- Geothermal Energy -

Part I: A New Future For Deep Depleted Wells – Geothermal Energy From Sedimentary Basins

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* Which well is for natural gas? *
* Which well is for geothermal? *
.....
And which well produces both!?

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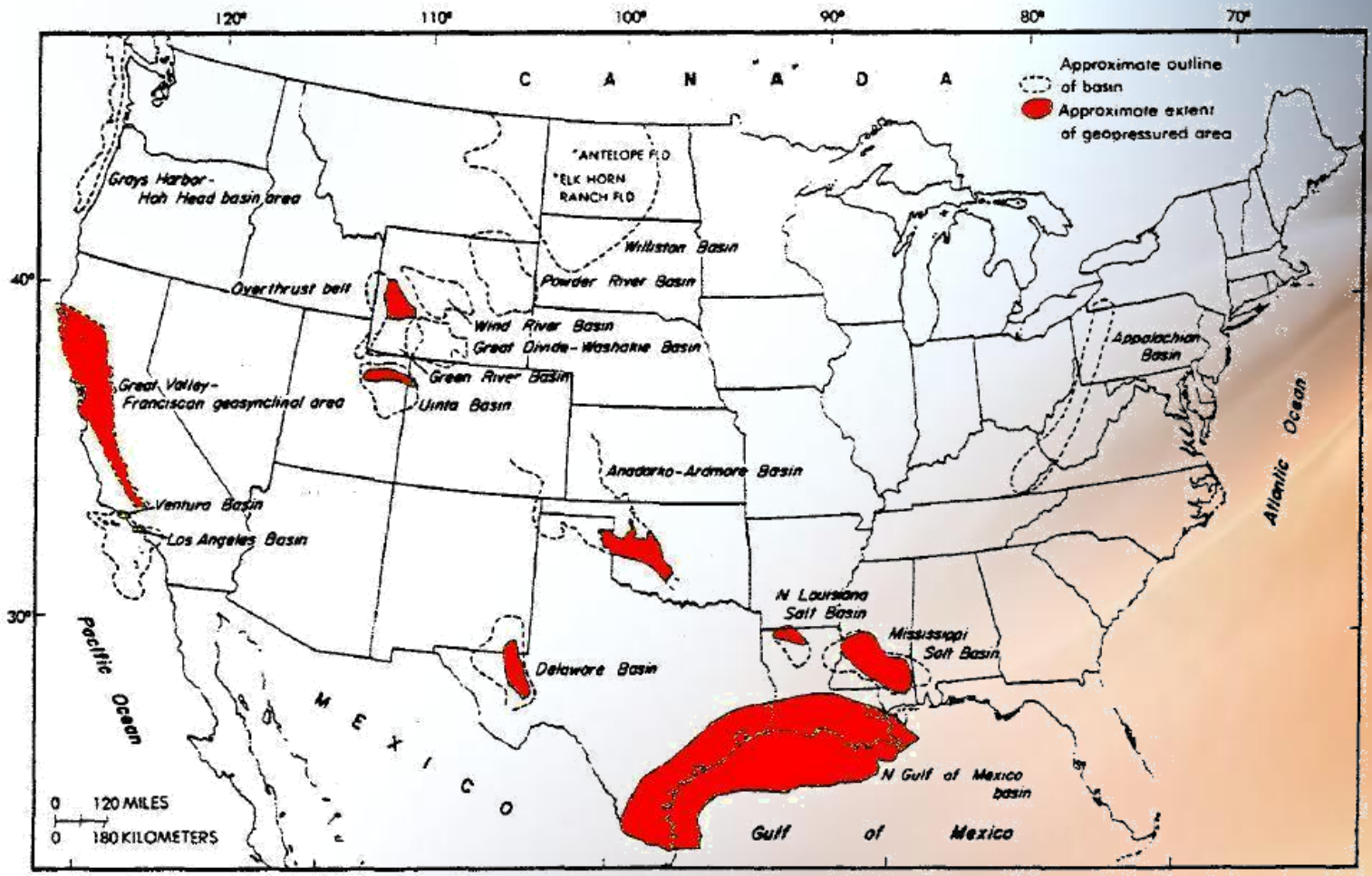
Presentation Overview

- Geopressured Regions & Deep Wells
  - Geopressured Gulf Coast
    - Geothermal Well Test
      - Geothermal Power Plant Test
        - Concluding Remarks

Geopressured Regions & Deep Wells



Wallace, 1982

- **Geopressured wells have a confining pressure above 0.465 lb/in²/ft.**

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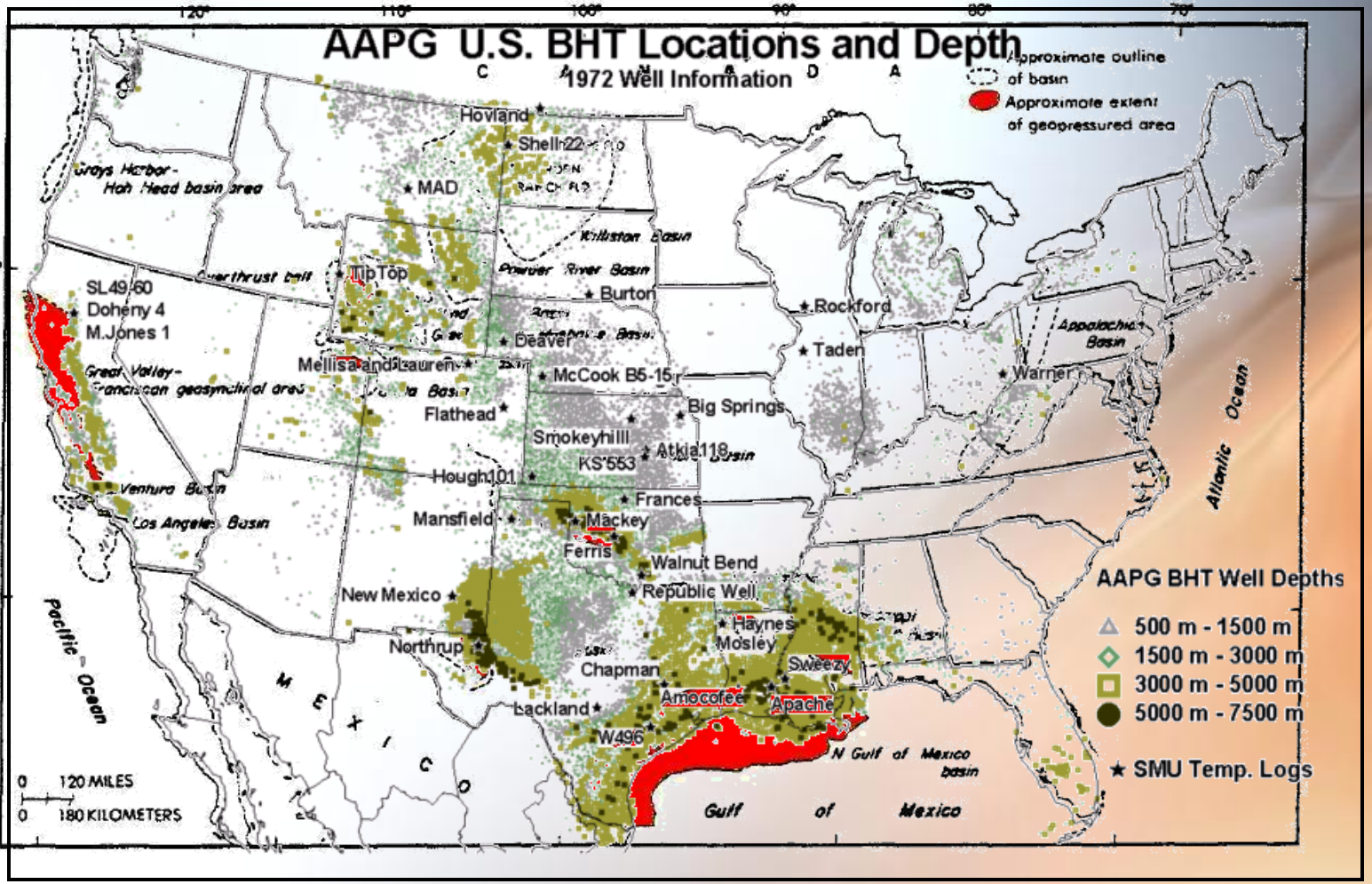
Geopressured Regions & Deep Wells



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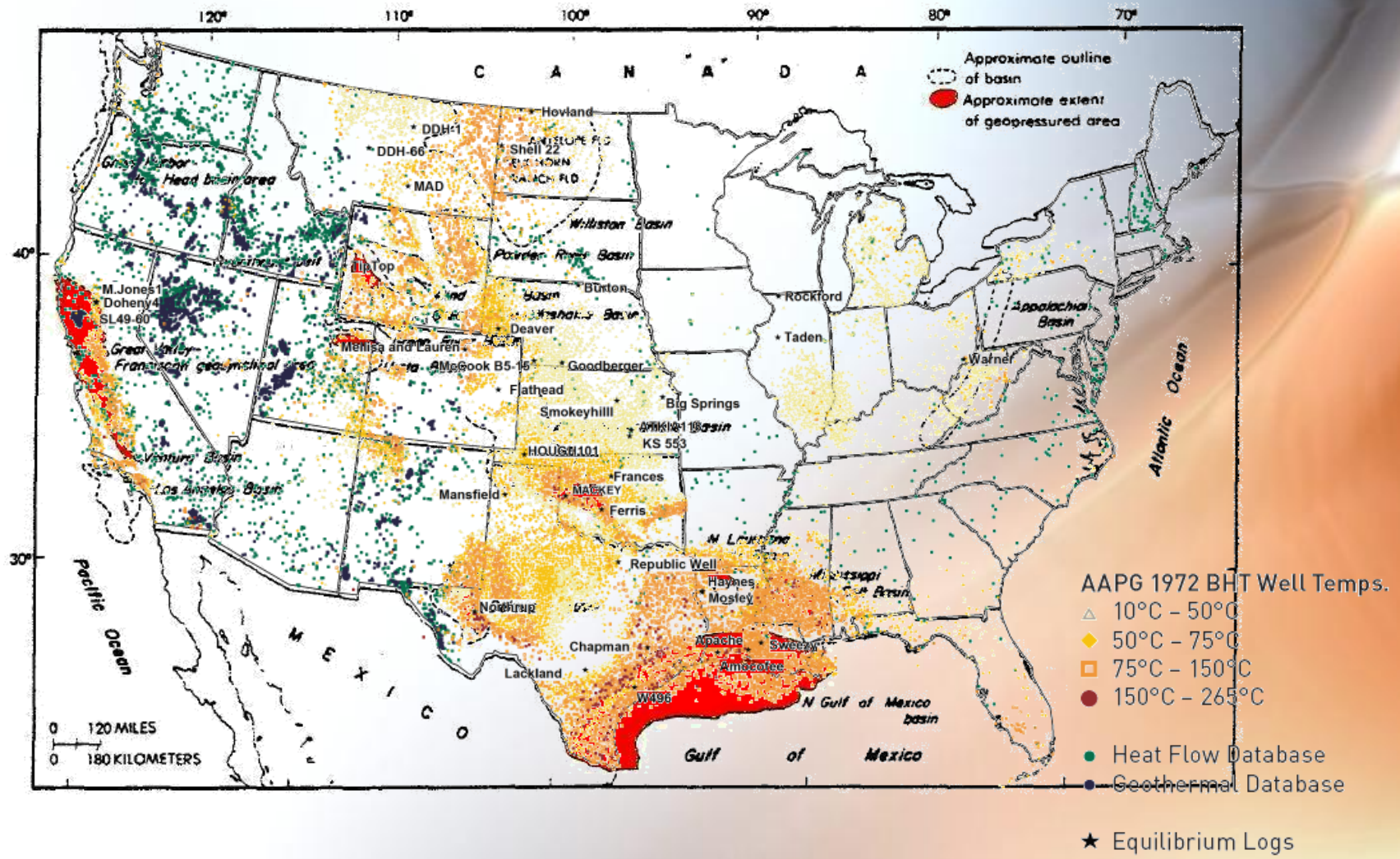
Geopressured Regions & Deep Wells



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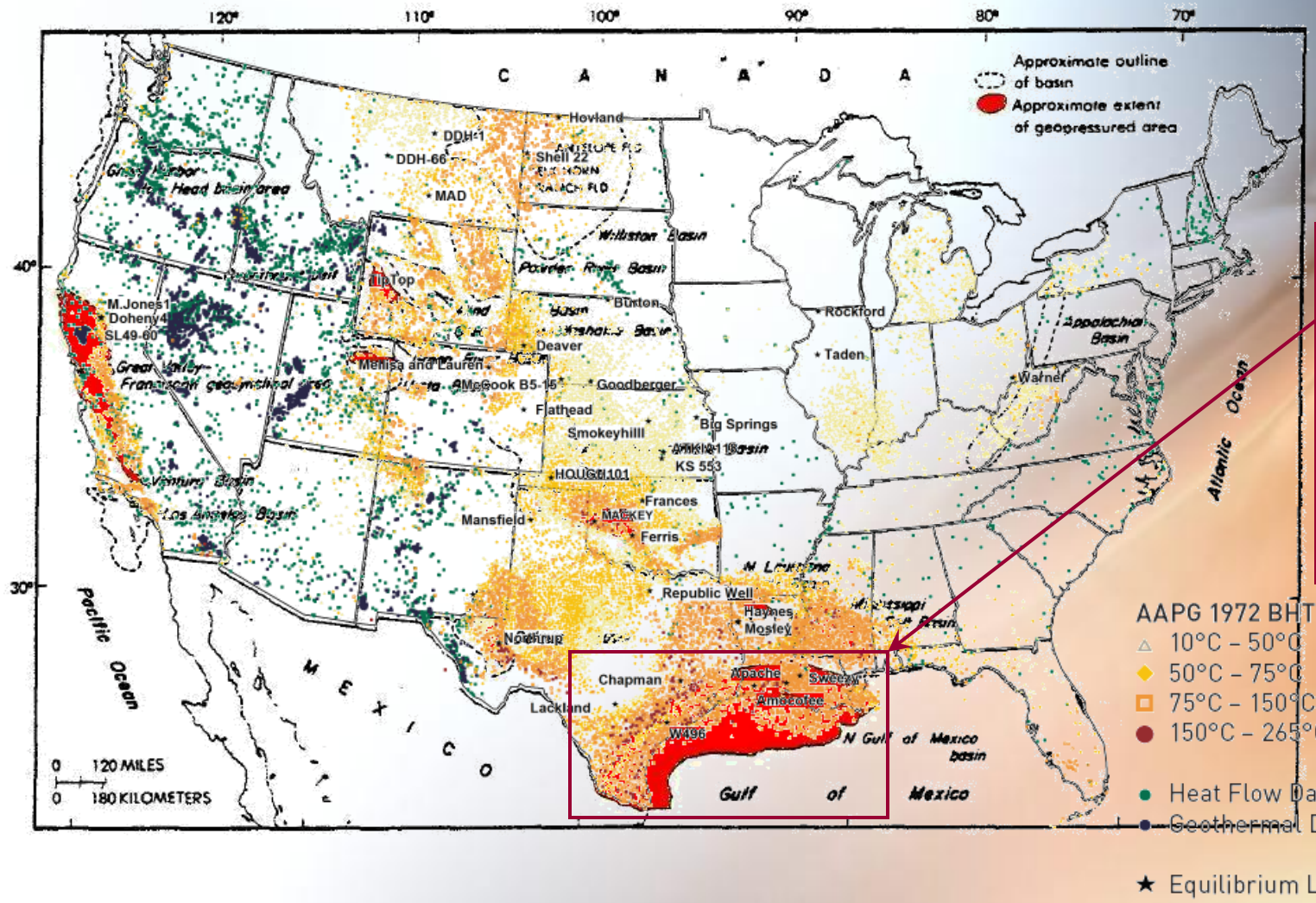
Geopressured Regions & Deep Wells



DOE Geopressured-Geothermal Program.

17 years.

$200 million.

- **Geopressured wells have a confining pressure above 0.465 lb/in²/ft.**

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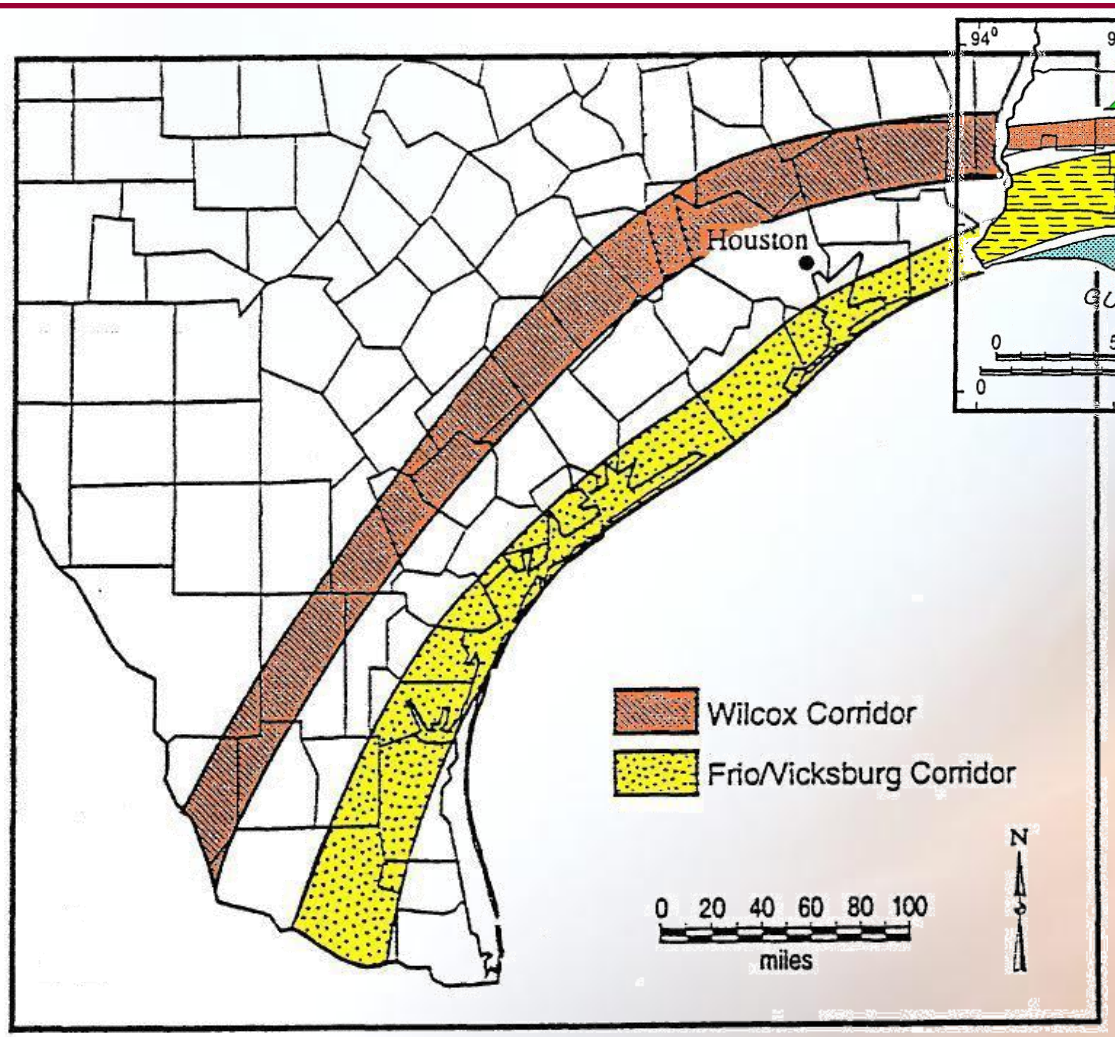
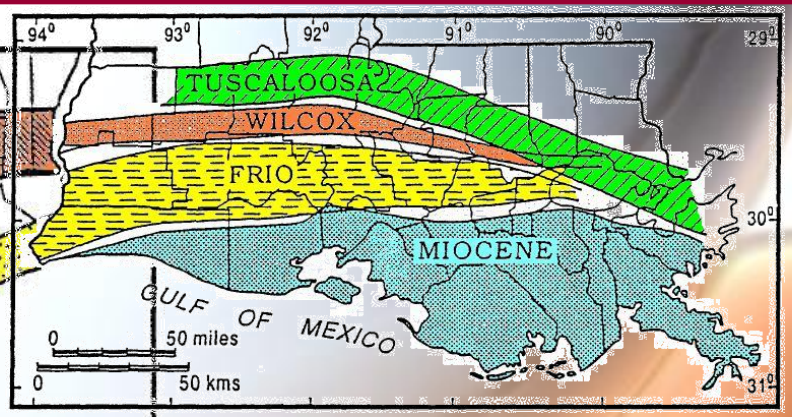
Geopressured Gulf Coast





DOE 17-Year Program – $200 million.

1) Chemical energy – dissolved methane.
2) Thermal energy – hot brine (>225°F).
3) Mechanical energy – Hi P / Hi flow.

7,500 – 18,000 psi and up

> 20,000 bbls brine / day

Various rock strata were investigated during the course of the project. In Texas, the primary fairways are the Wilcox and Frio/Vicksburg strata.

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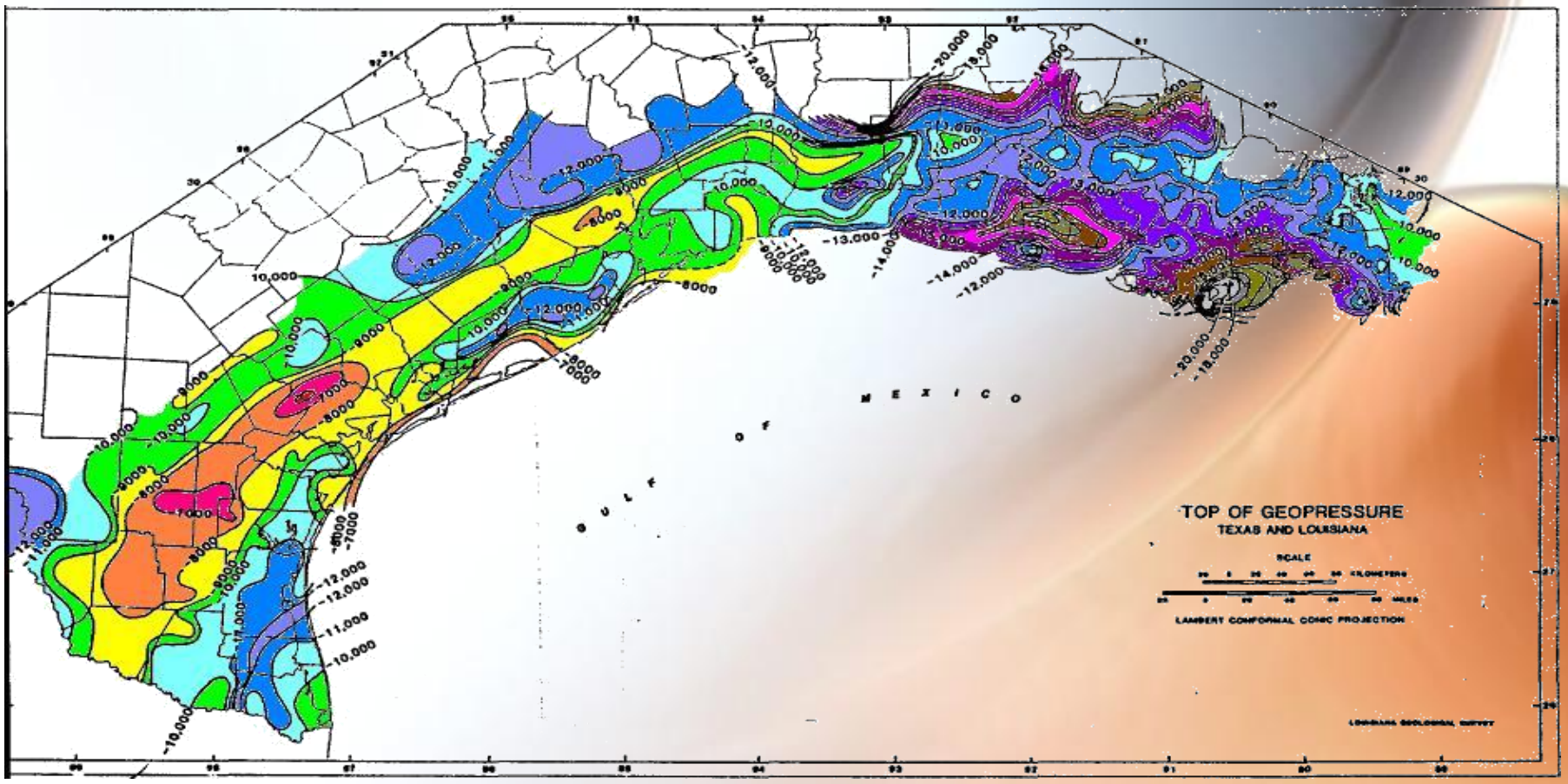
John et. al., 1998

Geopressured Gulf Coast



Structure contour of the top of geopressured zone along the Texas – Louisiana coast. Top of geopressured zone defined by break in electric logs showing a "low-density" shale.

Depth to top of geopressured zone ranges from 7,000 to 20,000 feet along Gulf Coast. Zone is shallowest along Texas coast.

John et. al., 1998

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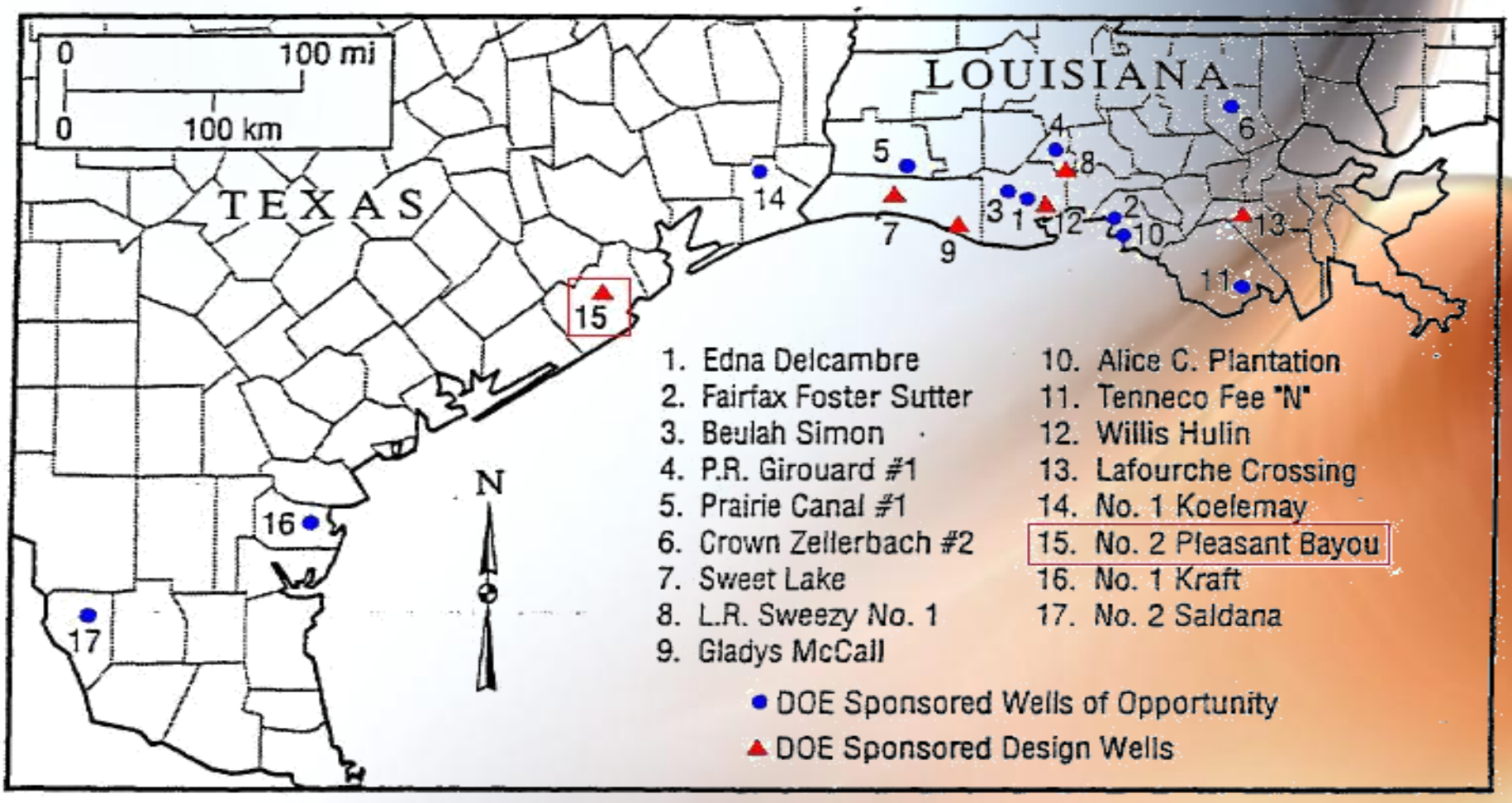
Geothermal Well Test



Wells of Opportunity = oil and gas wells made available for use by industry.

Design Wells = drilled on potentially favorable sites based on existing geological and geophysical studies.

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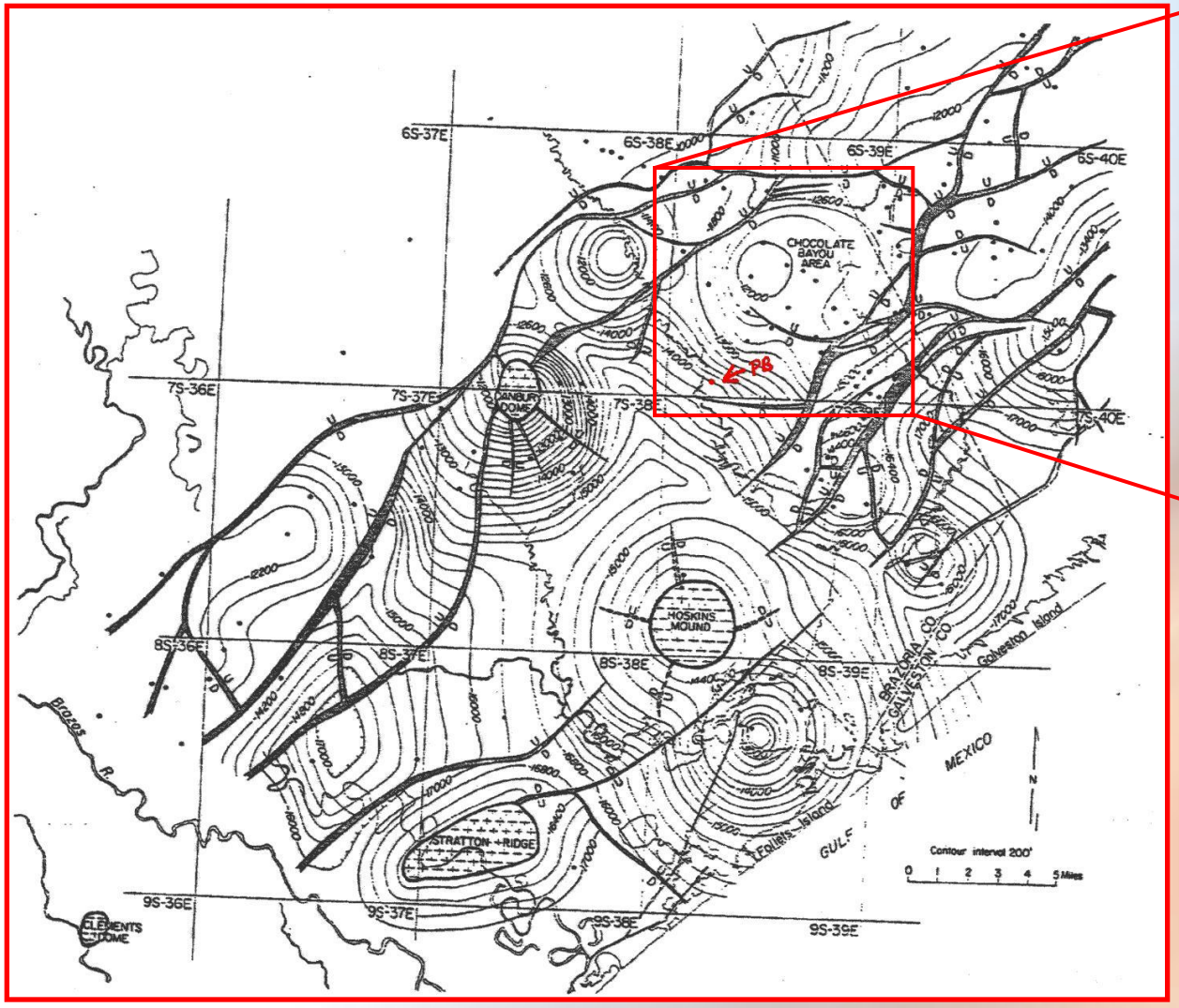
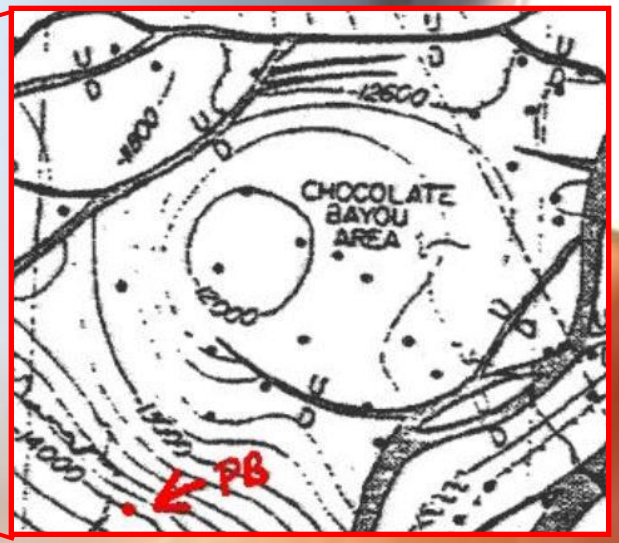
John et. al., 1998

Geothermal Well Test

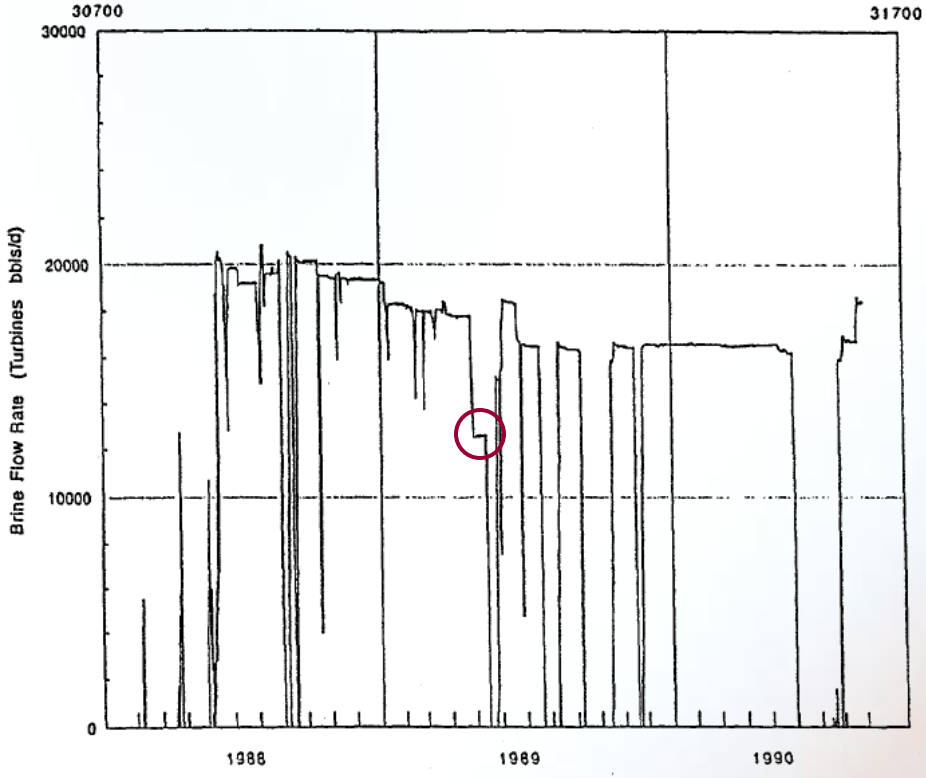




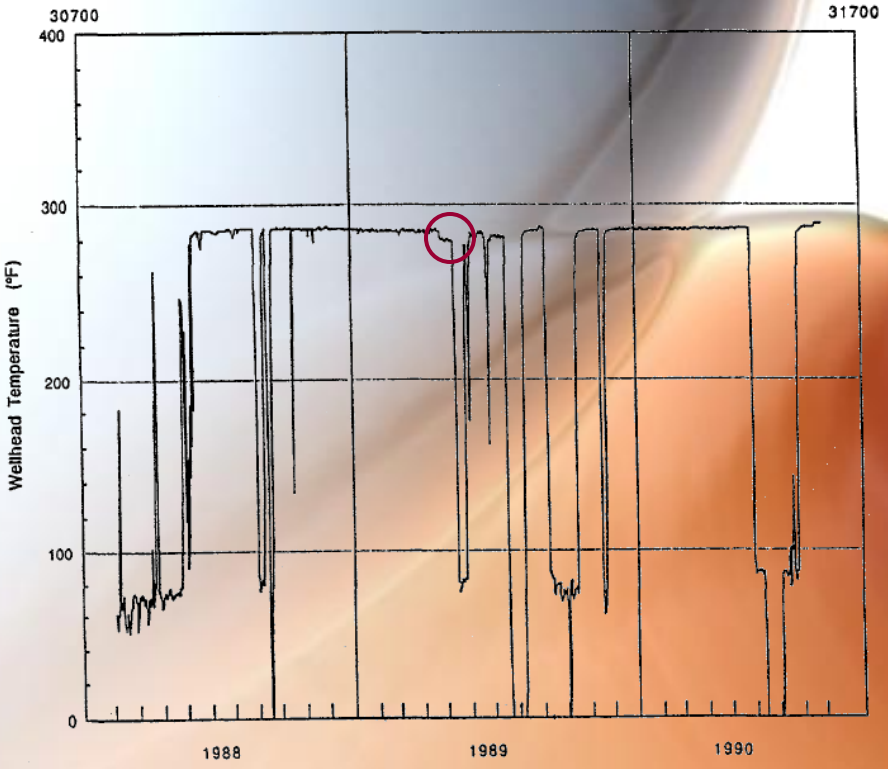
Structural map on top of the T5 marker. The T5 marker begins at a depth of –13,600 feet (-4,145 m) and continues much deeper. Sandstones in T5-T6 zone correlate with *Anomalina biraterali* Foraminifera zone of the lower Frio.

Bebout et. al., 1978

Geothermal Well Test



Brine flow rate over three years of production testing.



Production wellhead temperature over three years of production testing.

Flowing brine temperature at the hybrid power system (HPS) decreased from 291°F to 286°F in four hours after the brine rate was decreased from 17,100 bbls/d to 12,200 bbls/d on April 27, 1989.

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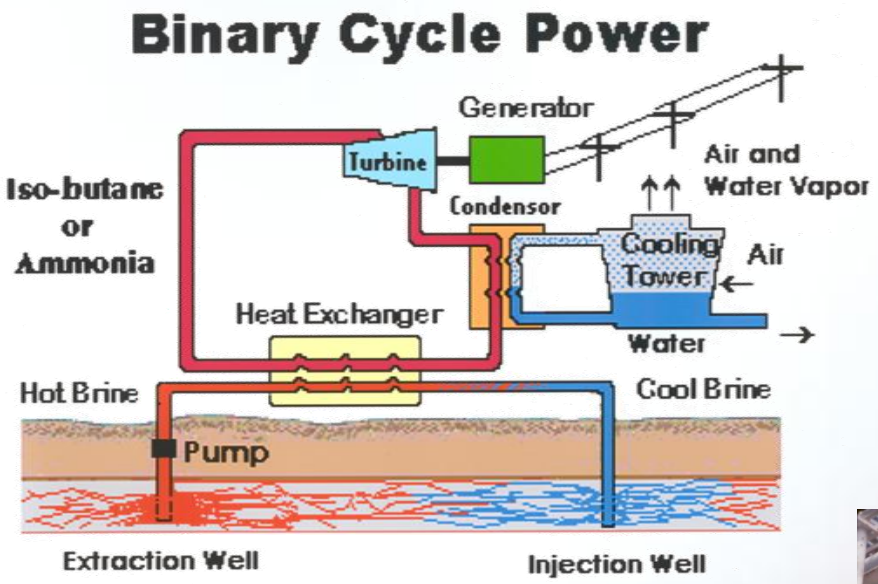
John et. al., 1998

Geothermal Power Plant Test

Standard Binary Plant System



There are three primary approaches for electrical production within a geothermal environment:

1) Dry Steam Power Plant
2) Flash Steam Power Plant
3) Binary Cycle Power Plant

Texas Hybrid Power System

Binary + Gas Engine

Binary Turbine

+

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Geothermal Power Plant Test

GEOPRESSURED PILOT PLANT PROCESS FLOW DIAGRAM
(Operated by Bibb & Associates, Inc. [Ben Holt Co.])

A - Brine and natural gas are separated into individual streams.

Gas Flow:

B - Gas enters engine and generates electricity.
C - Exhaust heat from engine heats isobutane in boiler.

Brine Flow:

I - Brine enters boiler and heats isobutane to vapor.
H - Brine leaves boiler and enters heater to preheat isobutane. Brine is then sent to injection well.

Isobutane Flow:

D - Isobutane vapor from 'C' and 'I' is combined and sent to generator to produce electricity.
E - Isobutane is condensed from vapor to liquid.
F - Liquid isobutane enters accumulator.
G - Isobutane pumped from accumulator.
H - Isobutane is preheated by brine, and is split into two flows.
I - Isobutane heated by brine to vapor.
C - Isobutane heated by gas engine exhaust to vapor.

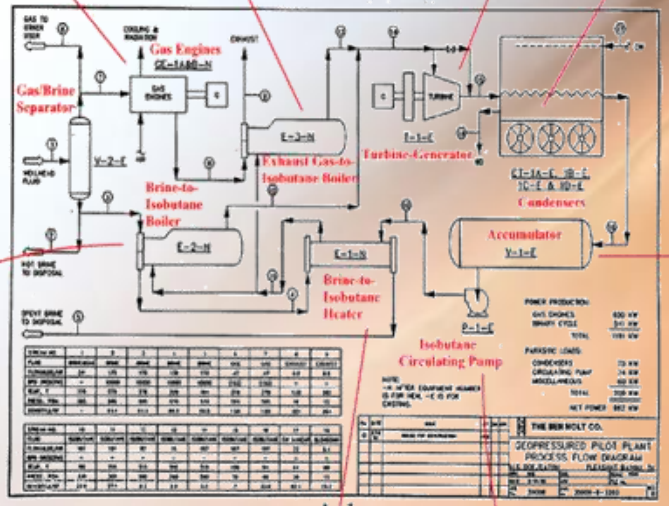

B


C


D

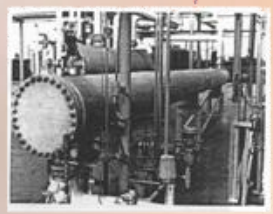

E

A




F


I


H


G

Process flow diagram.

Gas Flow
Brine Flow
Isobutane Flow

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Geothermal Power Plant Test

Summary Of Design Power Production And Parasitic Loads		
Power Production		kW Output
	Gas Engine	650
	Binary Cycle Turbine	541
	Total Gross Production	1,191
Parasitic Loads		
	Condenser	75
	Circulating Pmup	74
	Miscellaneous	60
	Total Parasitic Load	209
Net Power Production		982

Pleasant Bayou Geopressured Hybrid Project

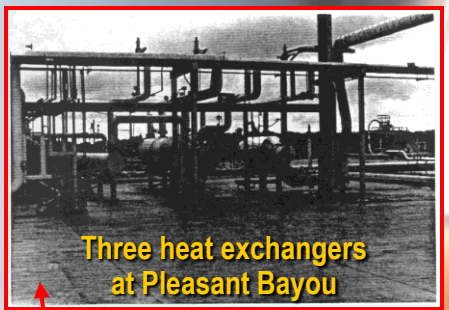
U.S. Department of Energy

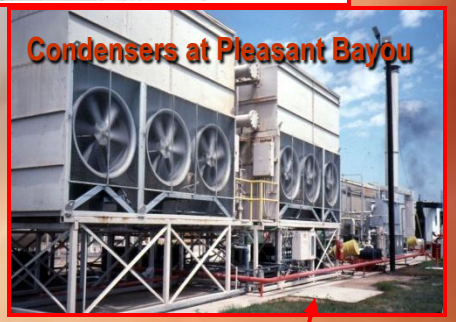
Geopressured Natural Gas, Hot Brine Effluent, Cat 399 Engine and Mafi-Trench binary expander

First of a kind innovative technology

Bibb and Associates, Inc. (Ben Holt Co.) was the EPC Contractor for the design, procurement, start-up and operation of a 1 MW hybrid binary cycle power power plant which utilized a geopressured resource. The facility consisted of a gas engine and a binary cycle coupled so as to maximize the energy output from a methane bearing geopressured fluid.

Bibb successfully operated the facility for one year, demonstrating the technical viability of this technology.





bibb projects

1 MW Geopressured Hybrid Project
EPC Contract
Chocolate Bayou, Texas

Fire protection system.

Capacity factor 80.2%
(3-day plant outage & 4-wk turbine outage)
Plant availability 97.5%

BHT = 309.2°F (154°C).
Max brine T = 277°F (136.1°C).
Permeability = 159.8 md.
Reservoir area = 36,000 acres (56.26 sq. mi.).

10,000 bbl/d (292 g/m) – 22 scf gas/bbl brine.
Could have reached >20,000 bbl/d or 583 gpm.

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Concluding Remarks

Comparing Power Technologies	
Technology	Expected Capacity Factor (%)
Coal	71
Nuclear	90
Geothermal	86 - 95
Wind	25 - 40
Solar	24 - 33
Natual Gas Combustion Turbine	30 - 35
Hydropower	30 - 35
Biomass	83

Geothermal Energy Association, West Coast Geothermal Finance & Development Workshop, May 2007

- **Heat is present in the Gulf Coast at temperatures capable of sustaining electrical energy production.**
- **Subsurface brine can move this heat and entrained natural gas into a surface hybrid/binary plant facility.**
- **Significant risk is alleviated due to existing data documenting the successful completion of a geothermal demonstration plant.**
- **The economics of geothermal development can be folded in with the economics of oil and gas development to form a more fully integrated energy industry.**

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