An investigation of thermal resources in the Sabine Uplift region of Northwest Louisiana and East Texas to inform the feasibility of grid-scale geothermal energy

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Collaboration Plan

We set up our shared Colab Notebook and our shared GitHub repository that we have been pushing and pulling to in order to collaborate on the code. We have been discussing the project multiple times a week over the phone with an in-person meet up time once a week since before break (about 4 times) to walk through our code and future plans.

Project Plan

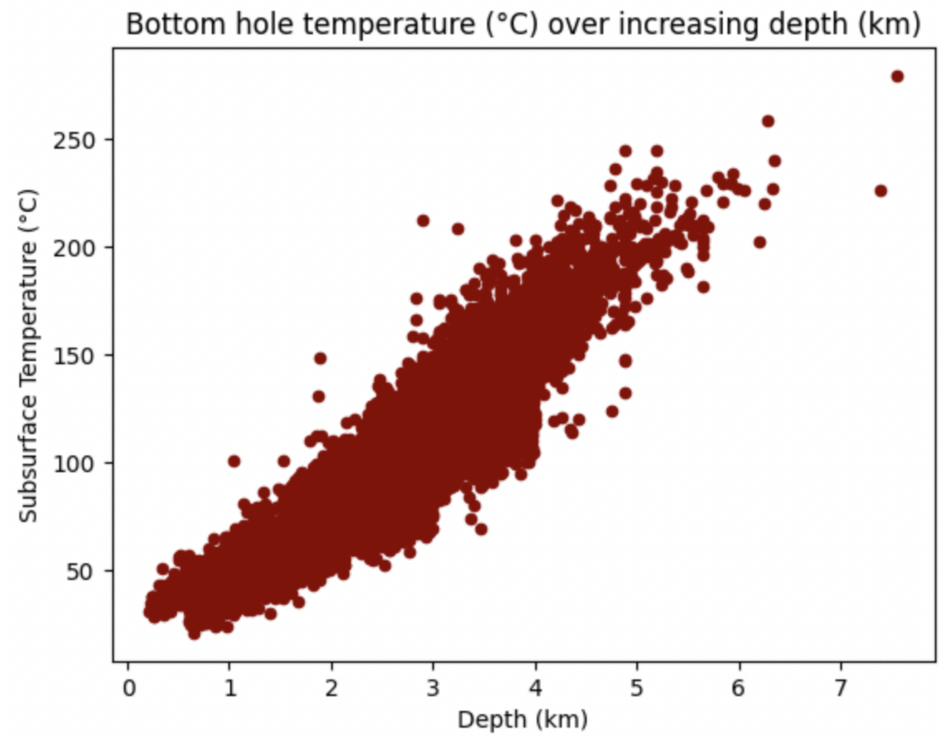
We want to identify well locations that can reasonably support grid-scale geothermal energy generation. To accomplish this, we want to use thermal well data and gravity data to identify exploitable shallow wells with high subsurface temperatures. High subsurface temperatures suggest abundant thermal resources. Gravity data can also inform subsurface formations that can help to identify thermal resources. Regions with high density and compaction are common harborers of geothermal resources; therefore, these areas are of great interest to our research topic. We acquired data for abandoned wells across the US from the SMU Geothermal Lab, which we will constrain to our areas of interest (TX and LA). We have also obtained Texas gravity data from USGS which we can use to identify and plot high gravity areas. Data is available for Louisiana as well, but it is included in another dataset along with Arkansas. We must filter for Louisiana observations and merge the dataset with the Texas dataset. All three of these datasets will help us to predict the location of thermal resources as well as the most feasible abandoned well locations for grid-scale geothermal development.

Datasets

SMU Bottom Hole Well Temperature Data

We acquired this data from Dr. Richards at the SMU Geothermal Laboratory, who collected data from wells across the US. This data includes information about bottom-hole temperature, heat flow, thermal conductivity, and thermal gradients. For our research, we wanted to focus specifically on the Sabine Uplift region and filter the data to our desired regions of Texas and Louisiana. We cleaned the data by changing encoding type by reading, replacing NaN values, and writing to a new file. This dataset included multiple variables that are related to BHT, meaning Bottom Hole Temperature, which is a key factor of our research. This is because BHTs can be influenced by many physical factors. To create wells, contractors use high-powered drills to penetrate the surface. These drills use an extreme amount of force to break through solid rock. Inevitably, this results in a buildup of friction that heats the borehole during the drilling process. Corrections must be made for this rightward bias in order to obtain an accurate BHT reading. Following this logic, we will only reference corrected BHT values in our analysis.

We are searching to find “Good Wells”, so what makes a good well? In order for a thermal resource to be considered for grid scale production, it must be within a reasonable exploitation range for both temperature (>120°C) and depth (~<4 km) to be profitable. This means the most desirable sites are shallow wells with high BHTs.



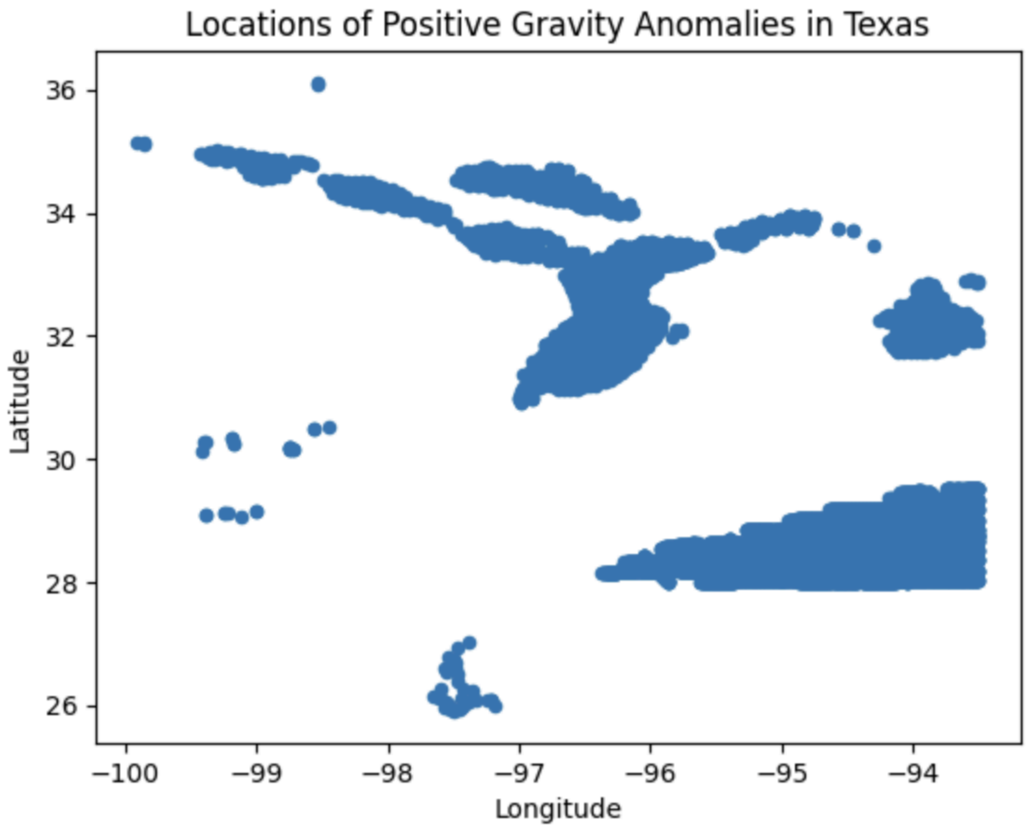
We visualized the data using a scatterplot and then used data analysis to find important statistics. We found that there seems to be a mildly strong, positive correlation between depth and bottom hole temperature of 0.93. This suggests that increasing depth may be related to increasing subsurface temperatures. We also found the most frequent BHT across the sampled Texas and Louisiana wells is 143°C with 45 wells sharing the same BHT and the average depth for wells with the most frequent BHT of 143°C is 3.58 km.

<u>USGS Gravity Anomaly Data</u>

Gravity data measures local gravity anomalies due to differences in rock density in the subsurface. We can use this data to infer rock composition and geological structures like the Sabine Uplift. For our purposes, we can identify high gravity regions that are indicative of geothermal resources. We have imported public gravity data from USGS below for the Texas (and eventually Louisiana).

This data was formatted so that station ID is in the first column, however, we see that some station IDs contain spaces. This makes it difficult for Pandas to interpret the station IDs as one column like we would expect. In order to read in the data, we modified the raw file using the Bash command !awk. Since we're operating on a macroscopic scale of the East Texas/Northwestern Louisiana region, geographic location of observations like latitude and longitude are more useful than station IDs. Therefore, we can use !awk to remove the column by specifying a subset of each line starting after the station ID. This method avoids issues involving space delimiters.

After cleaning up the data, we loaded it into a Pandas DataFrame so we could visualize and extract important information to identify high gravity areas that suggest the presence of geothermal resources.



This scatterplot shows clear clustering of positive gravity anomalies in Texas; only 13% of Texas observations have positive gravity anomalies associated with dense rock formations. This allows us to clearly visualize high gravity anomalies as well as regions likely to have thermal resources. We also discovered that there is a strong, negative correlation between Bouguer gravity anomaly and station elevation of -0.93. This suggests that increasing elevation may be inversely related to observed gravity anomalies. In addition, we saw there is a weak, negative correlation between observed gravity and station elevation of -0.52. This suggests that elevation may not be related to observed gravity in the same way that Bouguer gravity is. This is likely due to Bouguer topographical corrections that account for mass variations while observed gravity is the raw calculated value at the surface.