SMU GEOTHERMAL LABORATORY

SECO State Energy Conservation Office

Eastern Texas Geothermal Mapping

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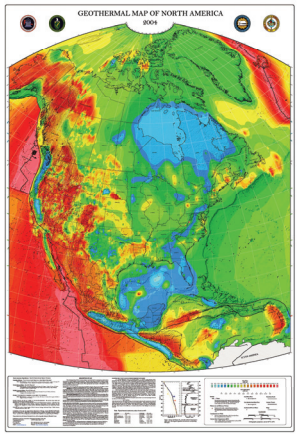
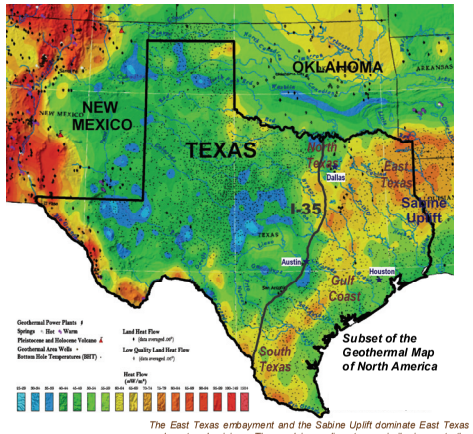
ABSTRACT

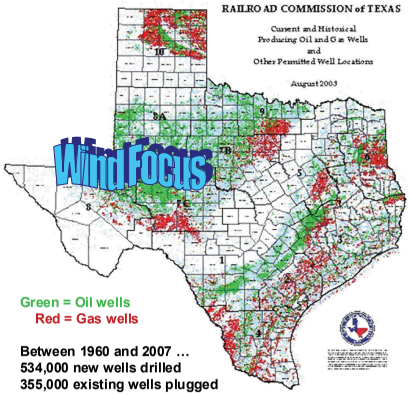
The idea of using oil and gas wells for geothermal energy production was brought to the forefront in 2005 and 2006 (McKenna et al., 2005; SMU Geothermal Energy Utilization Conference, 2006; Erdlac et al., 2006). This concept has prompted a review of existing research in Texas from the 1970s to 1990s on geopressure and a new resource assessment based on oil and gas well data. Through the combination of new and previous data sets, a series of temperature maps at depths ranging from 7000 to 14,000 feet for eastern Texas have been created. South Texas has the highest temperatures (420°F). The Gulf Coast geopressure resource is best defined and closest to electric markets, making this an initial first choice for development.



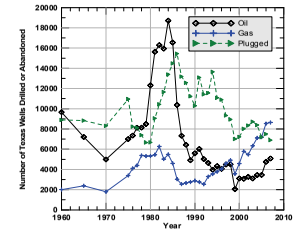


Subset of the Geothermal Map of North America

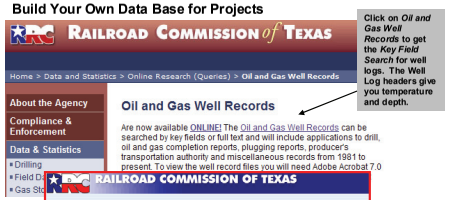
The East Texas embayment and the Sabine Uplift dominate East Texas and western Louisiana. The overlying sediments are similar in age to the Gulf Coast. The Sabine uplift has basement rock with a unique composition which contains higher levels of natural radioactive decay than other basement rocks in the region. This impacts the sediments in the vicinity of the Sabine Uplift and increases the heat flow for the area.



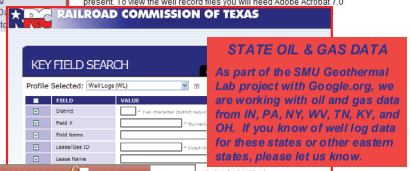
http://www.rrc.state.tx.us/forms/maps/specialmaps/mapproducts.php
http://www.rrc.state.tx.us/data/drilling/txdrillingstat.pdf



Build Your Own Data Base for Projects

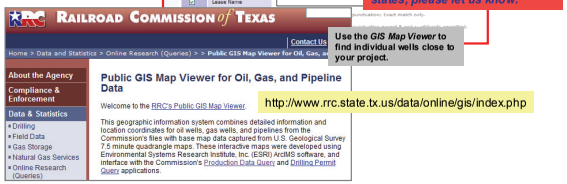


Click on *Oil and Gas Well Records* to get the *Key Field Search* for well logs. The Well Log headers give you temperature and depth.



STATE OIL & GAS DATA

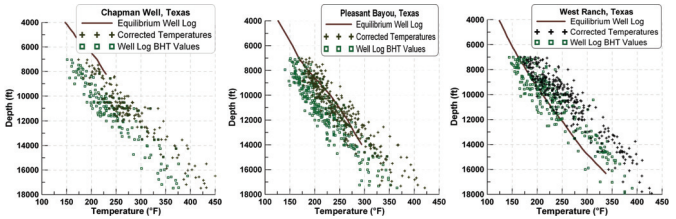
As part of the SMU Geothermal Lab project with Google.org, we are working with oil and gas data from IN, PA, NY, WV, TN, KY, and OH. If you know of well log data for these states or other eastern states, please let us know.

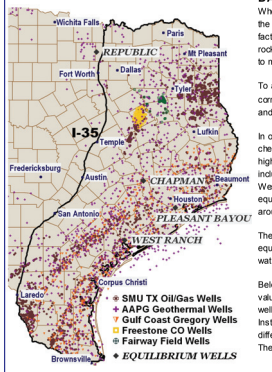


Use the *GIS Map Viewer* to find individual wells close to your project.

http://www.rrc.state.tx.us/data/online/gis/index.php

EQUILIBRIUM WELL COMPARISON





DATA CORRECTION and EQUILIBRIUM WELLS and PRESSURE TEMPERATURES

When drilling a well, fluid is injected and circulated. The fluid impregnates the surrounding rock formations, thereby cooling the borehole at the deeper depths according to the surface air temperature, drilling speed, type of drilling fluid, etc. Many factors effect the time needed for a well to return to the in-situ temperature (equilibrium) including the formation pressure, rock thermal conductivity, pore fluid movement, and drilling conditions. This process of reequilibrating usually takes weeks to months (Harrison and Luza, 1985).

To adjust for the difference in temperature between the well log bottom hole temperature (BHT) and equilibrium state, a correction is done. The correction used is Y = [-16.51213476 + 0.01826842109 * X] - [0.000002344936959 * X²] (Blackwell and Richards, 2004b; Harrison and Luza, 1985). It was applied to the raw well log BHT data in this study.

In order to assess the validity of the calculated equilibrium temperatures from the equation above, the new values were checked against equilibrium well logs. The well locations (Chapman #1 and West Ranch 496) were previously logged using high-accuracy temperature logging gear (Wisian et al., 1996; and Negraru et al., 2008). An additional temperature log was included from the Pleasant Bayou DOE demonstration well (Institute of Gas Technology, 1992). The plots of the Chapman, West Ranch, and Pleasant Bayou wells (above) show the difference between the well log data values and the corrected equilibrium values. The area data were chosen according to their location being within ±0.5° of latitude and longitude around the primary equilibrium well location.

The temperature graphs above show how the log BHT data are generally too cold in comparison to the calculated equilibrium temperature for each site. The West Ranch well has the least correlation to the corrected data probably due to water flooding of the field for increasing hydrocarbon production, thereby cooling the original deeper formation temperatures.

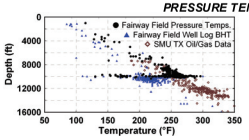
Below, the Fairway Field pressure data were used to review the application of the Harrison Correction on the raw BHT values from the production well drilling records. Pressure data are collected with a temperature value throughout the life of a well. These are not considered equilibrium temperature measurements because the well is active and has been flowing. Instead they represent values undisturbed by drilling fluids, so are considered close to equilibrium. The pressure data has differing values for a specific well which can be used to indicate a reasonable spread of temperatures at that specific depth. These temperatures usually vary between 10 to 25°F for a similar depth measurement as shown by the sample set of wells.

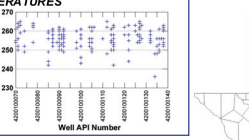
Location of data used and # of wells:

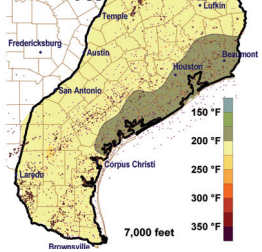
1. SMU Texas Oil/Gas Temperature Database (1990-2005) [# 4887]
2. AAPG Geothermal Survey Well Data (1972) [# 2498]
3. Gulf Coast Gregory et al. (1980) [# 654]
4. Freestone County (Burns, 2004) [# 174]
5. Fairway Field (Hunt Oil and Kweik, 2009) [# 148]

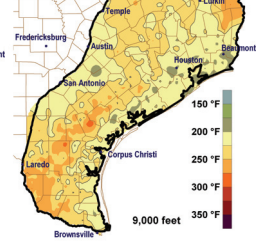
Locations of equilibrium wells are shown as black diamonds.

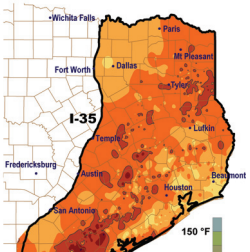
PRESSURE TEMPERATURES

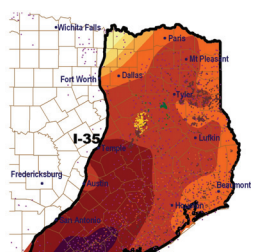


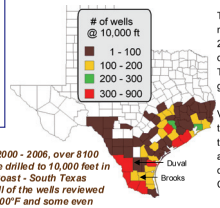










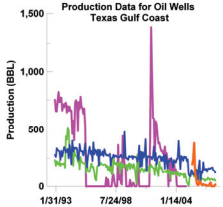


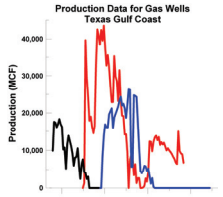
The depths of 9,000 and 12,000 feet were chosen for the detailed temperature maps because 9,000 feet is the initial depth where most of the area is near 200°F. Temperatures at 12,000 feet were chosen because the majority of deep oil and gas wells for this area are completed between 12,000 and 13,000 feet. This depth range is representative of what is currently available to use as a geothermal power exploration tool.

Values continue to increase with depth such that at 13,500 feet the corrected temperatures are consistently over 300°F. At 14,500 feet the average corrected temperature value is almost 350°F. The deepest well collected as part of this assessment was drilled is in Brooks County, along the Gulf Coast reaching depths of 19,829 feet with a temperature of 404°F. The hottest well is in Duval County, also South Texas, at 420°F measured from 17,030 feet deep.

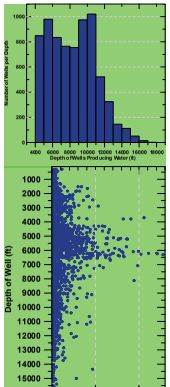
Between 2000 - 2006, over 8100 wells were drilled to 10,000 feet in the Gulf Coast - South Texas region. All of the wells reviewed are over 200°F and some even reach 300°F.

Each color in the plots below represents a different well over its lifespan to show how production varies between oil and gas wells, along with how quickly gas wells taper off.





Like most geothermal areas, in Texas finding the right combination of hot water and high flow rates is not as easy as it sounds. It is reported that over 12 billion barrels of water are produced yearly. What is now known is the highest flow rates are from water-floods with temperatures between 150 - 180°F; not generally high production in deeper oil/gas wells. But Oil/Gas companies do everything they can to prevent water, generally leaving zones of water behind.



CONCLUSION

This eastern Texas Geothermal Assessment used the resources accessible through reasonable and economical drilling depths associated with oil and gas wells. The advantage of this method is the ability to review the resources at depth, reducing exploration costs. When working with existing oil and gas fields, the existing infrastructure necessary for geothermal project development, i.e., roads, well pads, electrical connections to the grid, etc is already in place. There are hundreds of thousands of exajoules of thermal energy to be extracted under Texas (Tester et al., 2006, Richards et al., 2008). Since Texas has extensive and diverse geothermal resources for electrical production it is helpful to divide them into three categories: 1) geopressured resources, 2) coproduced fluids, and 3) enhanced geothermal systems (EGS). The Gulf Coast - South Texas geopressure resource is the main scenario for large-scale energy production in Texas because of the pressure, highest temperatures, and fluid flow. Most of East and North Texas oil and gas fields are more applicable to coproduced projects on a smaller basis or site specific projects tapping into the deeper formations. South Texas and the Sabine Uplift maybe ideal for EGS analysis into the basement rocks with the highest temperatures.

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