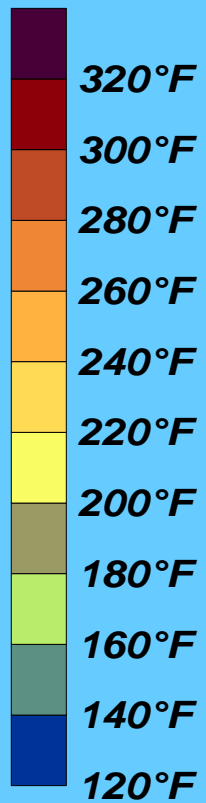


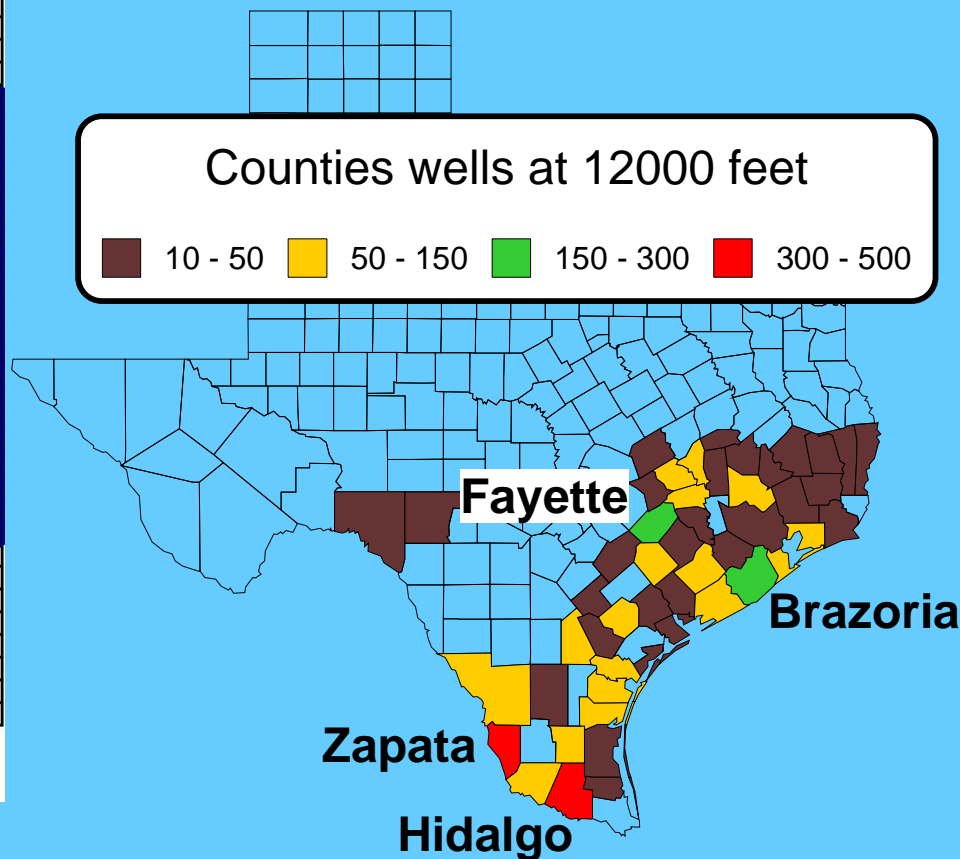
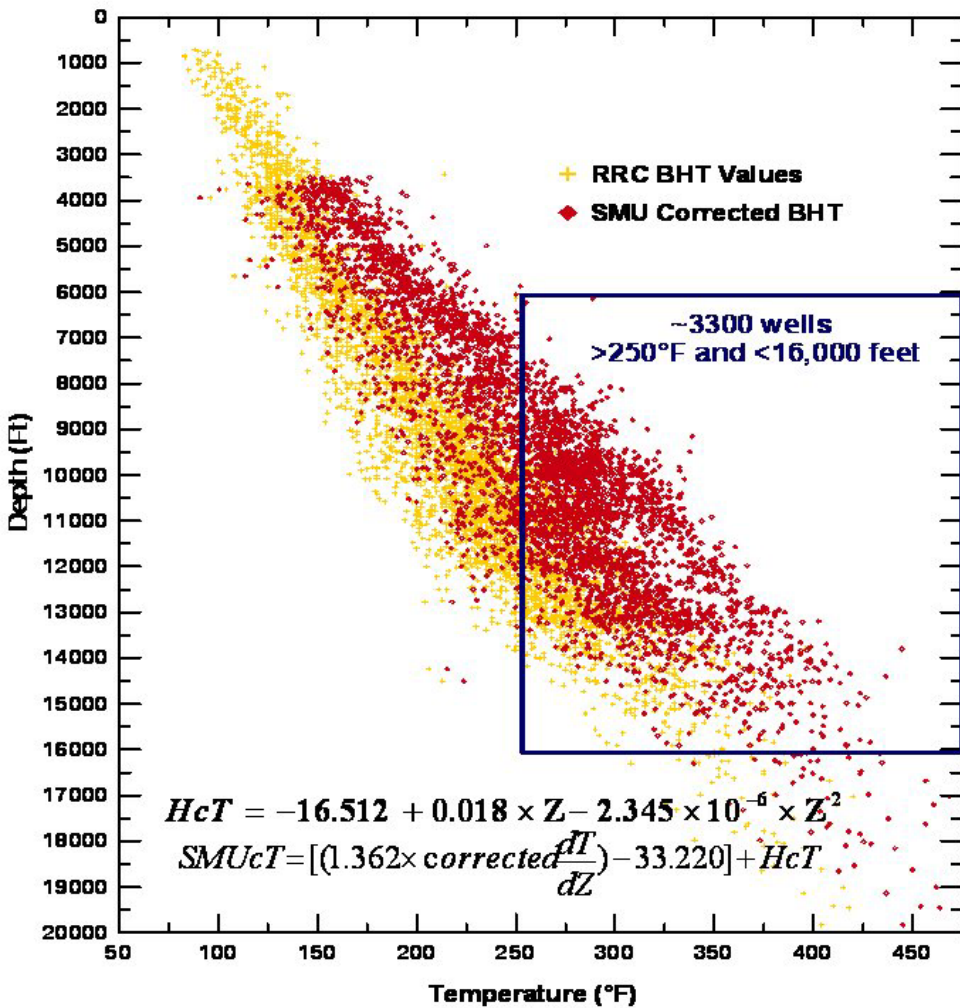
Chena Mobile Power System





Schematic cross section, central Texas Gulf Coast, showing relationship among major growth faults, expansion of section, sand depocenters, and top of geopressure (after Bebout and others, 1982).





3648 wells

Gulf Coast Wells active in 2000 - 2005
Total Wells 18,224

Geopressure



•Pleasant Bayou, Brazoria, Texas 1989-1990

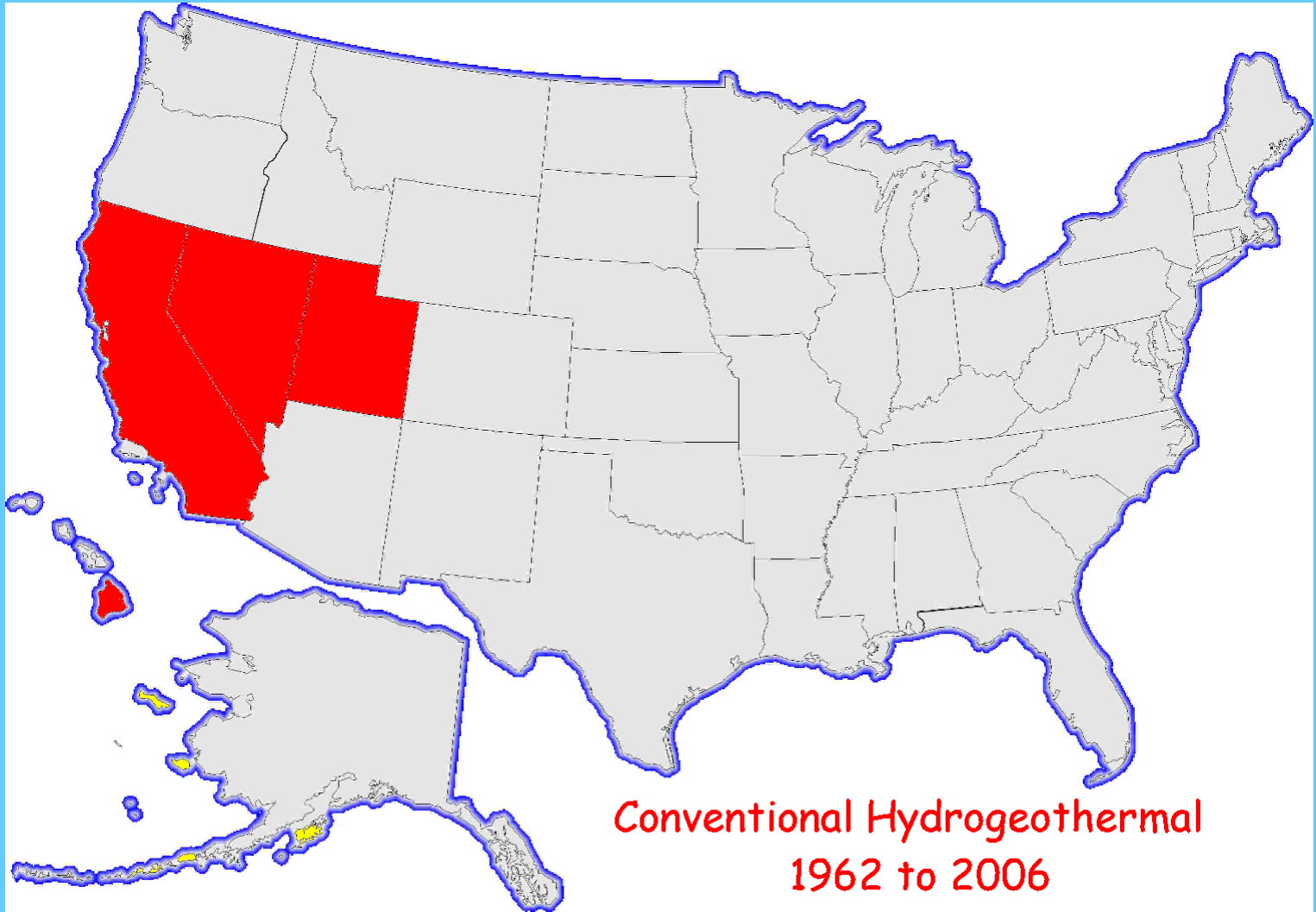
Geothermal Energy from Oil and Gas Fields

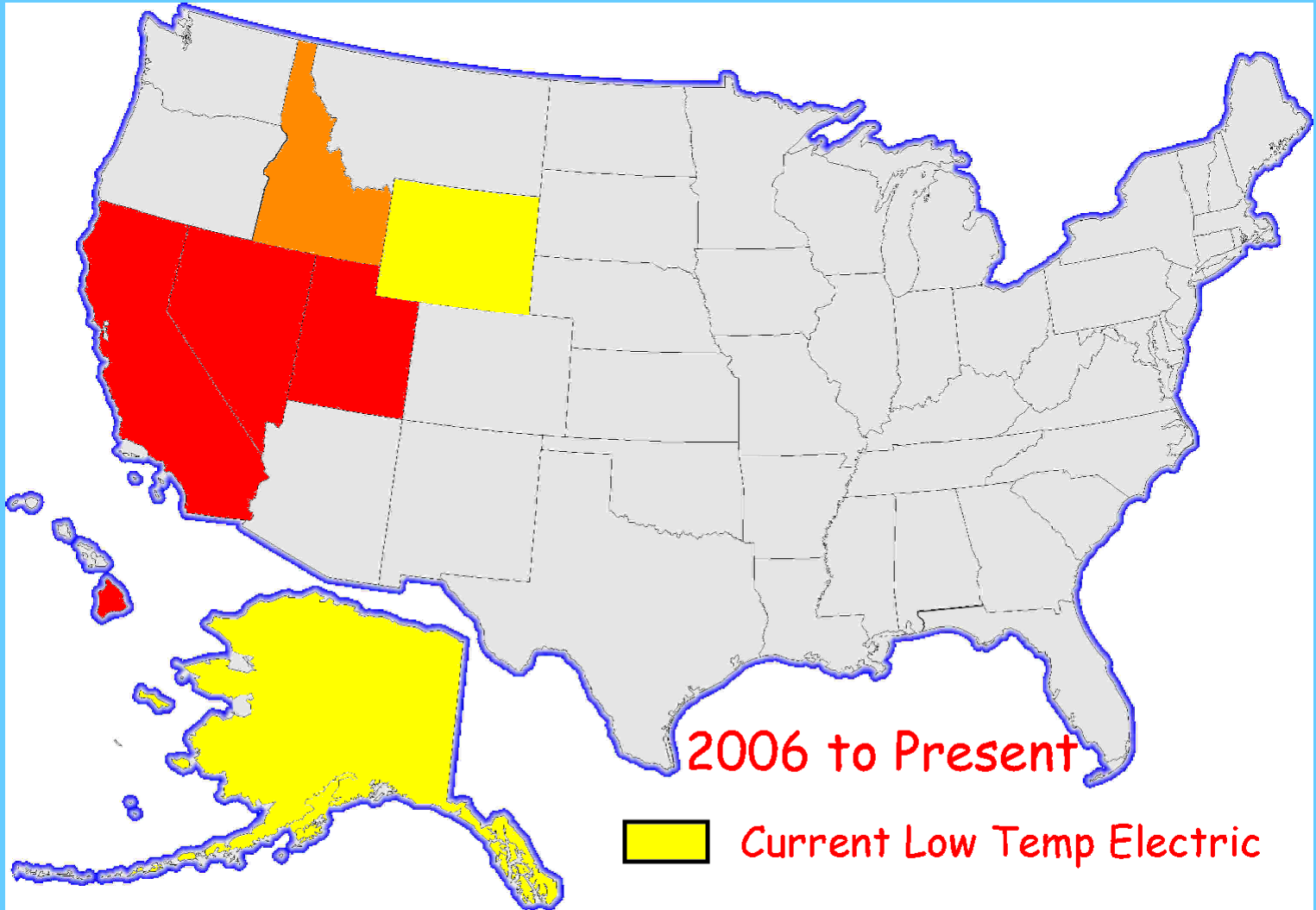
- ❖ Base Load
- ❖ Green, no emissions
- ❖ Located in industrialized areas
- ❖ Financing by long term loans
- ❖ Lowers cost of production
- ❖ Multibillion dollar market in Texas alone
- ❖ Large scale gas resources developed with geopressure

Scaling Up Geothermal Development

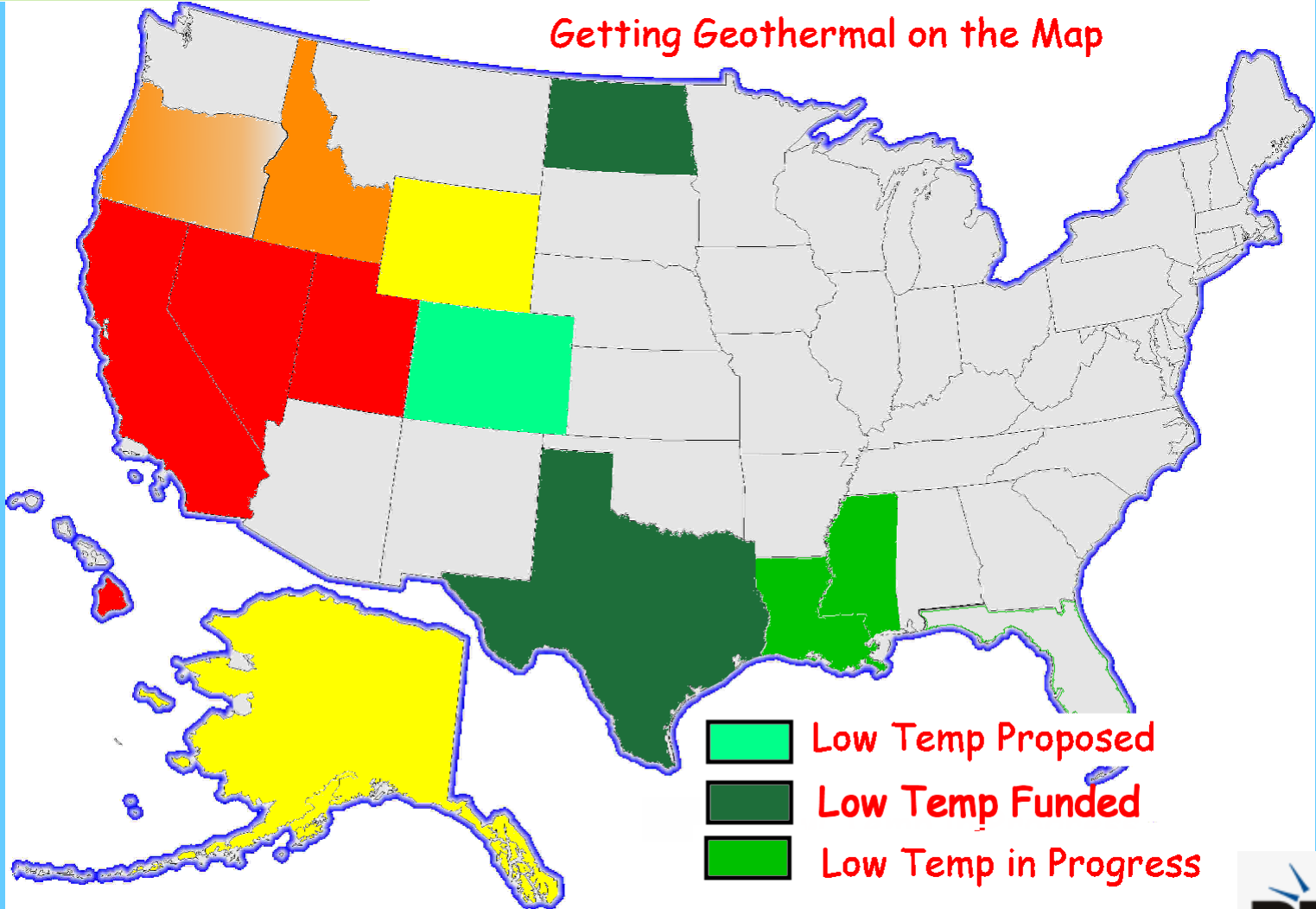
- 50,000 MW by 2050 (FGE2006)
- 10,000,000,000,000 MW potential
(current US Installed 1,000,000,000 MW)
- Presently 2,000 MW (~1,000 wells of which 500 wells are producers)
- Need ~25,000 wells for 50,000 MW
- 1 EGS drilling project in progress today!

Potential of Geothermal has to be Appreciated!





Getting Geothermal on the Map



-  Low Temp Proposed
-  Low Temp Funded
-  Low Temp in Progress

If Life Gives You Hot Water



Make Ice!



