Unconventional Geothermal Energy and the US Energy Supply

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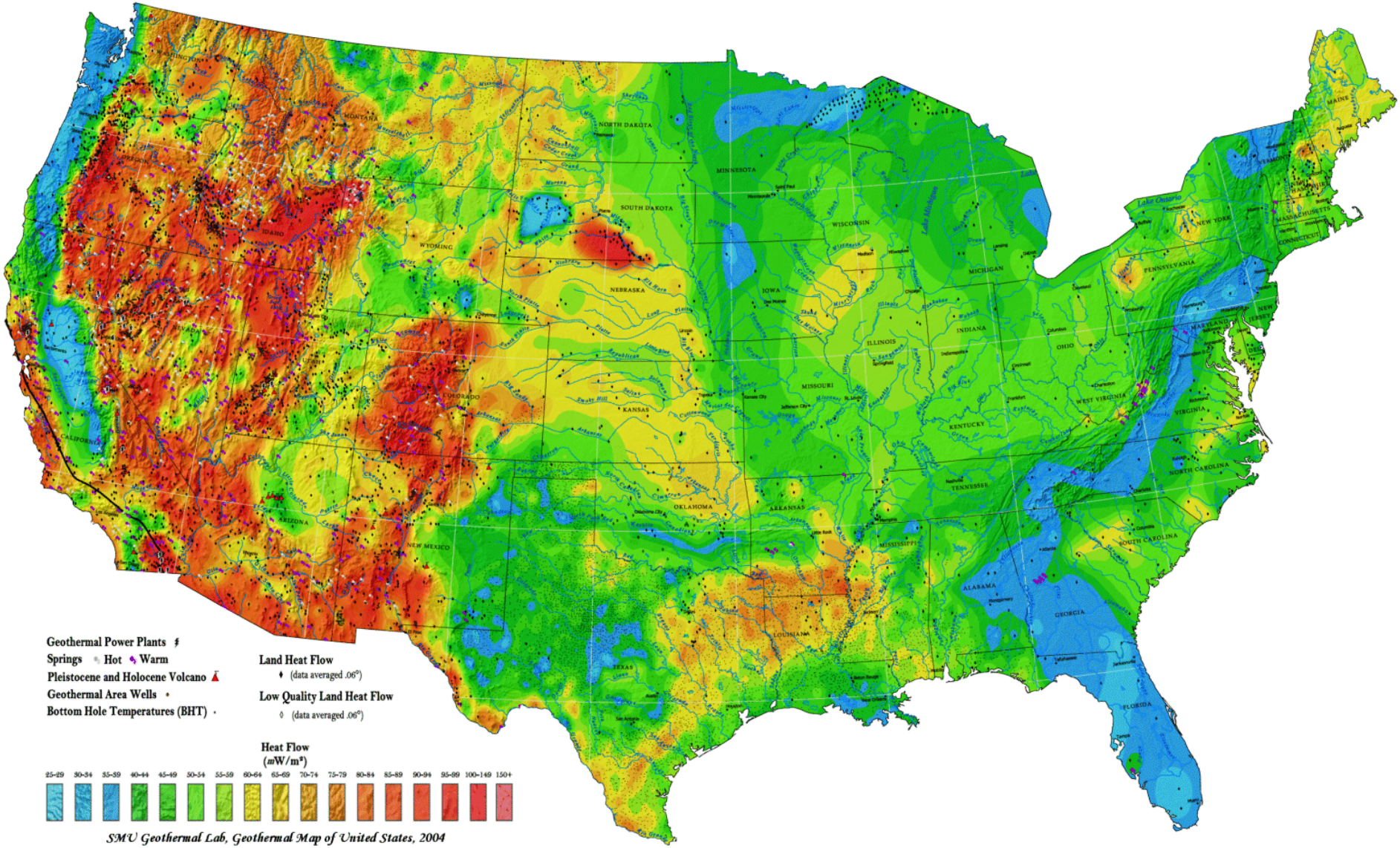
The Future of Geothermal Energy

- We must introduce uncertainty in the necessity of a coal and nuclear future!
- We must emphasize systems analysis in planning the energy future (the real costs and impacts must be considered)!
- We must consider nationwide market penetration
- We must have several 10's of MW of unconventional geothermal energy on line by 2010
- Definition of EGS-What should we be talking about?

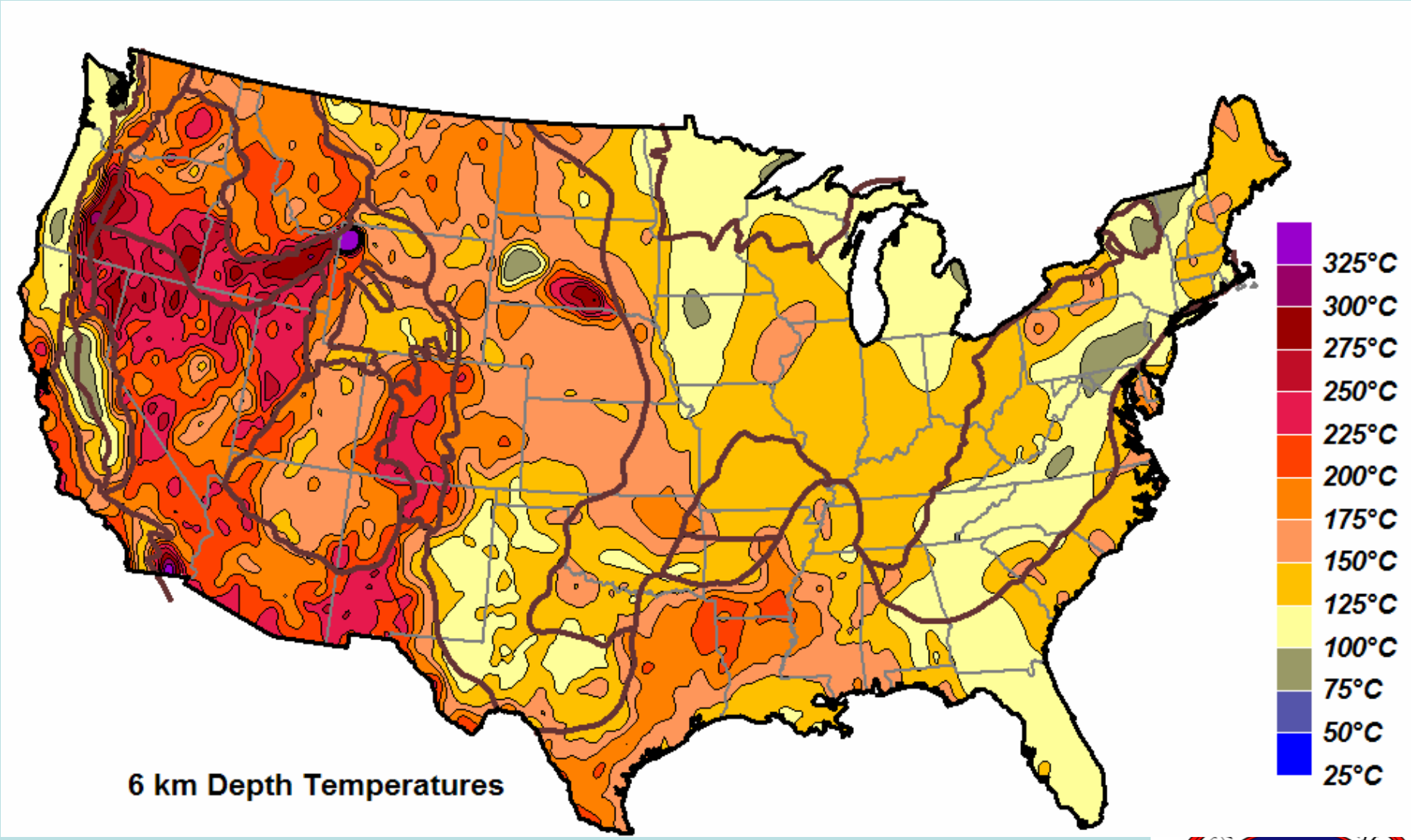
The MIT Report: Source of Data and Methods of Analysis

- The analysis is described in the MIT report (also Blackwell, Negraru, and Richards, 2007)
- Regional Study-compare Great Basin Study-based on detailed geology
- Data gaps
- Unknowns-basement geology

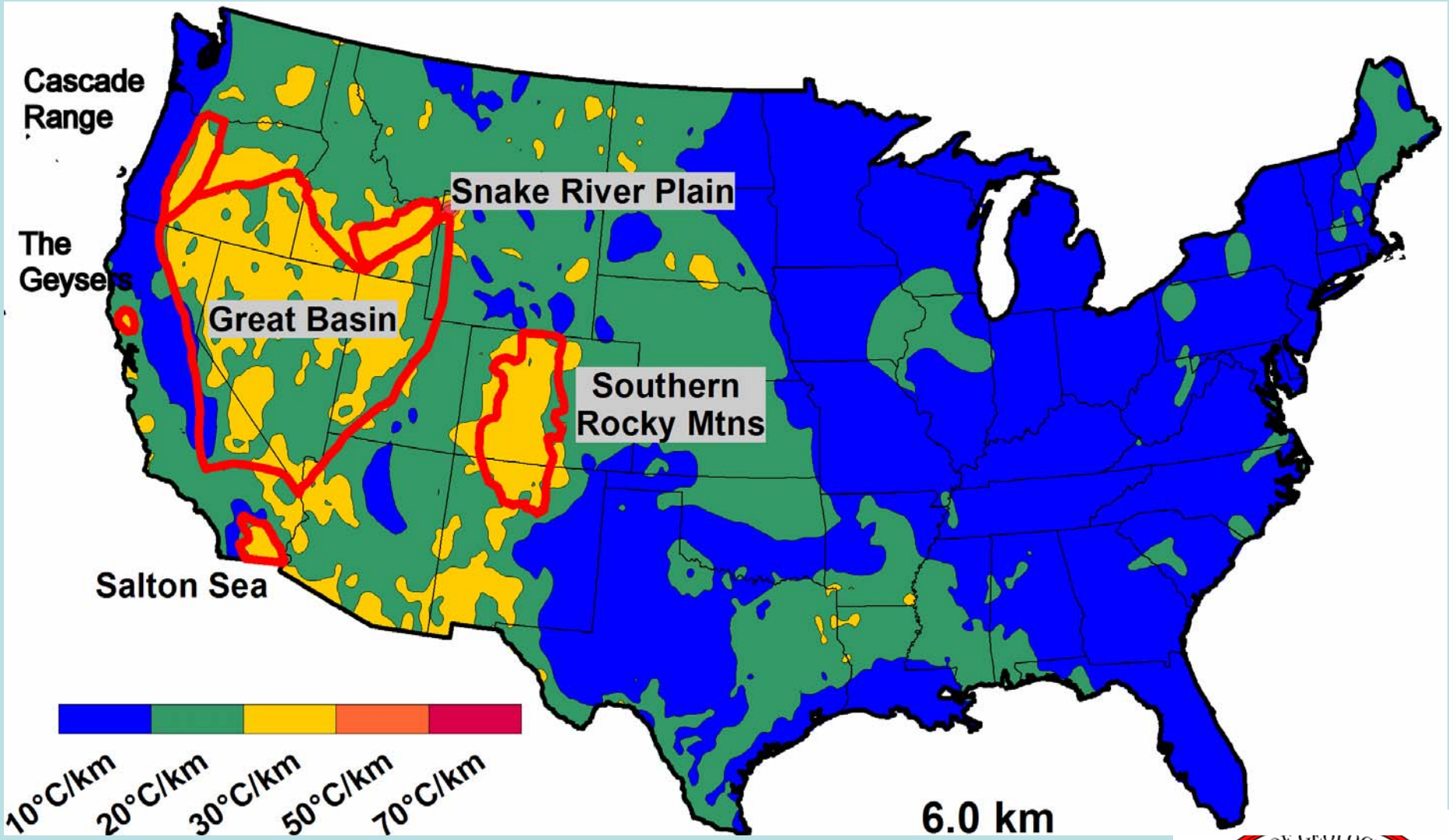


30 35 40 45 50 55 60 65 70 75 80 85 90 95 100

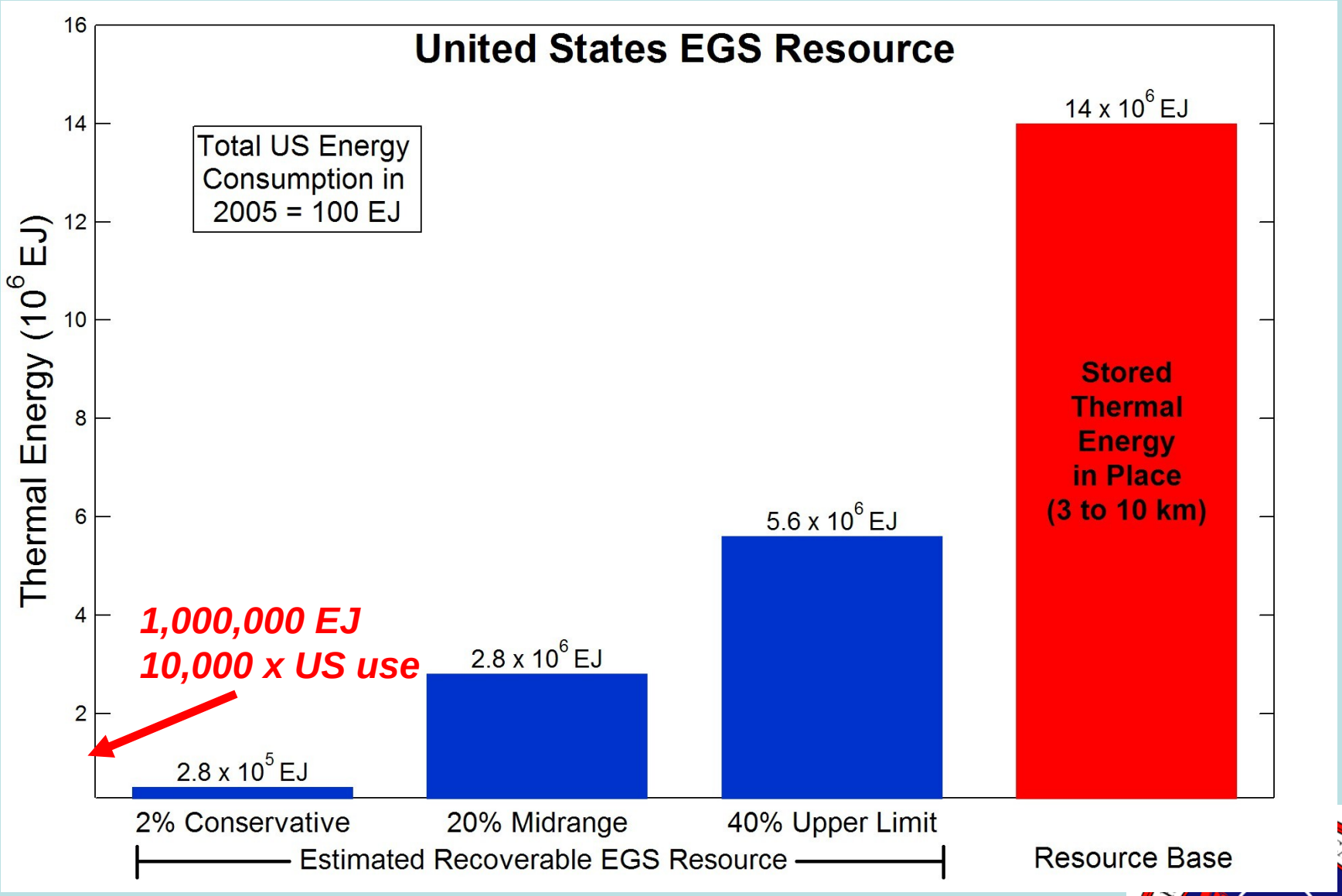
2004 Geothermal Map of North America (Blackwell & Richards)



Temperature at 6 km (18,000 ft) from Blackwell, Negraru & Richards (2007)



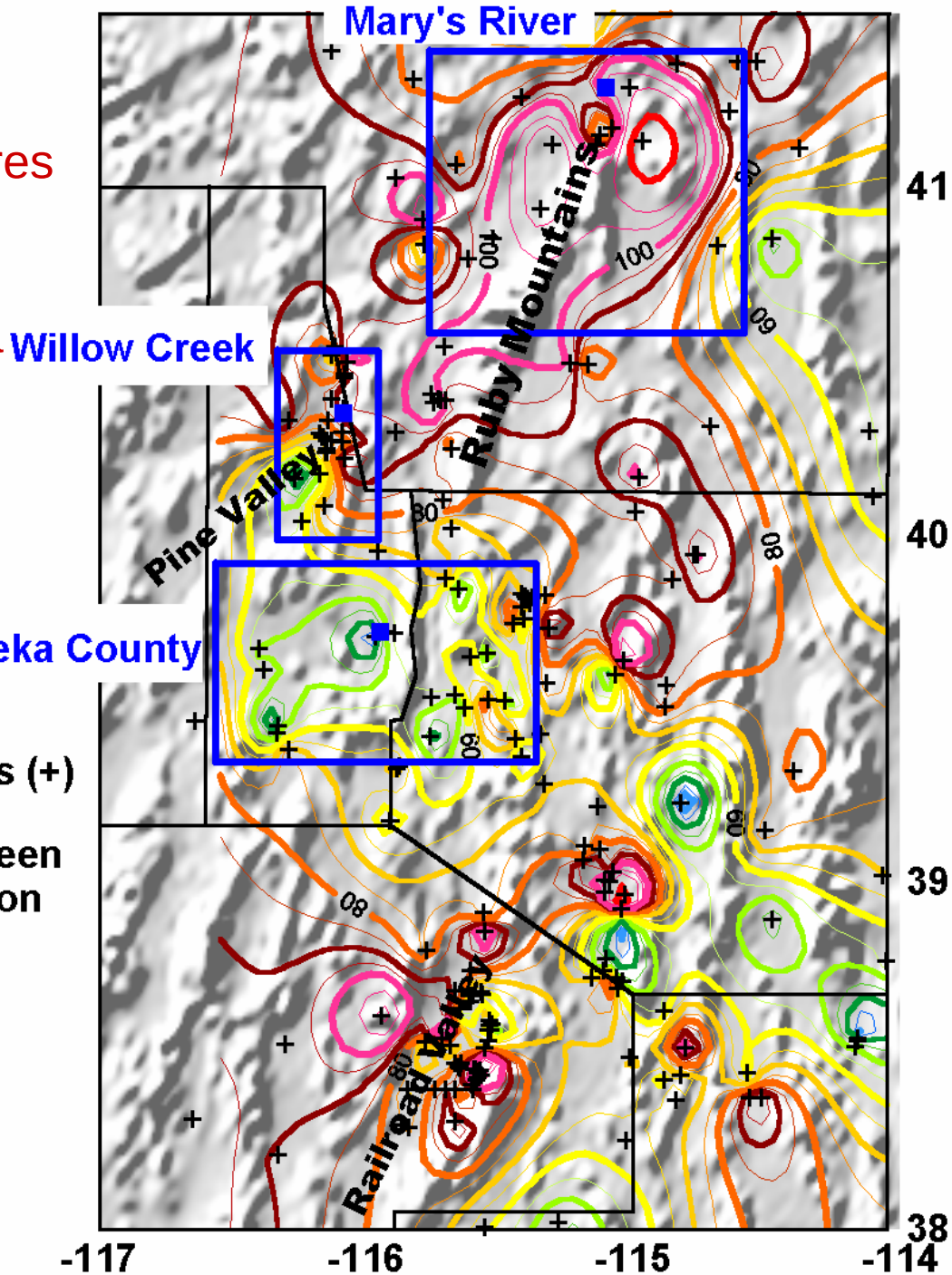
Mean Gradient to 6 km and regional EGS areas



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

Example: High temperatures in sediments

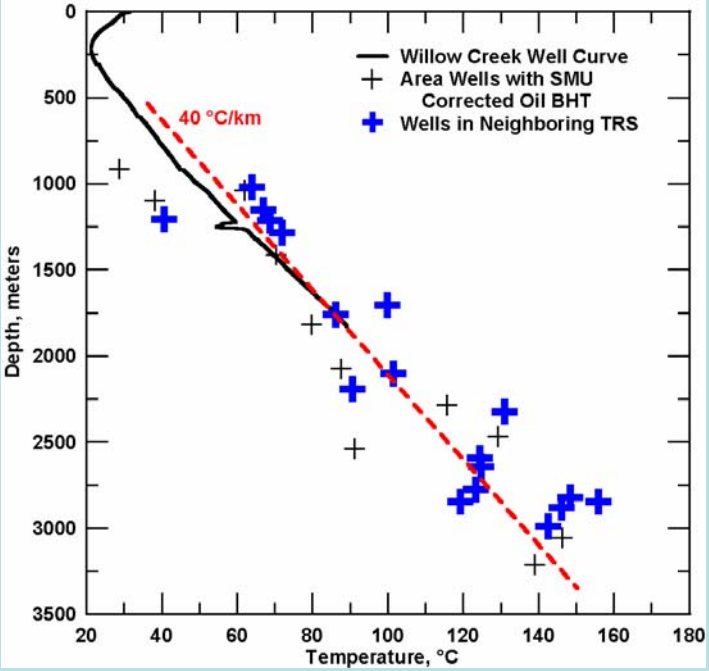
A large area in NE Nevada has high temperatures at about 10,000 ft in high permeability sedimentary rocks

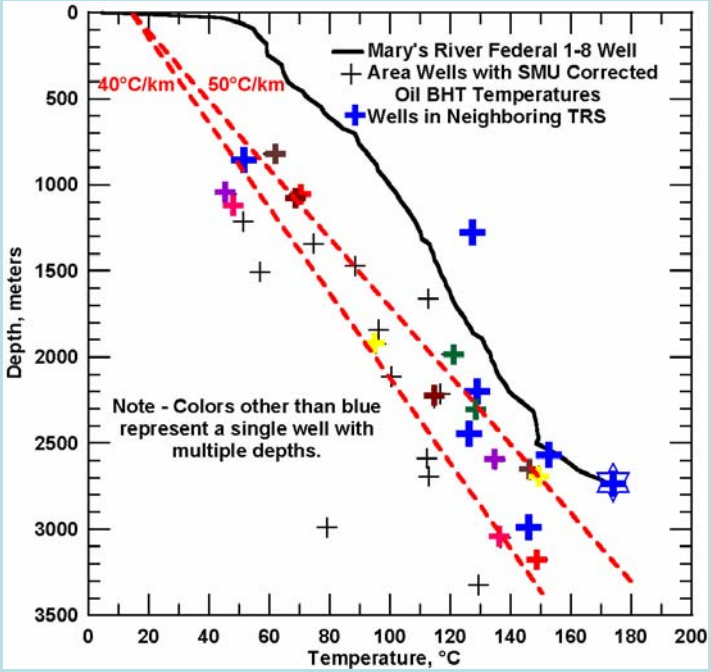


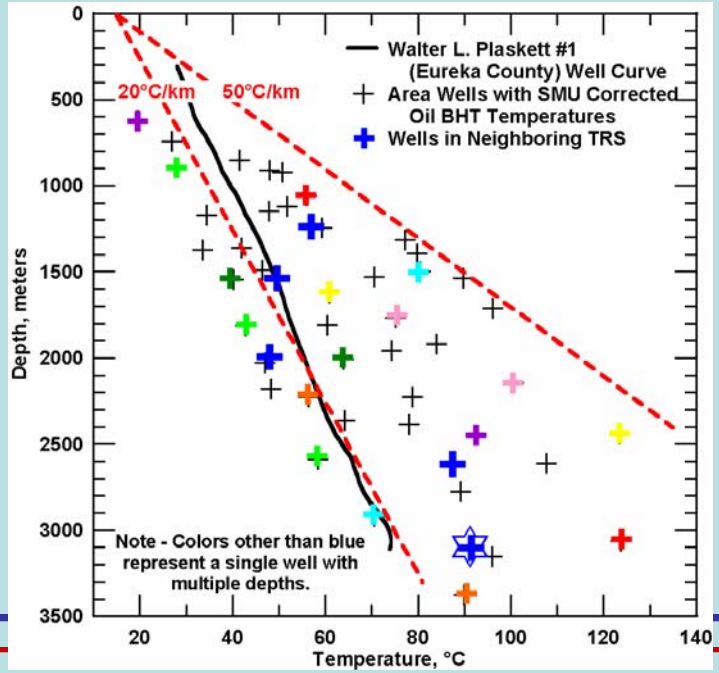
Locations of NE Nevada Oil Wells (+)

Locations for comparisons between TD curves and SMU Correction

Heat Flow Contours (with 20 mW/m2 intervals)







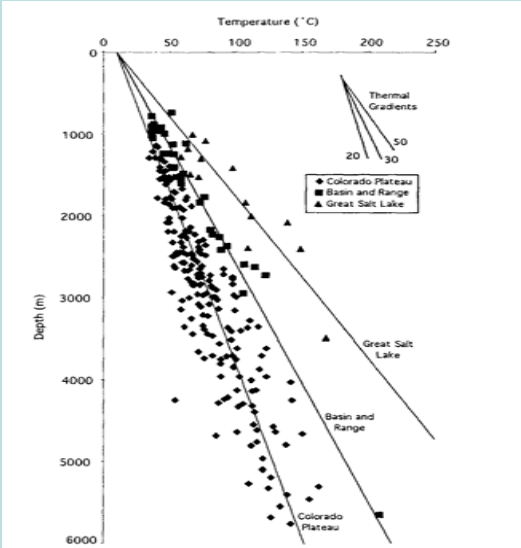
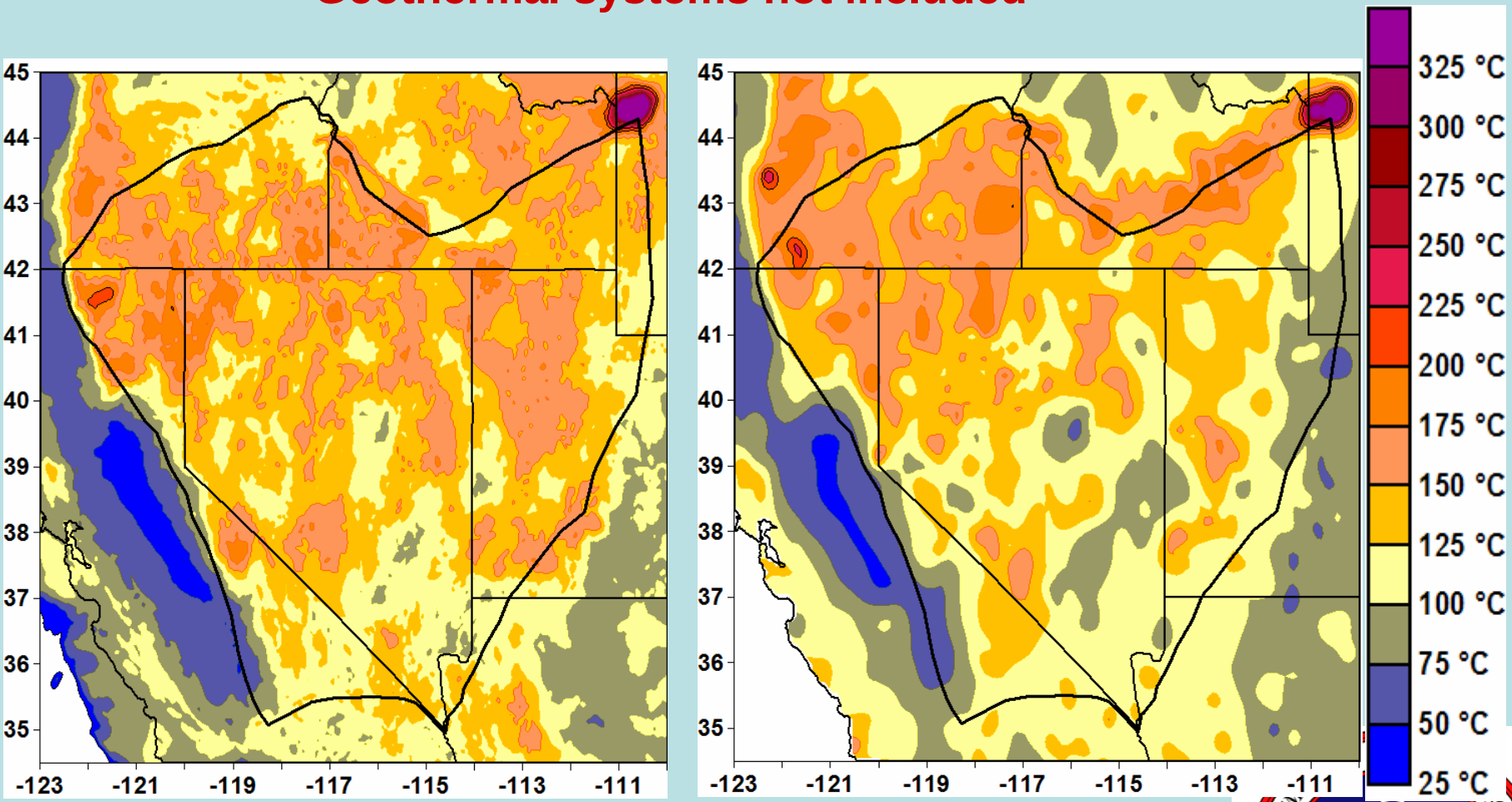


Figure 5. Temperature versus depth for all of the data collected in this study. Average thermal gradients projected on the figure are for the Great Salt Lake (60°C km^{-1}), Basin and Range (35°C km^{-1}) and Colorado Plateau (26°C km^{-1}). The Basin and Range and Colorado Plateau are separated according to the geomorphic transition.

Examples of Data Gaps

- Illinois Well
- South Dakota Aquifer anomaly
- West Virginia/Penn. shale gas plays

3 km Depth Temperatures
Geothermal systems not included

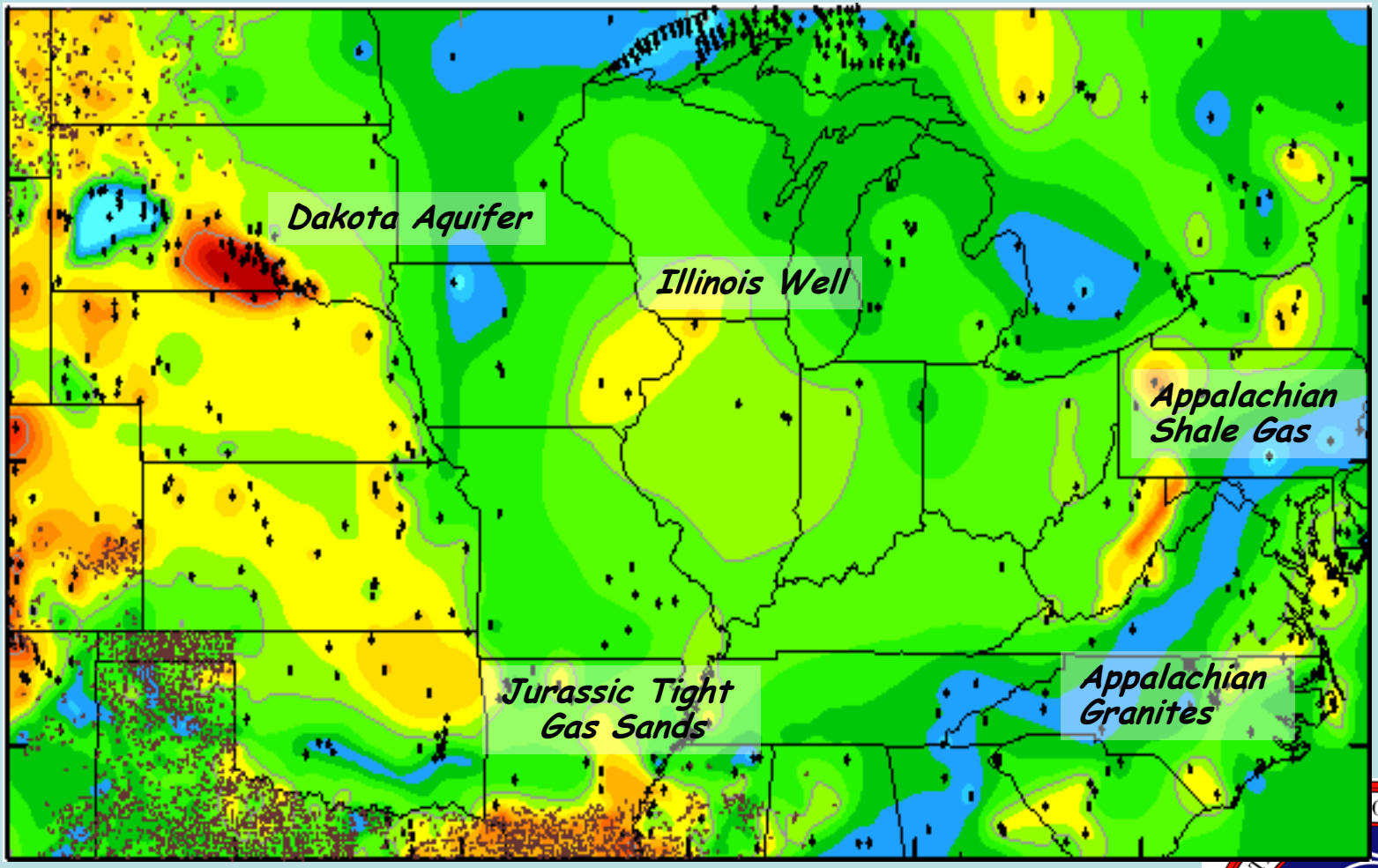


Based on Geology and Heat Flow

Based on Surface Temp. & Heat Flow

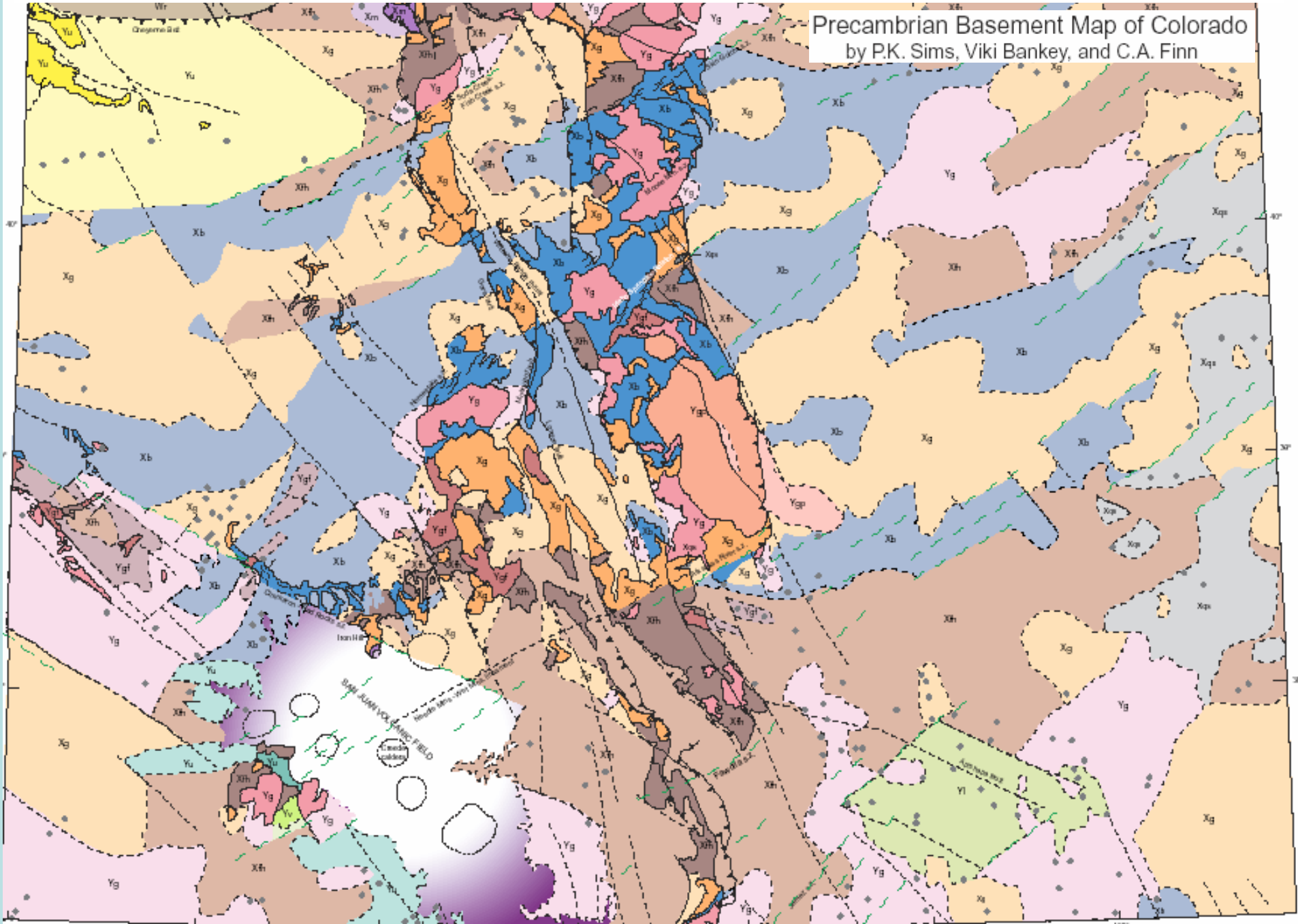
Comparison of 5’ and 2.5’ resolution with geological detail

Examples of Thermal Data Set Coverage in Eastern US



Map from the Geothermal Map of N. America, 2004

Example of basement geological map that can be matched to thermal mapping results



The Future of Geothermal Energy

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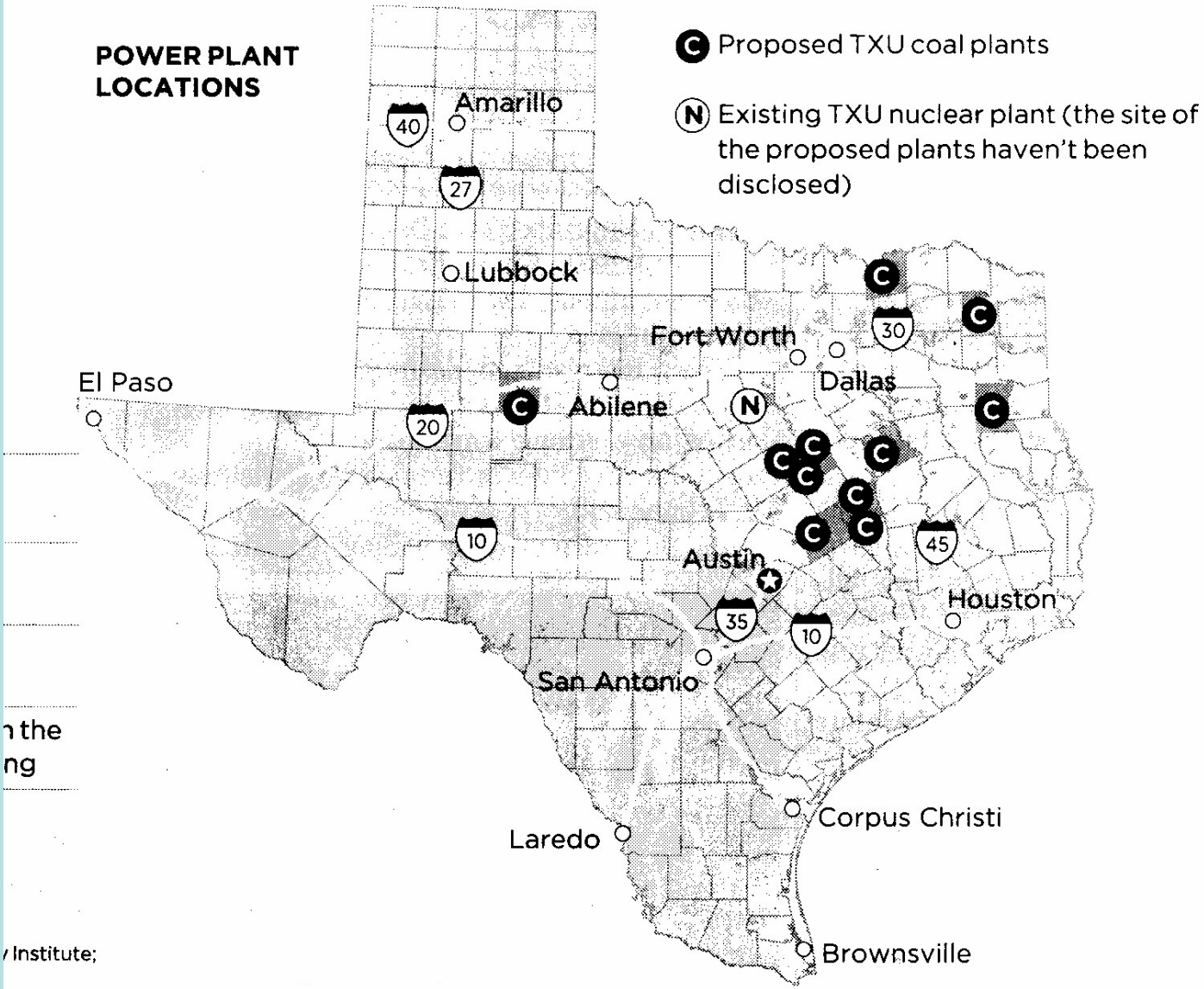
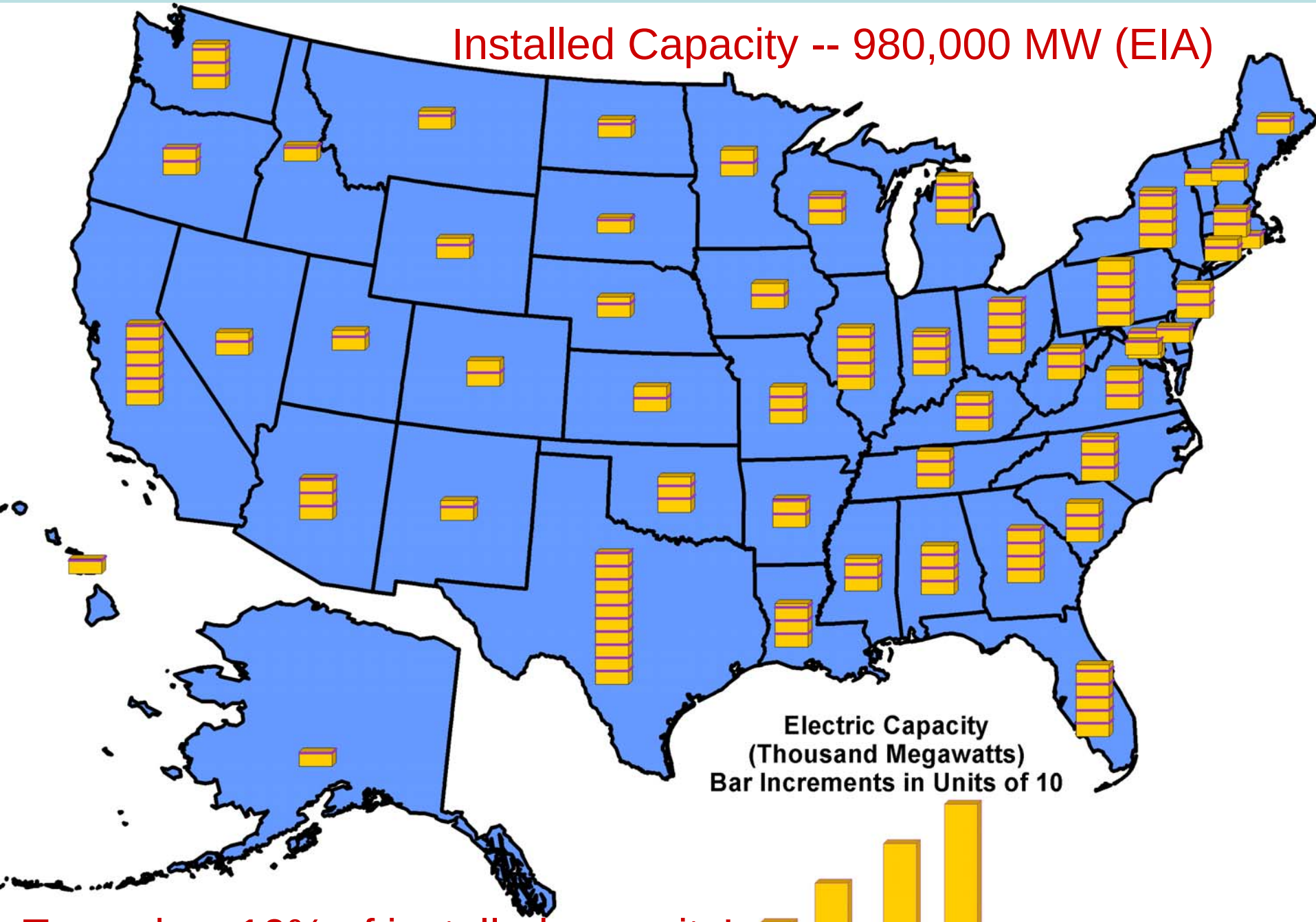
DallasNews.com
Page 16A Friday, September 1, 2006



The Future according to TXU?
14,000 MW Coal & Nuclear

Modified in early 2007

Installed Capacity -- 980,000 MW (EIA)



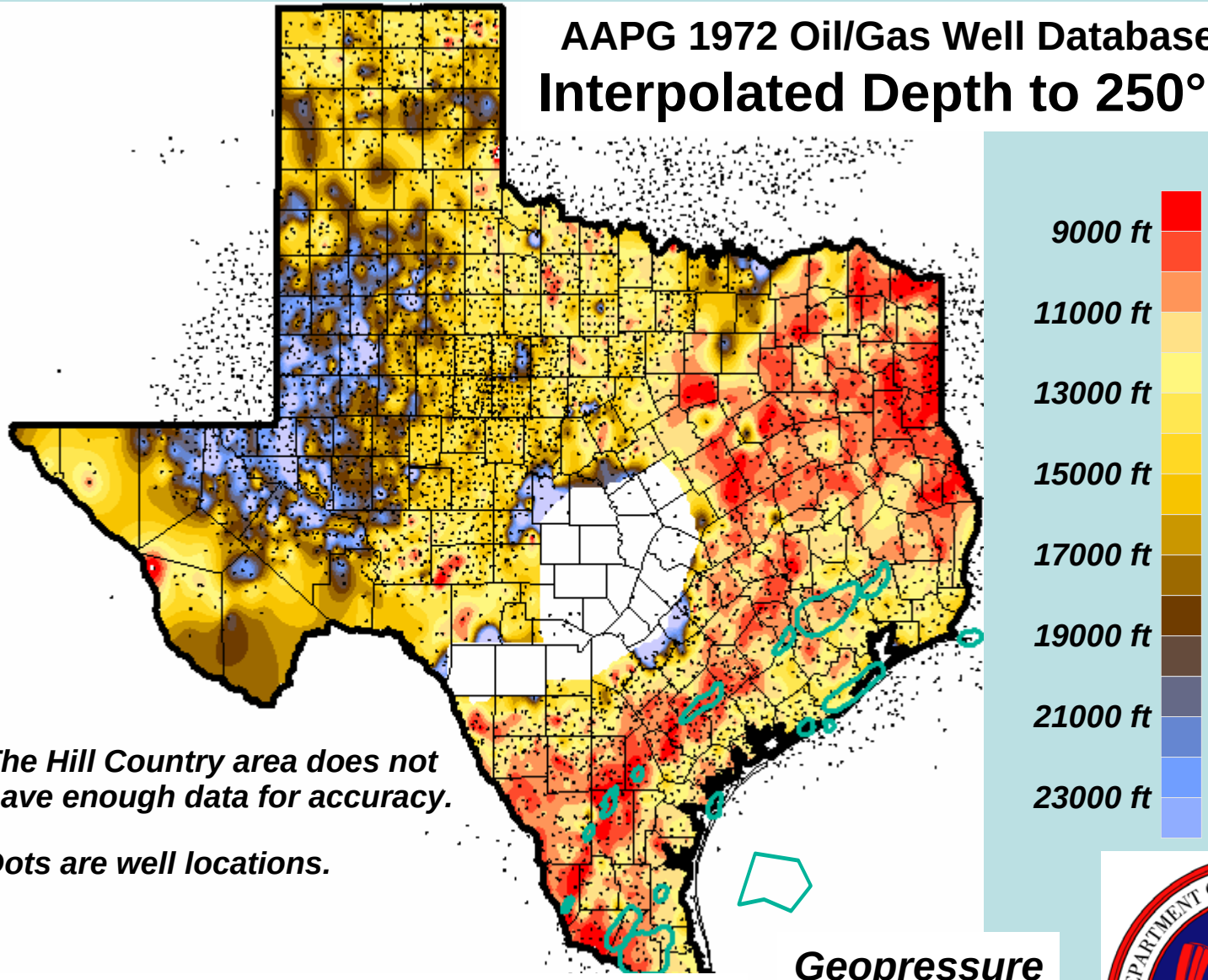
Texas has 10% of installed capacity!

Types of Resources

- Coproduced
- Geopressure-Gulf Coast/East Texas
- Tight gas sands-Pieance Basin/Wattenburg Field
- Thick Sediments in high heat flow areas
- Basement EGS
- Hydrothermal Margins

AAPG 1972 Oil/Gas Well Database

Interpolated Depth to 250°F



The Hill Country area does not have enough data for accuracy.

Dots are well locations.

Geopressure Fairways

Location of Texas Geothermal Resources

DEPARTMENT OF GEOLOGICAL SCIENCES
SOUTHERN METHODIST UNIVERSITY

Actual Gas Field Conditions

* Wells with BHT's over 300 °F at 15,000 ft or less, and often geopressure

* Many existing wells

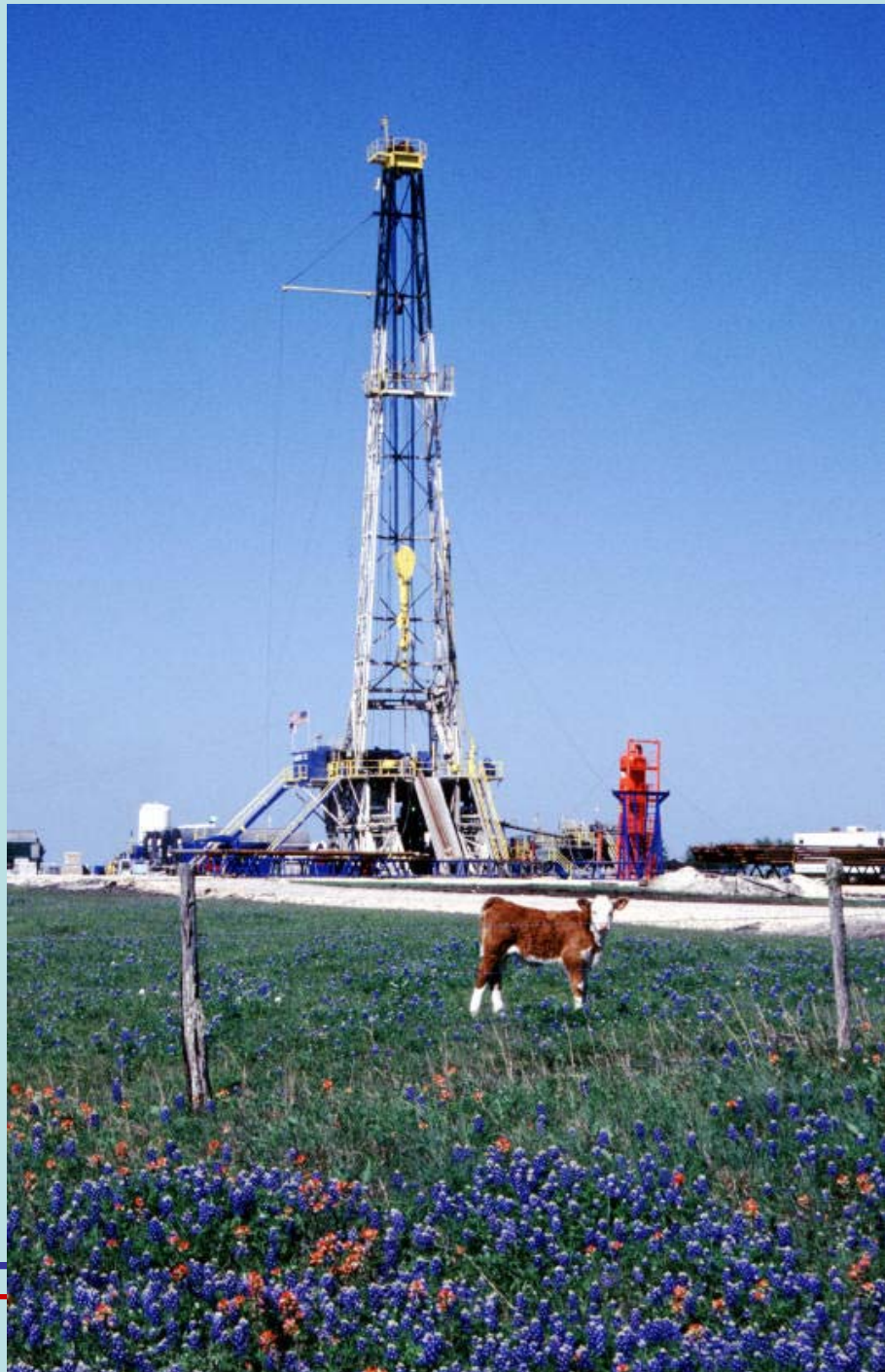
* Water from one well or adjoining wells

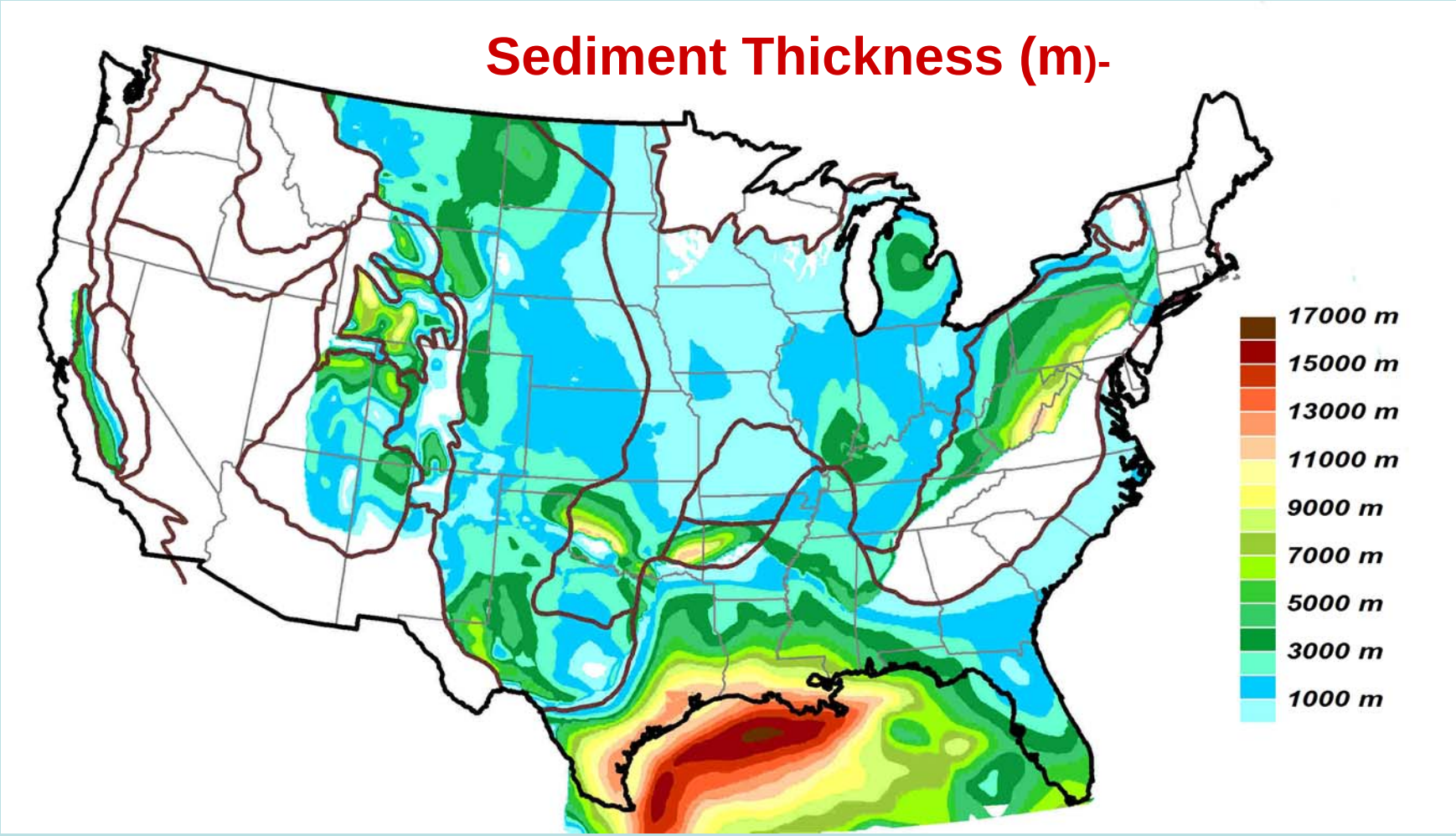
* Existing infrastructure of power lines, roads, pipelines, etc.

* Possibility of continued stripping of gas and oil in otherwise non-economic wells

Direct Costs to Develop an Oil & Gas System

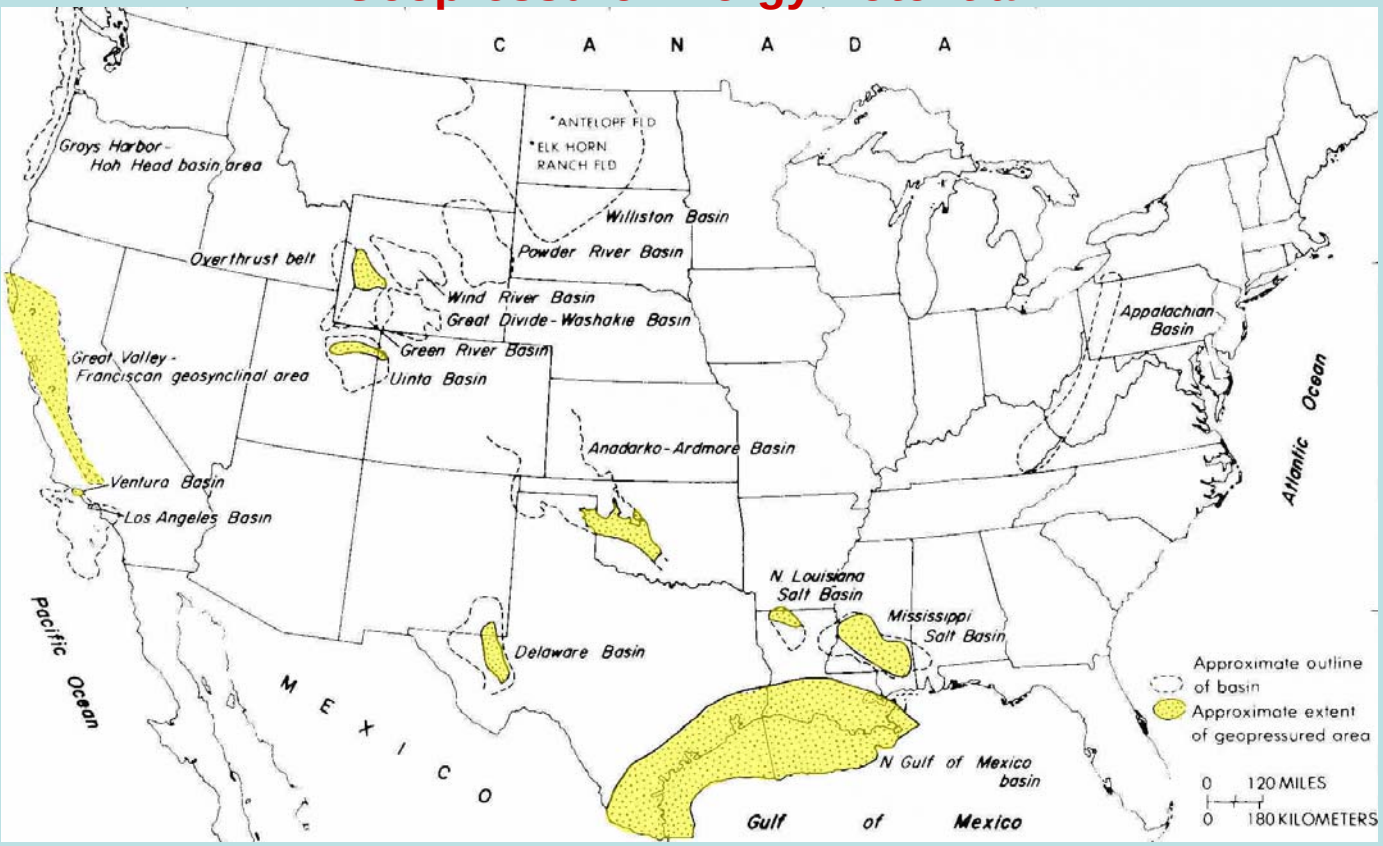
* Build mini power plants
* Re-complete some wells to increase flow
* Minor surface infrastructure upgrades (i.e., insulating pipes)
* Chemicals added to prevent precipitates
* Reinjection Well





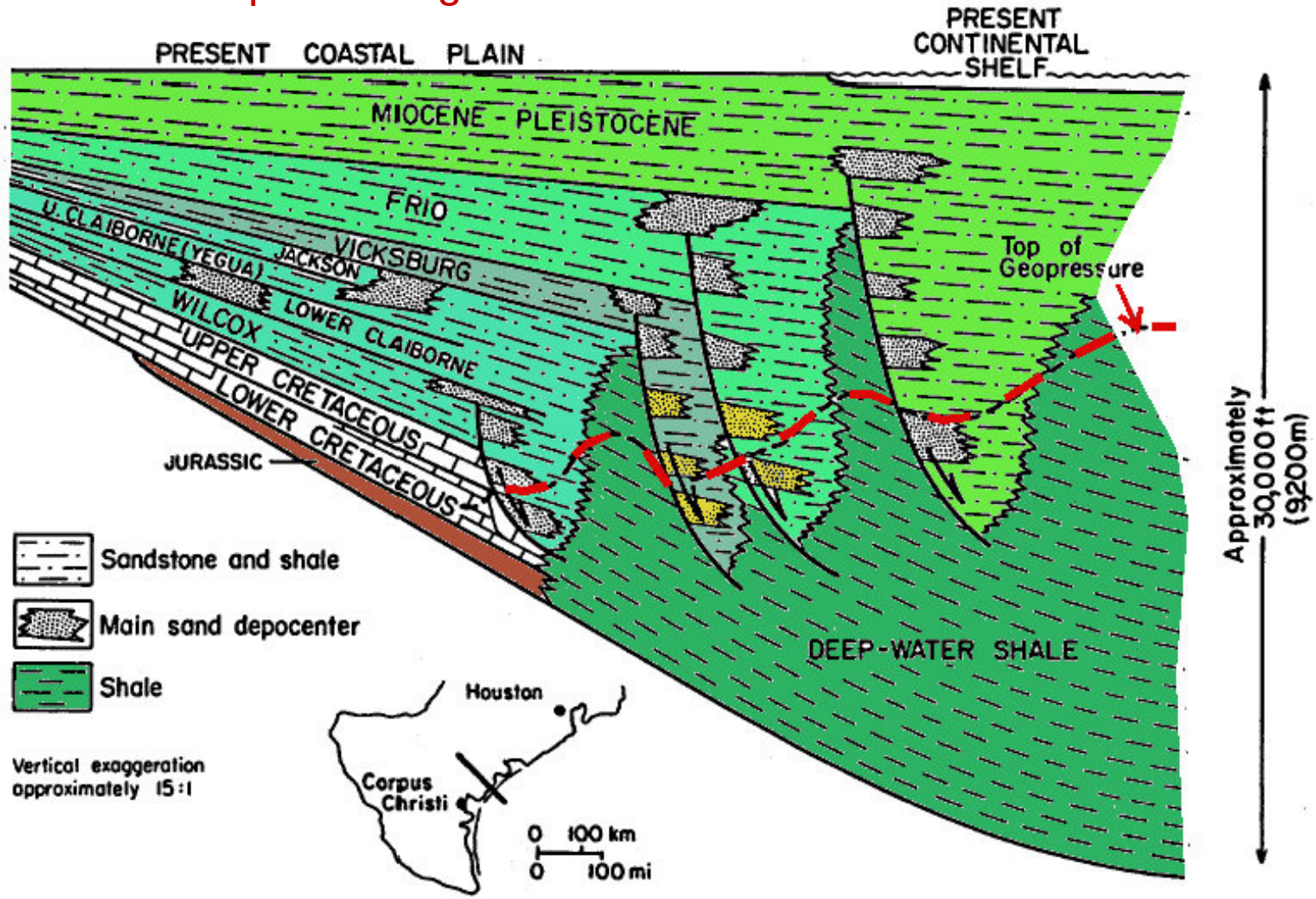
Location of sedimentary EGS, geopressure, coproduction

Geopressure Energy Potential



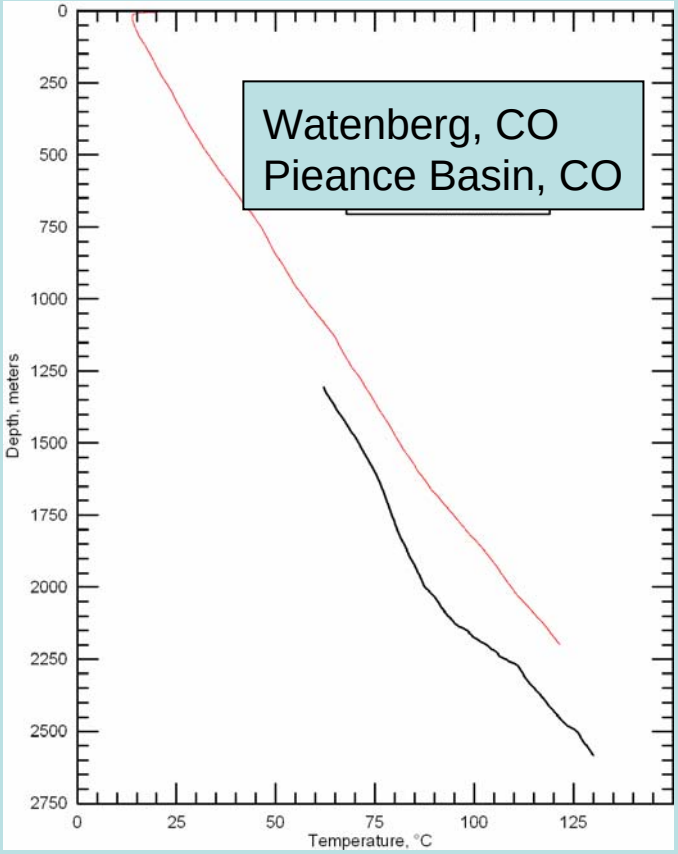
Source & Category	Thermal Energy (MW)	Volume of Methane (x 10^{12}ft)	Total Gas + Thermal Energy (MW)
1975 Geopressure Study Circular 726	4.60×10^{16}	669	7.1×10^{16}
1979 Geopressure Study Circular 790	1.10×10^{17}	59	1.7×10^{17}
Coproduced Resources	6×10^{-10} to 3×10^{-9} (Temperature dependent)		

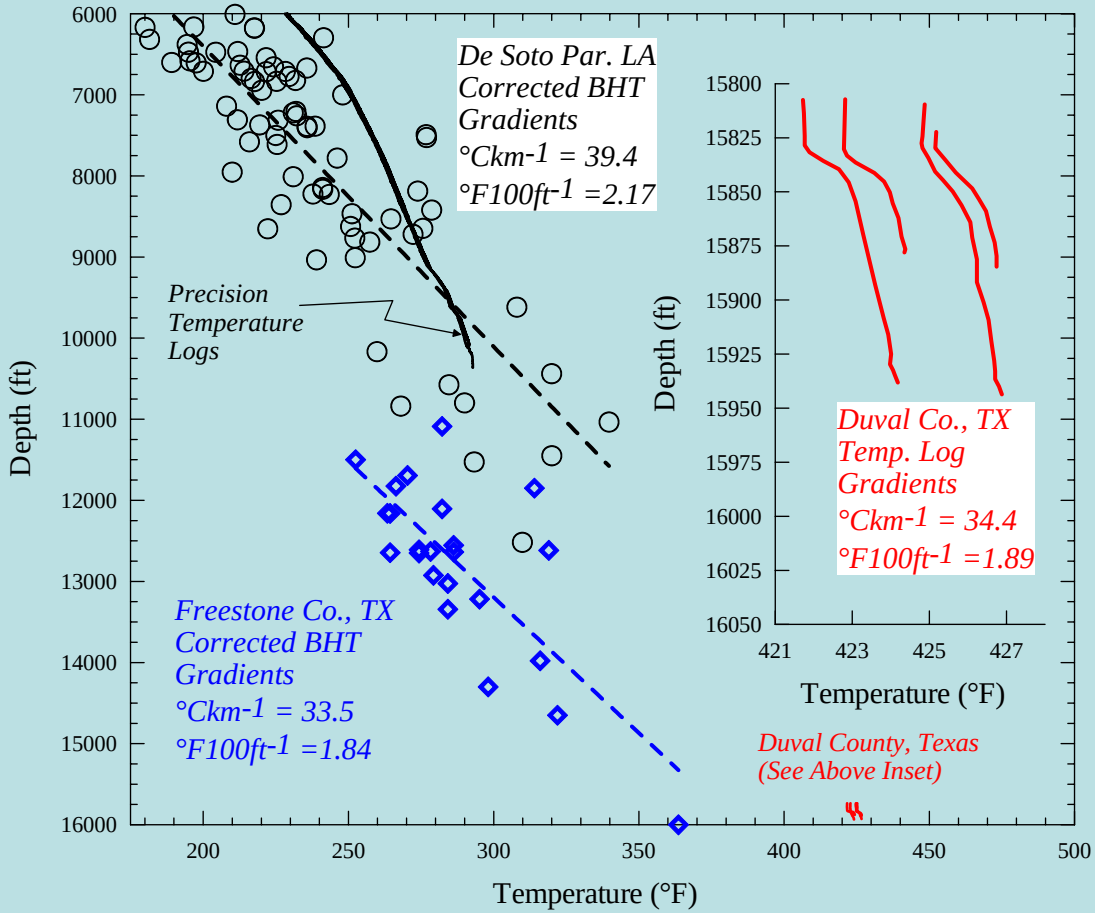
Geopressure may be the most cost effective to develop on a large scale in a short time



Bebout, D. G., Weise, B. R., Gregory, A. R., and Edwards, M. B., 1982, Wilcox reservoirs in the deep subsurface along the Texas Gulf Coast: their potential for production of geopressured geothermal energy: The University of Texas at Austin, Bureau of Economic Geology Report of Investigations No. 117, 125 p.

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).



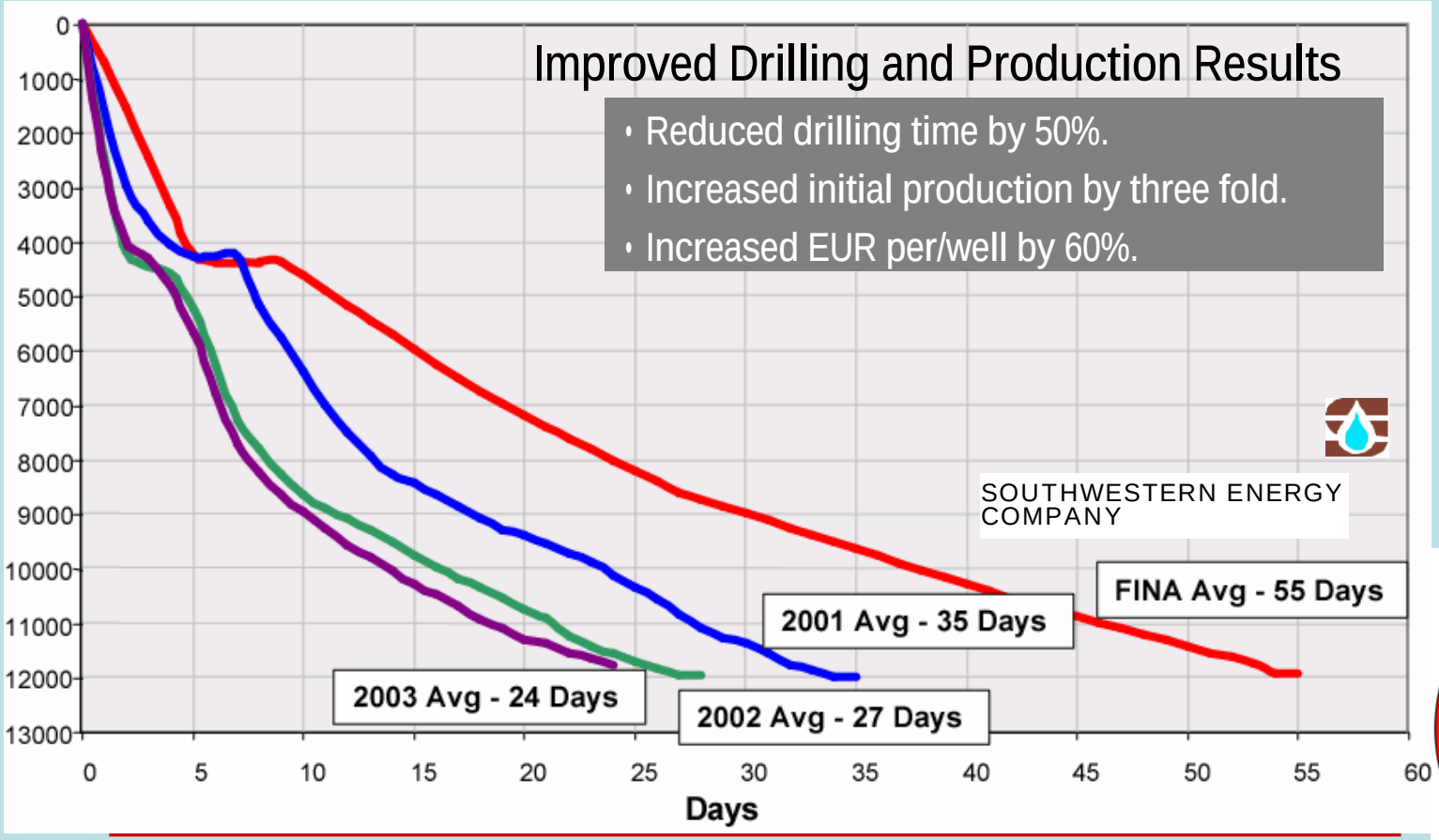


Specific sedimentary basin examples

Tight Gas Sands

- Hard, abrasive rock
- Mild geopressure
- Low natural permeability
- Temperatures of 150 to 225 °C
- Fracture treatments & horizontal wells
- Limited reservoir uncertainty

OVERTON FIELD, EAST TEXAS (COTTON VALLEY TIGHT GAS SANDS) Learning Curve Example (Kuuskraa, 2006)



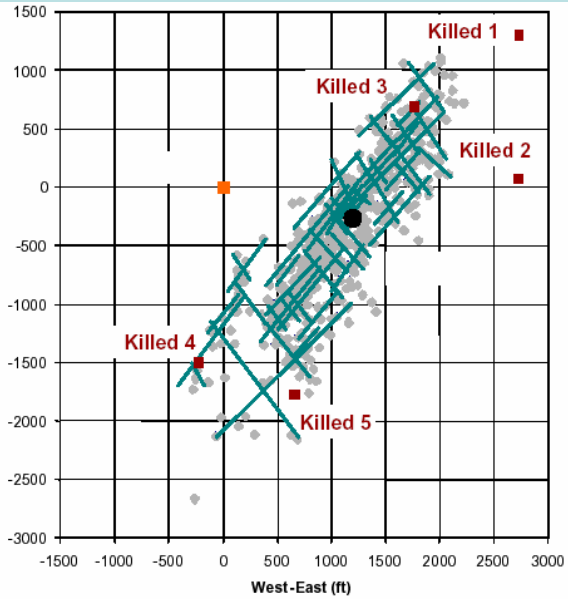


Figure 4 Example of fracture treatment map in vertical well from core area of Barnett.

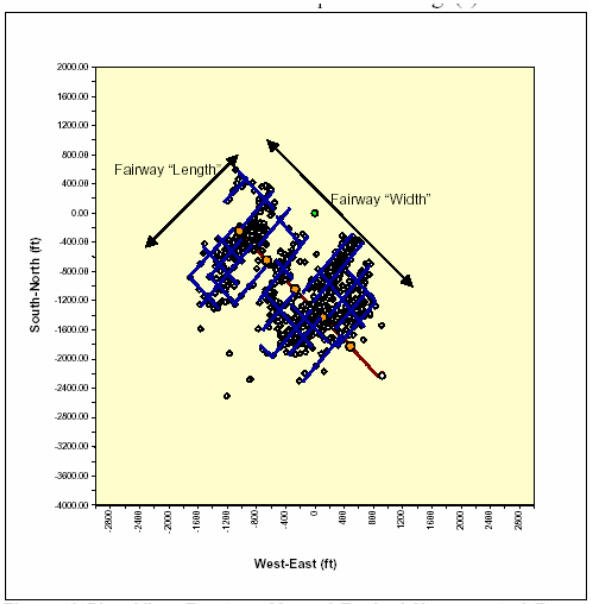


Figure 6 Plan View Fracture Map of Typical Uncemented Barnett Treatment with Fracture Structures Illustrated

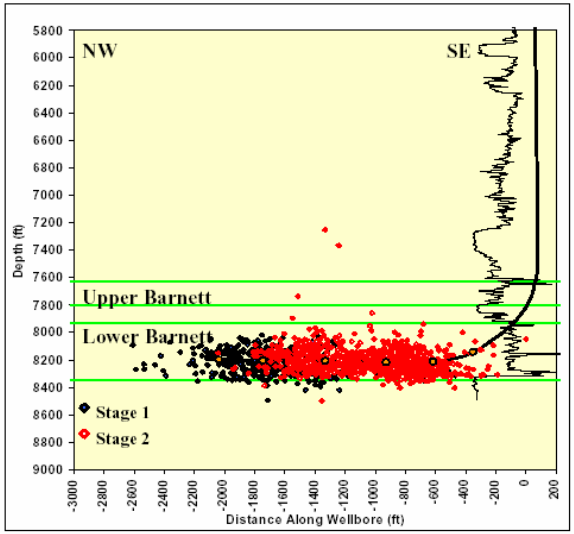


Figure 7 Side View Fracture Map looking normal to uncemented lateral of Barnett treatment with Fracture Height confined to Lower Barnett only. Events shown are for 2 fracture stages. Stage 1 treatment, (filled diamonds) appears to have grown slightly higher than Stage 2 (open diamonds).

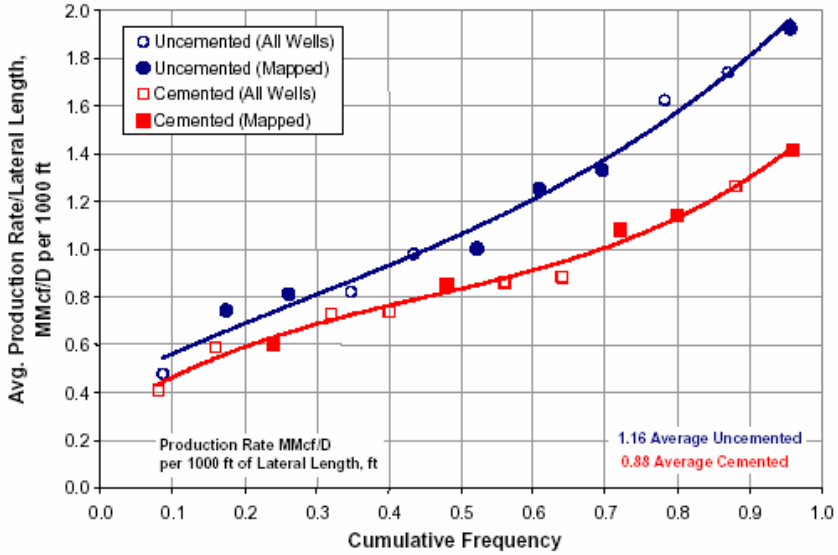


Figure 16 Cumulative Frequency distribution, average production rate normalized by length of horizontal section.

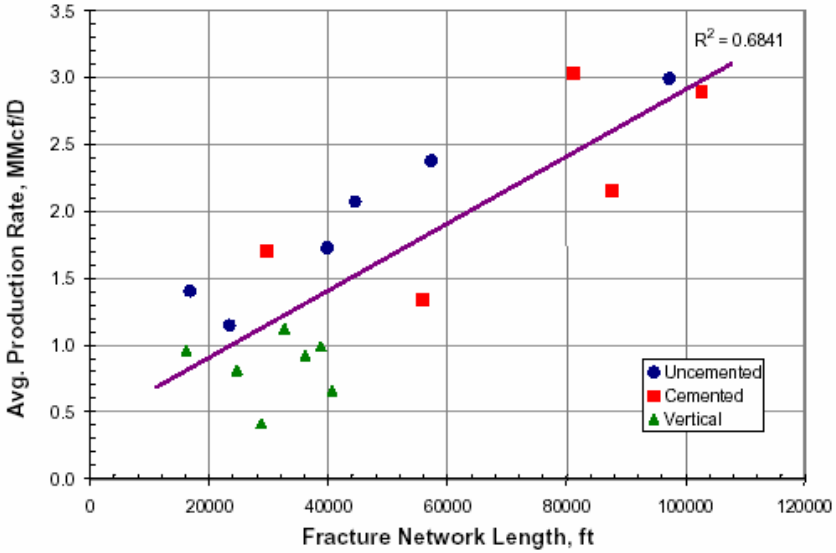


Figure 18 Cumulative length of individual fracture segments correlates to improved well productivity.

Fisher et al (2004)

Criteria for Focus Areas

- Resource quality and/or characteristics
- High CO2 producing states
- High energy usage areas
- Transportability of technology developed

Research Priorities

- Focus on unconventional systems
- No drilling research for 5 years
- No focus on hydrothermal margins for 5 years (too long for large scale & too limited in area)
- Scalable resources in unconventional areas in power and/or CO_2 needy areas
- Locating sweet spots/demonstration areas
- Large scale fracture and fluid circulation experiments

Resource studies: Unconventional Geothermal Energy

- Coordinated studies with clear specifications (state or area based)
- Extensive thermal logging of deep wells
- Develop thermal expertise
- Lithology as function of depth and position
- Lithology of basement
- Some heat flow drilling on geophysical anomalies
- Require digital reporting of BHT
- Outline and characterize100 MW's of sites country wide