March 22, 2013

To: DOE TMT Team

From: Flint Geothermal LLC: Lee Robinson, Rick Zehner, Karen Christenson

Subject: Geothermal Potential of the Penrose Area, Fremont County, Colorado

PROLOGUE

U.S. Department of Energy Grant DE-EE0002828 Recovery Act: "Direct Confirmation of Commercial Geothermal Resources in Colorado using Remote Sensing and On-Site Exploration, Testing and Analysis", has been implemented by Flint Geothermal LLC ("Flint"). The Program is separated in three Phases: Phase I – Acquisition, Processing and Analysis of Remote Sensing Data, Phase II – Conduct On-Site Geophysical and Temperature Surveys and Map Results, and Phase III – Drill, Core and Test Geothermal Resources. Phase I assembly of data and its analysis began in April 2010 (SOPO Task 1) at CIRES (CU – Boulder). The process employed was taking ASTER and LANDSAT thermal imagery to look for areas of warm ground as a result of undiscovered underlying geothermal systems. A preliminary geological assessment was incorporated (SOPO Task 2) and 29 sites of interest were established on the West Slope of Colorado. Within those 29 areas of interest, in May 2011, 14 prospect areas were selected (SOPO Task 3).

In June 2011, a technical team prepared a GIS data base (SOPO Task 4.1) was deployed to the field to confirm the remotely sensed thermal anomalies (SOPO Task 4.2). Ground surveys of the geothermal anomalies within the 14 prospective areas were inconclusive. As a result CIRES was requested to refine the model created in Phase I. In this reassessment, the CIRES team found a way to reduce the amount of interfering solar reflectance and impact from topographical effects on the refined scenes. However, given the distance of the remote viewing platforms (750 - 915 miles) and the pixal resolution on the ground (90m x 90m), it was accepted that this technique has a limited value as a lead exploration tool. The CIRES Final Report is dated 12/26/12.

While the CIRES model was being refined and its Report prepared field studies of generally known geothermal areas continued using more conventional exploration means such as conducting shallow (2m) temperature surveys, spring and water geochemistry, structural geology, geothermometry all complemented by an extensive literature search. By the middle of 2012 several high priority sites and numerous secondary sites had been selected for further work. A Final Report on the top five Prioritized Sites (the "Priority Sites") was prepared by Geothermal Development Associates and is dated 09/19/12. The areas highlighted in that Report include Routt Hot Spring in Routt County, Wagon Wheel Hot Spring in Mineral County, Poncha Hot Springs in Chaffee County, Rico-Paradise hot spring area of Dolores County, and Lemon warm springs in San Miguel County.

Due to such issues as property tax liens, legal matters, regulatory barriers, friction among neighbors and NIMBY issues , Flint was unable to obtain rights to conduct surveys on the Primary Sites. In the latter half of 2012 work then turned to picking a viable secondary target with a viable land position on which to continue Phase II assessments. As a result of negotiating a working relationship with an Industrial partner in the Florence Area, Flint was given access to an extensive Report prepared by Meridian Ltd. This Report provided a detailed literature search and analysis of the geothermal potential within the Florence Canon City Area. That report (completed in May 2012) was prepared specifically for the Industrial partner who requires an average of 30 Mw/H of peak usage for its operations. As a result they are motivated to investigate cost effective alternatives and have chosen to investigate local geothermal resources. Flint and the Industrial have been working closely together since mid- 2012 to cooperate in formulating a comprehensive exploration program which is explained herein.

The Penrose area has ranked high on our secondary target list, and has the advantage of landowners willing to have geothermal development occur on their lands. It has the added advantage of lots of bottom hole information from prior deep drilling work performed at the project area and the nearby Florence oil and gas field. This memo is meant to outline the single target that we believe is suitable on which to continue Phase 2 work. Much of the Meridian report has been incorporated into this memo.

INTRODUCTION

Thermal waters have long been known to exist in the Canon City embayment (CCE) along the Front Range of Colorado (Figure 1). The earliest known occurrence, and the only thermal spring in the CCE, is the Canon City Hot Springs on the west side of the embayment. It discharges 5 gpm of 40^{o} C (104^{o} F) water. Several other thermal wells occur in the Canon City area. East of Canon City around Florence and Penrose, thermal fluids also have been encountered in wells. Deep (1.2 km) wells in the Florence oil and gas field have measured temperatures in the 70^{o} C range (e.g. 32-29 Patti), centered in an area a mile northeast of Coal Creek. In the eastern portion of the embayment southwest of Penrose, several thermal wells of varying depth have lower temperatures than 32-29 Patti, but higher shallow temperature gradients.

Because of the high temperature gradients and unique structural setting of the eastern CCE, Flint Geothermal LLC has decided to conduct further work in the area. This report focuses on the geothermal potential of the Penrose area in the eastern portion of the embayment.

GENERAL GEOLOGY

The CCE is a south-southeast plunging synformal basin formed by west- or southwest-directed Laramide thrusting of a thick Paleozoic and Mesozoic sedimentary package up and against Precambrian basement rocks to the west (Fig 2). Within the embayment the sedimentary rocks form a series of smaller antiforms and synforms that are subparallel (i.e. NNW) to the basin (Zacharakis et al., 1982). The most prominent of these is the Brush Hollow Anticline (BHA) on the east edge of the CCE, which is interpreted as a small, northeast striking horst block bounded on both sides by several en echelon normal faults of relatively small displacement (Figure 3). Geothermal activity in the Penrose area appears to be centered on the BHA.

The Precambrian rocks consist of foliated biotite-quartz-plagioclase gneiss "granodiorite" and feldspathic gneiss, which are locally intruded by Cambrian mafic and ultramafic rocks. Zacharakis et al. (1982) and Vinckier (1982) both speculate that geothermal activity in the CCE originates in the basement rocks, possibly due to their high proportion of radioactive minerals (and as evidenced by high radon levels). The nearest Precambrian rocks are exposed some 12 miles to the west, in the Wet Mountains.

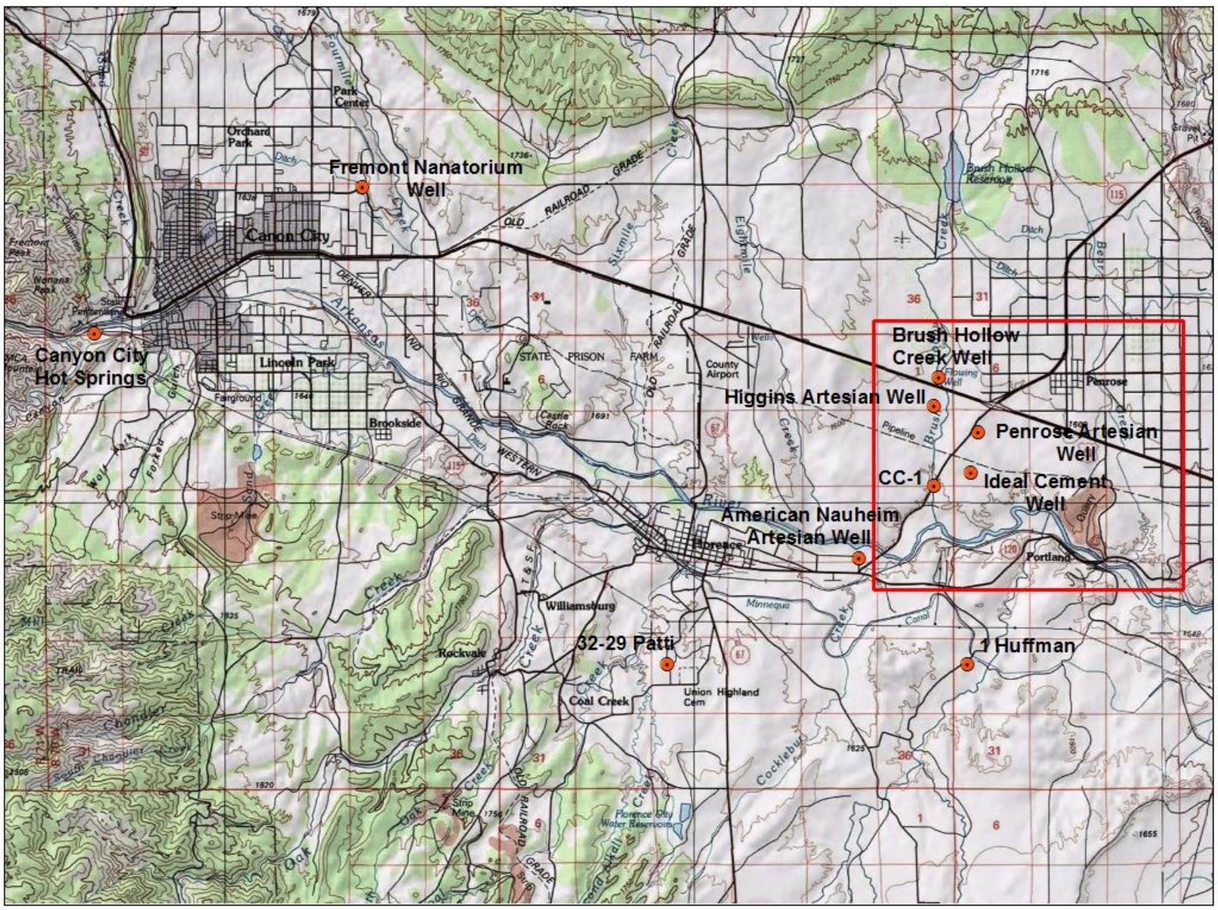


Figure 1. Locations of some of the thermal springs and wells in the Canon City - Penrose area. The study area is outlined in red.

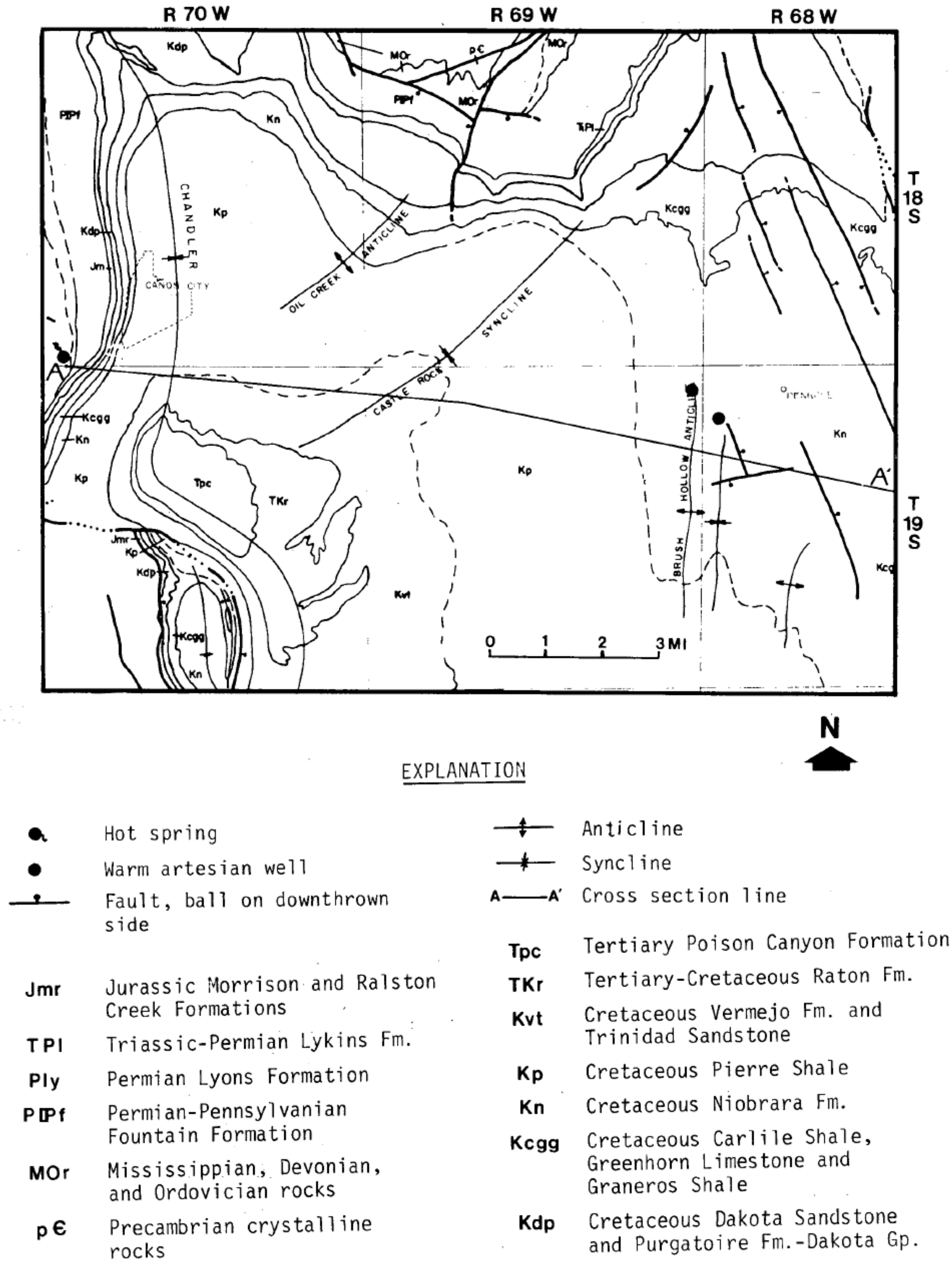
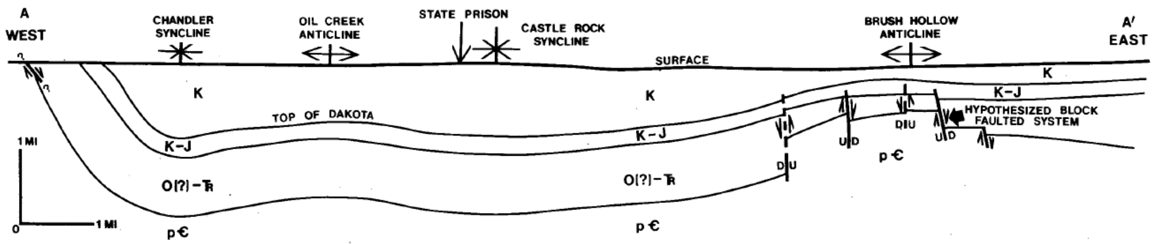


Figure 2. Geologic map of the Canyon City Embayment (from Vinckier, 1982).



EXPLANATION

K	Upper Cretaceous undivided
K-J	Jurassic and lower Cretaceous
O ? Ꞧ	Ordovician -- Triassic
p€	Precambrian

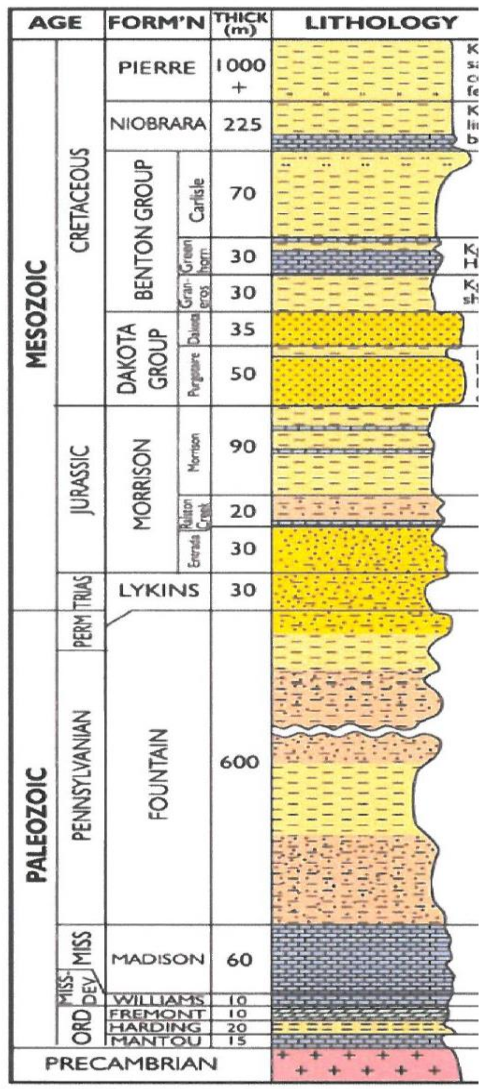
Figure 3. Generalized east-west cross section through the Canon City Embayment. From Zacharakis (1982).

The overlying sedimentary package is a maximum 2.3 km thick and consists primarily of low permeability siltstones together with interbedded layers of higher permeability sandstone and limestone units (Figure 4). From the top of the BHA in the Penrose area, this package dips gently to moderately westward into the CCE. It is interesting to note that oil and gas production in the Florence oil field occurs in fractured areas within the otherwise impermeable Pierre Shale. Further to the west, along the Wet Mountain range front, these sedimentary units ramp up against the Front Range Precambrian rocks to form vertical and even overturned beds.

Several units within the Mesozoic sedimentary package have relevance to the geothermal landscape of the study area. First, the 85 m thick Lower Cretaceous Dakota Group contains several permeable sandstone horizons, making it one of the primary aquifers of the region, both for water and hydrocarbons. Locally high radon levels from Dakota aquifer waters suggest that this unit is connected hydrologically with the Precambrian basement rocks. Zacharakis (1982) noted this and hypothesized that the thermal waters in the study area were associated with the Dakota Sandstones (there less than 500 m from the surface), probably derived from a Precambrian basement source.

Another important formation in the section is the upper Cretaceous Niobrara Shale. The Niobrara is the bedrock unit exposed in the study area. It is composed of shale, calcareous shale, and minor limestone and sandstone.

The third unit of interest is the kilometer thick upper Cretaceous Pierre Formation, which directly overlays the Niobrara Shale. The Pierre is composed predominately of oil-bearing shale with low primary permeability. However, fractured areas within the Pierre serve as the reservoir for the Florence and West Florence oil fields. Thermal data from the oil field and surrounding wildcat drilling provides the basis for establishing temperature gradients for the region (see below).



'igure 2. Generalized stratigraphic column (

Pierre	5 ohm-m
Niobrara	15-20
Benton	10-15
Dakota	10-50
Morrison	5-20
Lykins	15-100
Fountain Upper Lower	 15 50
Carbonates (if present) and Basement	500+

Figure 4. Stratigraphic section of the Canyon City embayment, showing average resistivities that will be described below.

OIL AND GAS WELLS

The Florence Oil Field was discovered in 1862, one of the earliest US fields and the first one in the Rocky Mountains. Exploration and drilling has seen a recent surge with production from Cretaceous shales (Pierre, Niobrara) and sands (Dakota).

STRATIGRAPHY

The Colorado Oil and Gas Conservation Commission (COGCC) databases all oil and gas well information online at http:// http://cogcc.state.co.us. Companies are required to lodge certain data with the state as wells are permitted, completed, etc. Historical data (wells) have also been added to the database.

The database contains, among other things, geophysical logs, formation tops, completion data, and well depth. These data are found by searching either a map plug-in, or text entry (location, well name, etc.). We extracted about 350 wells for possible use in our databases.

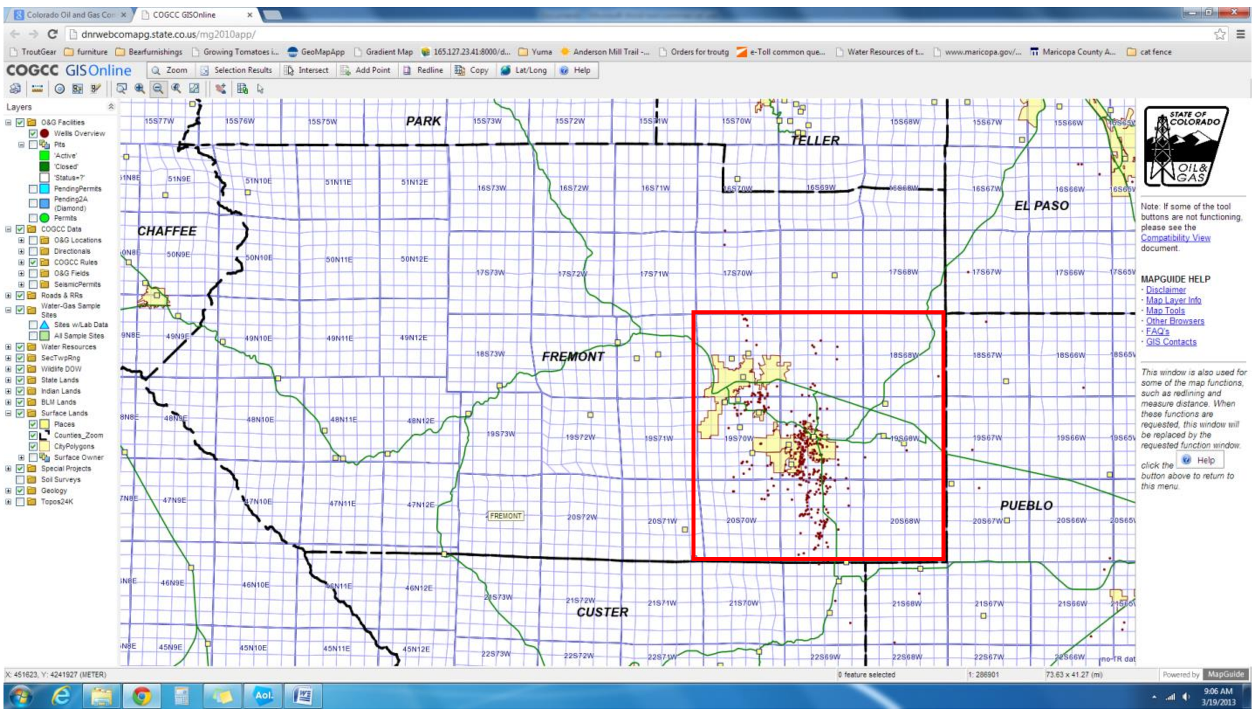


Figure 5: Screenshot of COGCC Map-based plug-in that shows oil/gas wells in Fremont County. Well data were extracted for the study area and to the west (into the Canon City Embayment) as shown by red rectangle

Not all wells have useful data. Either those data, such as geophysical logs, were not run, or older data are not available. However, many wells provide several useful data:

- Geophysical logs (including resistivity or density)
- Formation tops (depth where a certain formation was encountered during drilling)
- Temperature logs
- Bottom-hole temperatures (BHTs)

GEOPHYSICAL LOGS

The geophysical logs are useful to determine what rock-property contrasts are present in the subsurface and if resistivity or gravity measurements will aid in mapping subsurface structure. Resistivity models were run (specifically MT) using inputs derived from the various electrical logs (discussed later under 'Geophysics')

FORMATION TOPS

Formation tops can be used to map depth to certain formations, and create structure contour maps, isopach maps, etc. These data can also be used to construct cross-sections. This formation data is generally very accurate, and much more accurate than any geophysical mapping technique.

Where available, formation tops are presented in the CGS database similar to shown in the following table (an example from one well):

Formation	Log Top
PIERRE	0
NIOBRARA	2916
FORT HAYS	3389
CODELL	3482

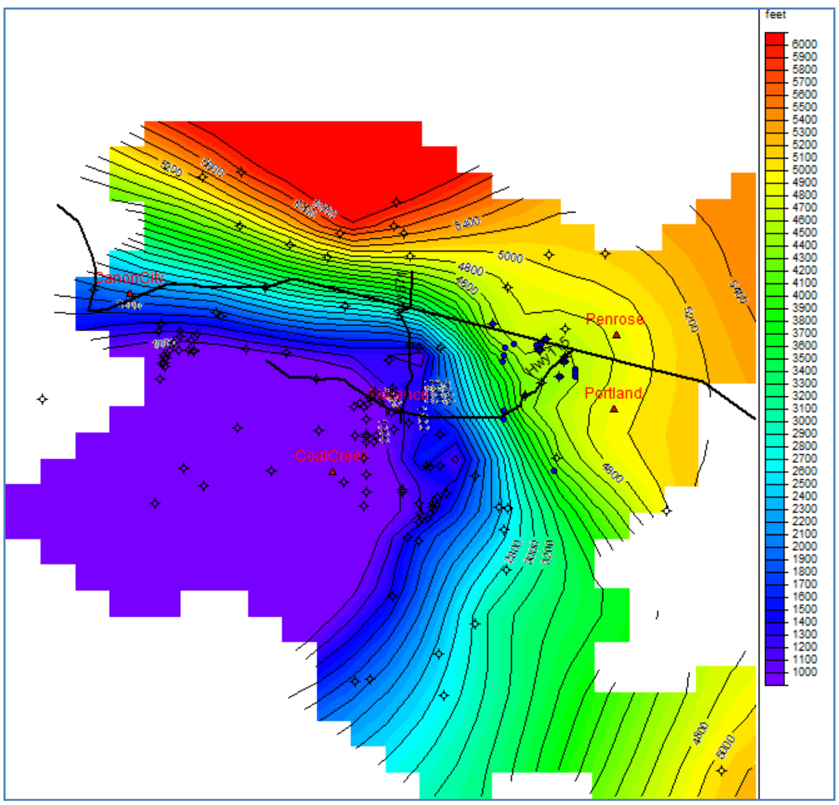


Figure 6: Elevation on top of the Dakota formation in the Canon City and Florence Area

These data were extracted from all wells (where reported) within the initial study area and entered into our own database. We also gathered information from a few other sources, such as water wells (where formation was reported and deemed accurate) and geologic maps (contacts on surface). We did a similar data search of all water wells within our immediate study area. We reviewed every driller's log and extracted information on formations (where given) and any noted temperature information

Both maps and cross-sections were developed from the well database in order to develop a stratigraphic and structural model for the study area and Canon City Embayment in general.

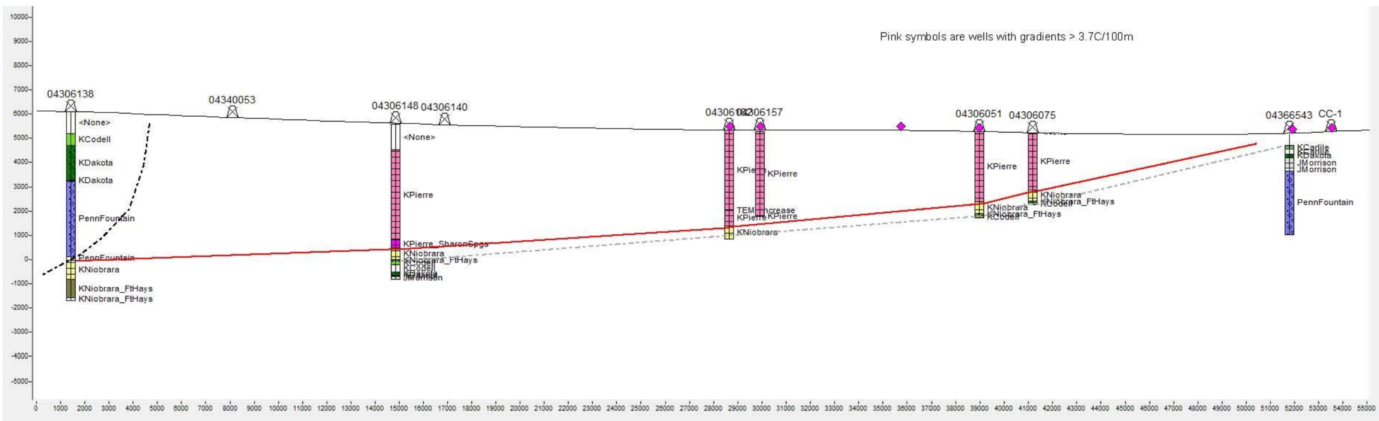


Figure 7: Cross-section of stratigraphy from well tops, west to east, across the Florence Oil Field to the study area

TEMPERATURE DATA

Temperature logs are available for five exploration wells. Shallower temperature logs have also been measured by SMU and the Colorado Geological Survey (Ringrose, 1980).

Bottom-hole temperatures (BHTs) are recorded for some oil wells, either on logs or in completion reports. We reviewed all logs within the Florence Oil Field and recorded about 50 BHTs. Some of these data had also been reviewed by the CGS (Dixon, 2004).

Dixon summarized the BHTs for all wells she reviewed in the Canon City/Florence area (from just oil well data) were plotted and are shown in Figure 10.

The CGS data were corrected for circulation mud; our data were not. However, comparing our data with CGS data for the same wells, the difference was not that substantial, and an anomalous well would still stand out.

The oil well with the highest geothermal gradient is the Patti 32-29, which shows a gradient of 5.07C/100m based just on the BHT. The gradient in a portion of the temperature log (lower section) is much higher, about 19C/100m (see Figure 5), and appears to indicate convective heat transfer. This could be that 32-29 Patti is/was approaching a geothermal aquifer below. This would probably be the

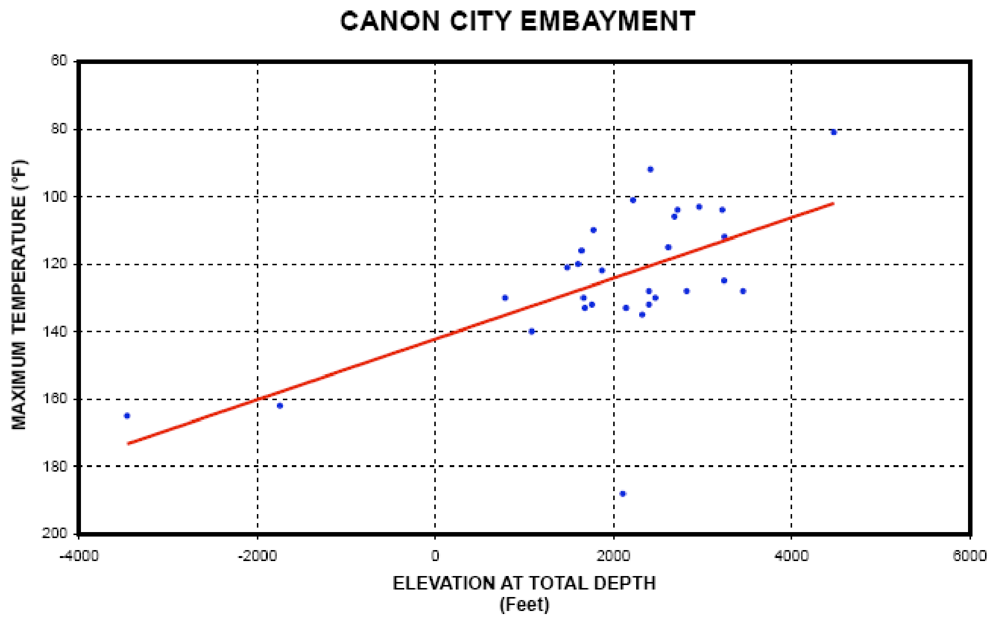


Figure 8: Bottom-hole temperatures plotted vs. elevation for the Canon City Area. From Dixon, 2004

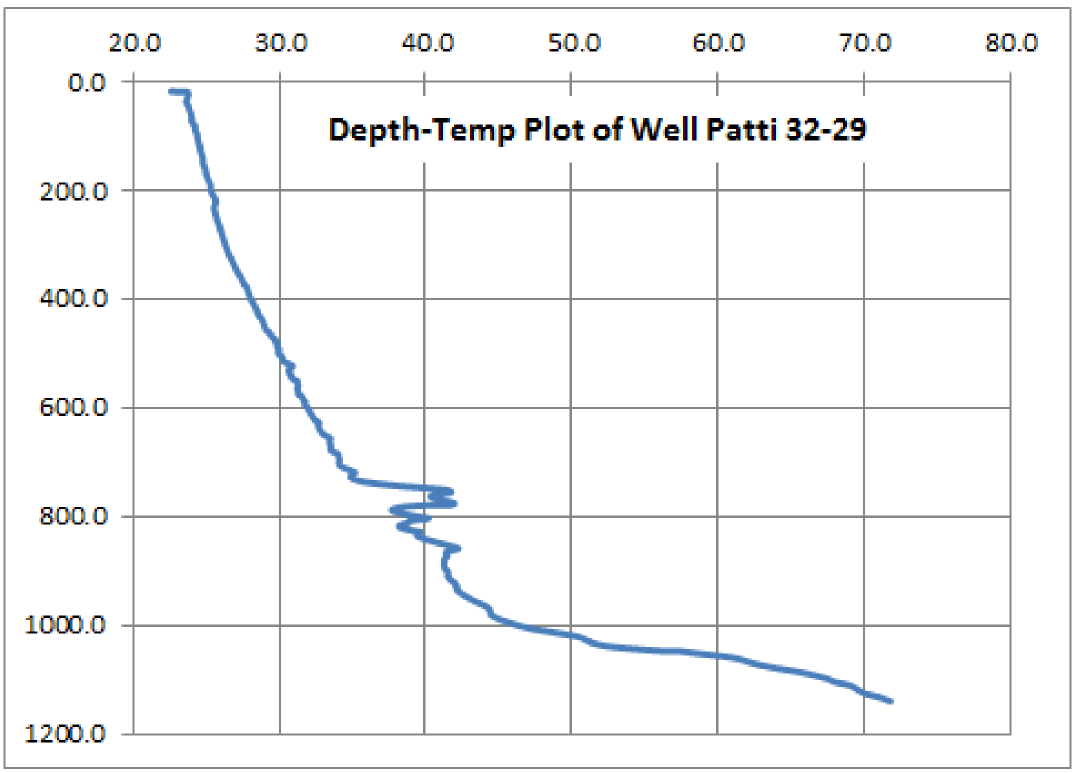


Figure 9: Temperature log data for the Patti 32-29 well, with temperature (in Centigrade) on the x axis and depth (in meters) on the y axis.

Sharon Springs member of the Pierre Formation. Alternatively, it could represent proximity to a near-vertical structure that serves as a conduit for geothermal fluids.

All BHT-derived temperature gradients (from just oil well data) were plotted and are shown in Figure 10.

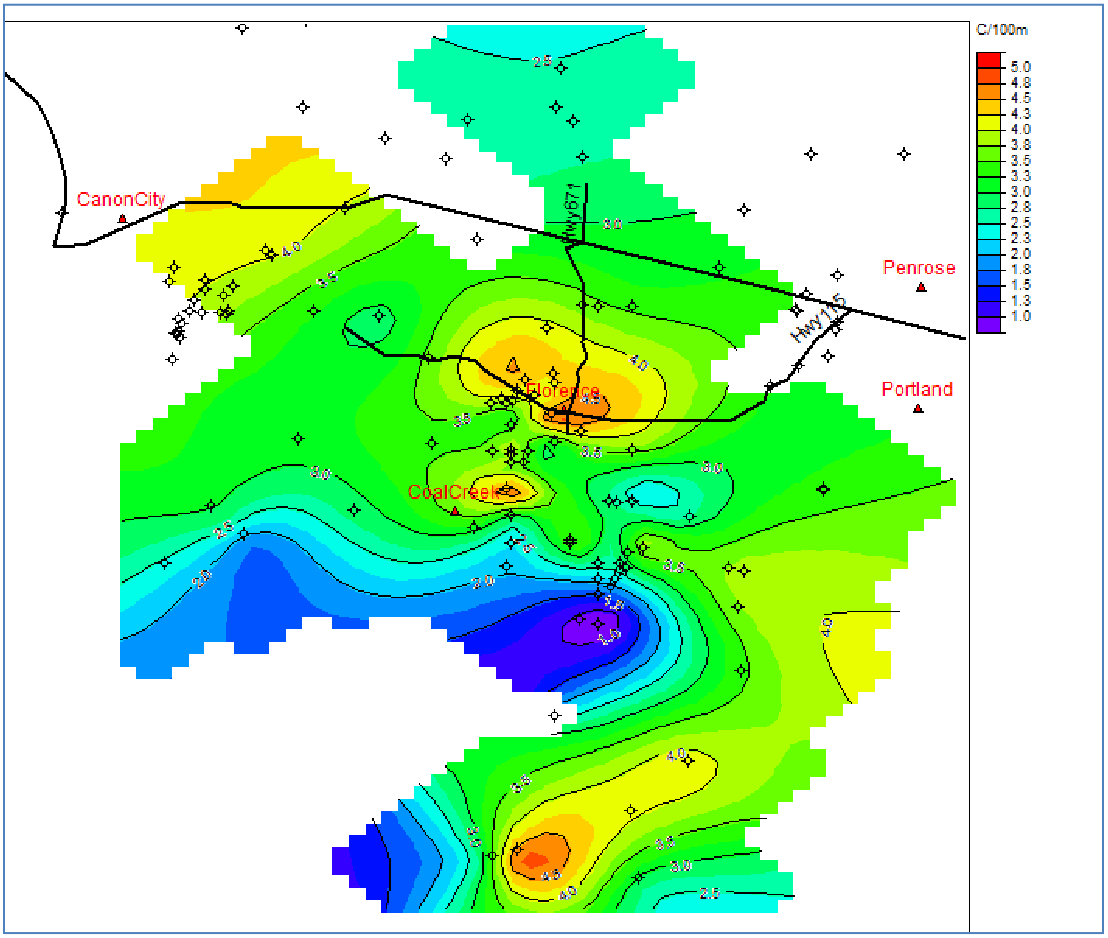


Figure 10: BHT-derived temperature gradients (just oil well data)

Determinations from temperature data

- Higher temperatures appear to be localized to a few areas
- One oil well, Patti 32-29, shows a gradient of 5.07C/100m based just on the BHT. The gradient in a portion of the temperature log (lower section) is much higher, about 19C/100m
- A few other oil wells showed above average temperature gradients
- The shallower measurements show much higher gradient than most oil well BHT-derived gradients
- Based on the Patti, similar changes in temperature gradient probably occur at other locations. One other oil well, the Royal Gorge #1 showed a probable sharp increase in temperature, also at or near the top of the Sharon Springs member of the Pierre Formation.

- The shallow temperature holes, with higher temperature gradients, were drilled in the Niobrara Formation
- No correlation with formation, i.e. increase in temperature does not appear related to a given stratigraphic horizon
- Possible relation to major fault/fracture zones.

GEOCHEMISTRY AND GEOTHERMOMETRY

Thermal waters of the Penrose area are sodium-potassium bicarbonate waters with TDS in the 1,200 – 1,500 range (Table A). They are characterized by high magnesium, low chloride, and moderate sulfate (about 2x chloride values). A Na-K-Mg plot indicates that samples plot in the 'immature' region. Silica and cation geothermometry from these same samples are shown in Table B.

Table 1. Major constituents of thermal wells in the Penrose area. Well locations are shown in Figures 1 and X.

Sample Name	Temp C	Na	K	Ca	Mg	B	F	Cl	SO4	HCO3
1 Huffman Well	55.0	280	33	160	70	0.21	1.2	130	230	1170
1 Huffman Well	54.0	283	28	159	71	0.12	1.0	126	226	1140
1 Huffman Well	52.4	326	33	170	73	0.19		149	212	1190
1 Huffman Well	55.0	280	33	160	70	0.21	1.2	130	230	
Brush Hollow Creek Well	31.5	300	33	160	70		1.3	120	230	
Dakota Artesian Well	42.0	309	33	162	67	0.20		120	212	1140
Florence Artesian Well	28.0	270	32	180	78	0.13	1.1	98	210	
Florence Artesian Well	29.3	218	26	150	69	0.17		75	201	1060
Higgins Artesian Well	41.0	300	33	150	68		1.4	120	240	
Ideal Cement Well	33.2	291	31	161	75	0.20		112	239	1170
Ideal Cement Well	31.0	280	22	170	73	0.21	1.3	120	240	
Ideal Cement Well	31.5	290	32	160	71		1.4	120	230	
MF-5 Artesian Well	32.3	235	27	160	71	0.17		74	221	1070
Penrose Artesian Well	29.0	255	31	170	71	0.24	1.1	99	200	

Table 2. Estimated silica and cation geothermometer values from thermal wells in the Penrose area. Well locations are shown in Figures 1 and 18.

Sample Name	Chalcedony	Quartz	Na/K (Trues)	Na-K-Ca	Na-K-Ca-Mg	K/Mg (Gigg)
1 Huffman Well	53.6	85.2	205.9	179.7	-146.8	72.5
1 Huffman Well	50.9	82.6	185.7	99.3	-142.1	68.4
1 Huffman Well	51.7	83.4	188.5	173.6	-144.7	72.0
1 Huffman Well	53.6	85.2	205.9	179.7	-146.8	72.5
Brush Hollow Creek Well	48.1	79.9	198.0	106.2	-139.1	72.5
Dakota Artesian Well	52.7	84.3	195.4	176.4	-138.1	73.2
Florence Artesian Well	33.3	65.6	206.6	178.3	-147.4	70.5
Florence Artesian Well	36.2	68.4	206.9	94.9	-145.1	67.1
Higgins Artesian Well	54.9	86.4	198.0	107.8	-144.0	72.9
Ideal Cement Well	46.0	77.9	193.4	174.4	-157.9	70.0
Ideal Cement Well	45.1	77.1	162.9	89.2	-136.3	62.8
Ideal Cement Well	48.1	79.9	198.4	104.6	-141.3	71.6
MF-5 Artesian Well	40.5	72.6	203.8	96.1	-139.9	67.9
Penrose Artesian Well	35.1	67.4	209.6	179.2	-141.2	70.9

Geothermometer values from Penrose wells aren't particularly encouraging for a high-temperature (+150°C) geothermal system. Na/K geothermometers are uniformly high, but we've noted many "false positives" in Colorado water Na/K geothermometry and discount their value in this area. Silica geothermometers are relatively low, uniformly less than 90oC. Mg-corrected cation geothermometer estimates are well below freezing, possibly suggesting contamination problems. Only the standard Na-K-Ca geothermometer (without the Mg correction) values are somewhat believable and encouraging.

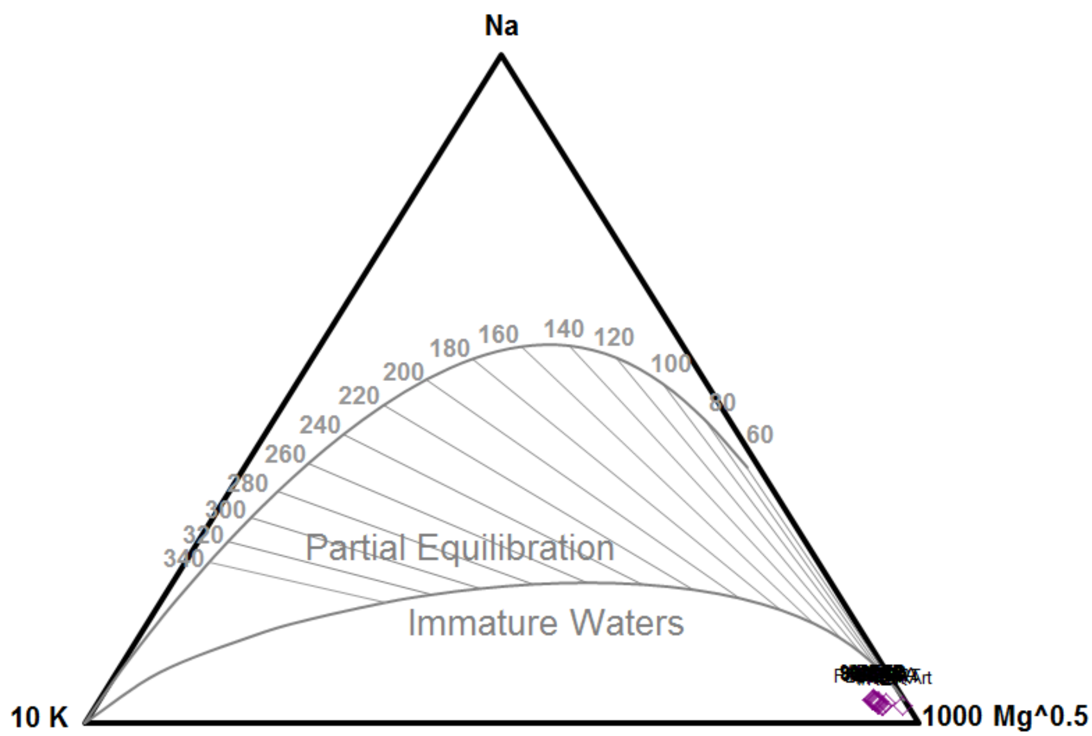


Figure 11. Na-K-Mg plot of Penrose well samples.

Cold groundwater from the area has a more bimodal distribution of values, with about half the samples having higher calcium and magnesium (and lower chloride and silica) values than the thermal waters. The other half of the cold samples are relatively low in all constituents. This is interpreted to result from dissolution of constituents from some of the samples during travel through some of the high Ca and Mg Mesozoic formations. Mixing and dilution of these waters with high silica, low Mg geothermal waters could be causing the low silica and Na-K-Ca-Mg geothermometer values.

GEOPHYSICS

We did an exhaustive search for geophysical data, available from either public or private sources. This search included:

- USGS
- CGS
- Data brokers
- Personal contacts
- Literature

We then compiled the findings into our databases, as appropriate. A summary of the geophysics is as follows.

GRAVITY AND MAGNETICS

Gravity and magnetic data are available from the USGS. No other data could be located, from data brokers or literature.

The USGS has the datasets available online, and portions of the Colorado data can be downloaded for any given area.

GRAVITY

The gravity data are somewhat scattered, mostly gathered along roads. They do not have the station spacing needed for detailed modeling. The gravity data show major structural features, such as the Florence Basin and areas where basement rocks are close to or at the surface, such as the Wet Mountains. Interestingly, in the vicinity of the study area, in the region of the BHA, there is a strong gravity gradient which parallels the north-northwest striking faults (Figure 12).

Density values are available from some well logs. We have had a detailed gravity survey designed for the study area, and may deem acquisition useful at some point in the future (coupled with a detailed ground magnetic program).

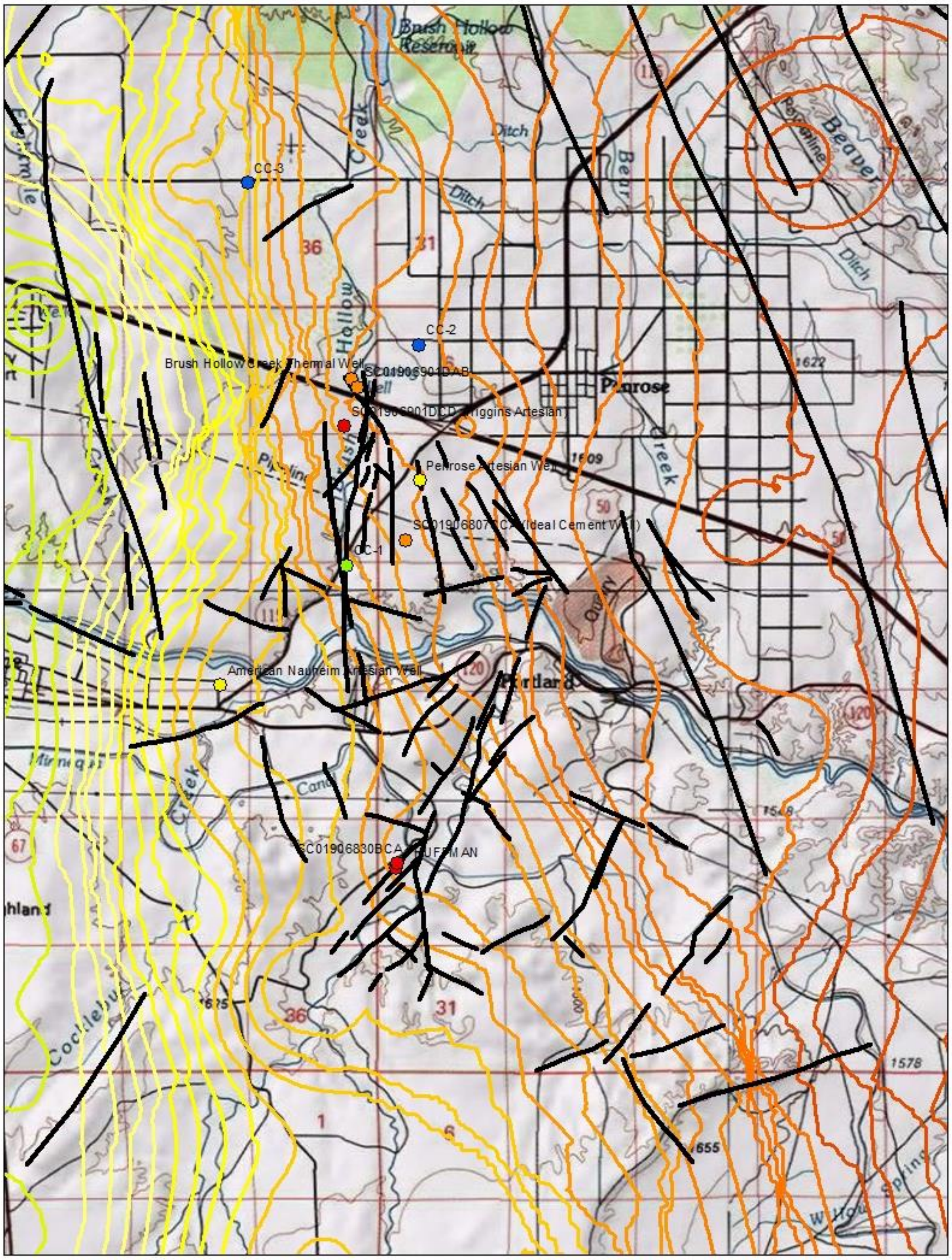


Figure 12: One milligal gravity isopach map of the Penrose geothermal area superimposed on mapped faults and lineaments from aerial photographs and LIDAR hillshades (see structural section below). Isopachs are colored from orange (higher density) to green (lower density), corresponding to westerly thickening of the lower density Paleozoic-Mesozoic package.

MAGNETICS

The magnetic data were flown by the USGS in 1960 mostly at a flight-line spacing of 1.6km EW. The area east of our study area was flown at 8 km EW in 1969. A detailed report for the Pueblo 1x2 sheet (which includes the study area) was done by Boler and Klein in 1990. Also useful was an interpretative geologic map of basement in Colorado based on aeromagnetic data (Sims et al, 2001)

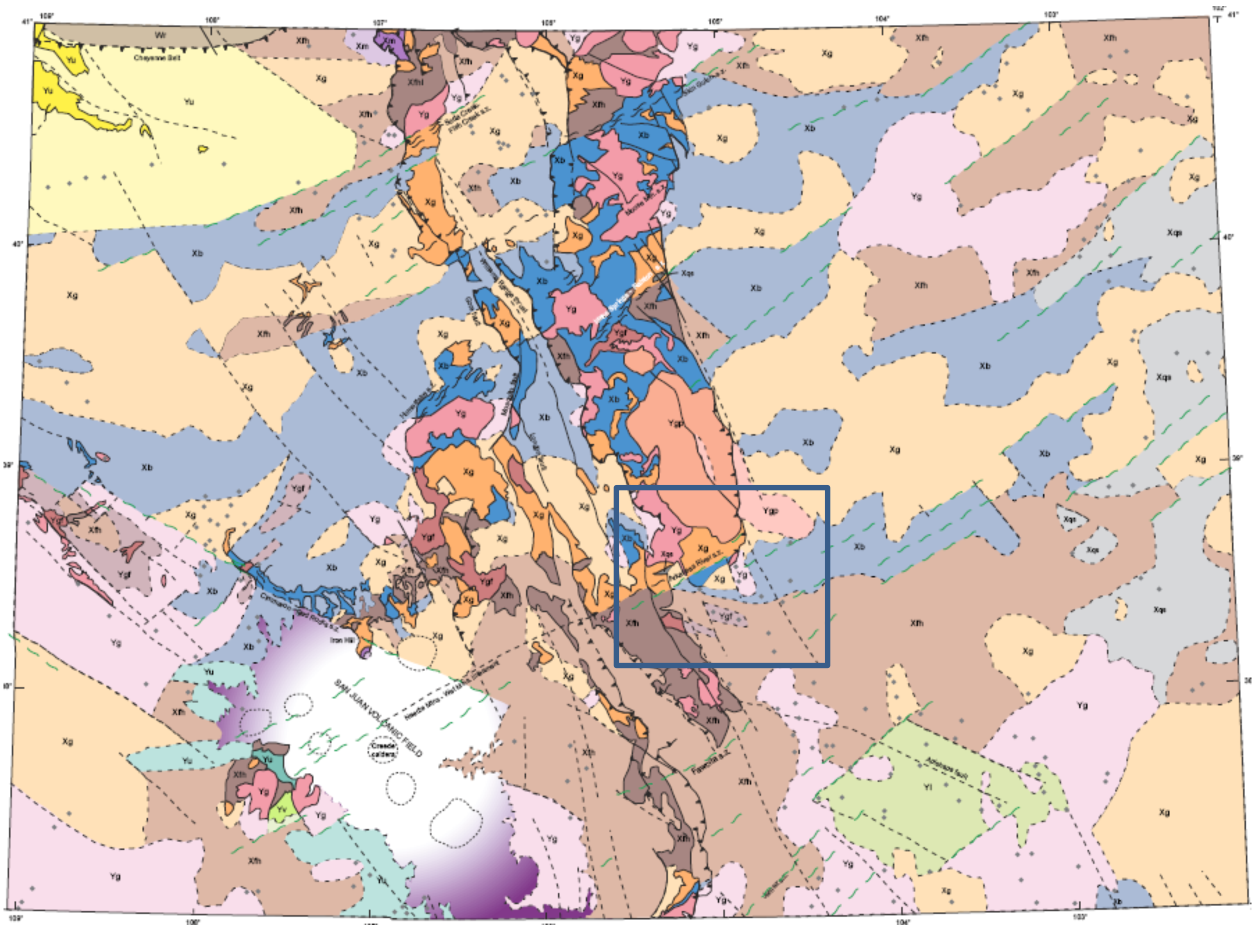


Figure 13: Interpreted basement geology from aeromagnetic data for Colorado (Sim et al, 2001). Expanded study area shown by blue rectangle

We extracted a portion of the Colorado data, surrounding our study area. To date, the magnetic data have been used to look for possible fault/fracture/lineament trends in an effort to develop our study area model. We did try various derivative and filtering algorithms on the magnetic data, but none of that seemed to aid our interpretation. There is a very definite NE trending low thru our area, which does align with some of the trends that we developed from LIDAR and other work.

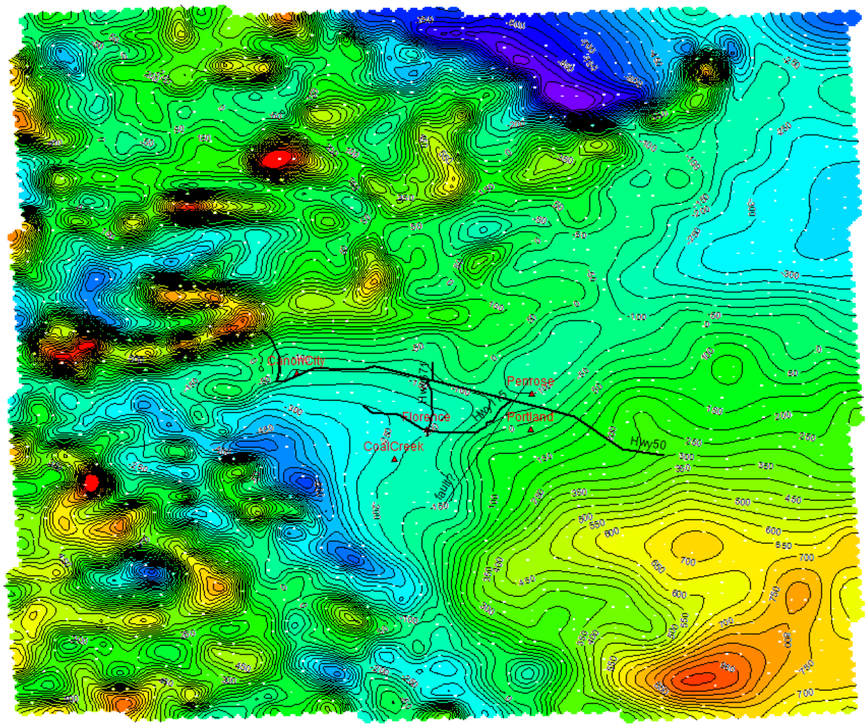


Figure 14: Total magnetic intensity map for expanded study area (from the USGS data set)

SEISMIC

Seismic data can often be very useful in the determination of structural style and elements, but are expensive and timely to acquire. We contacted seismic brokers and found two lines (from 1979) that trend through our study area. To date, we have only QC'ed a portion of each line. The dip line is quite noisy, and would definitely need re-processing. The strike line, which trends parallel to one of our interpreted major fault zone, has been re-processed. However, because it is a strike line, it may suffer from distortion and not image the features we are interested in.

We are also in contact with some oil companies that are active in the Florence Field. They have acquired both 2D and 3D seismic surveys within recent years. Our intent is to continue communications in that they might share some of their seismic data or results with our team.

MAGNETOTELLURICS

In order to determine the effectiveness of electromagnetic or electrical geophysics, including Magnetotellurics, a review of the subsurface resistivities was made. Fortunately, several of the area oil wells had resistivity logs run. Many of these wells penetrated only through the thick section of Pierre Shale. However, there are a few wells that penetrate other formations and have resistivity information available.

After reviewing numerous electrical and induction logs, a summary of average resistivity was made for each major formation. These finding are summarized in Figure 4.

Once resistivity values are established, numerical models can be run to determine the effectiveness of electromagnetic geophysics. Specifically, we wanted to determine how useful Magnetotelluric (MT) data might be.

A forward model was constructed along one of the stratigraphic profiles trending west to east across the Florence Oil Field and into the study area. The profile is similar to that shown in Figure 3. The input model is shown in the following (top) figure. From this model, synthetic MT data were calculated for stations shown across the top of the profile (b1 through b23). These data were then inverted; this process is meant to simulate actual acquisition of field data and see what result those data would provide. The resulting inversion is shown as the figure following the input model.

The resulting model demonstrates a well-known problem with MT. Magnetotellurics does not image the base of a thick conductive package well. As the resulting model shows, the ‘basement’ surface is ‘smeared’ or ‘blurred’. MT is best used in areas where it is desired the map the base of resistive rocks (such as the base of a basalt layer). This result shows that MT would not be effective in determining subsurface structure, especially in an area where numerous wells have been drilled, as they provide a much more quantitative result.

We contacted all MT data brokers. There are some vintage MT data available for sale, but they are to the west of the study area and would not add pertinent content to our investigation.

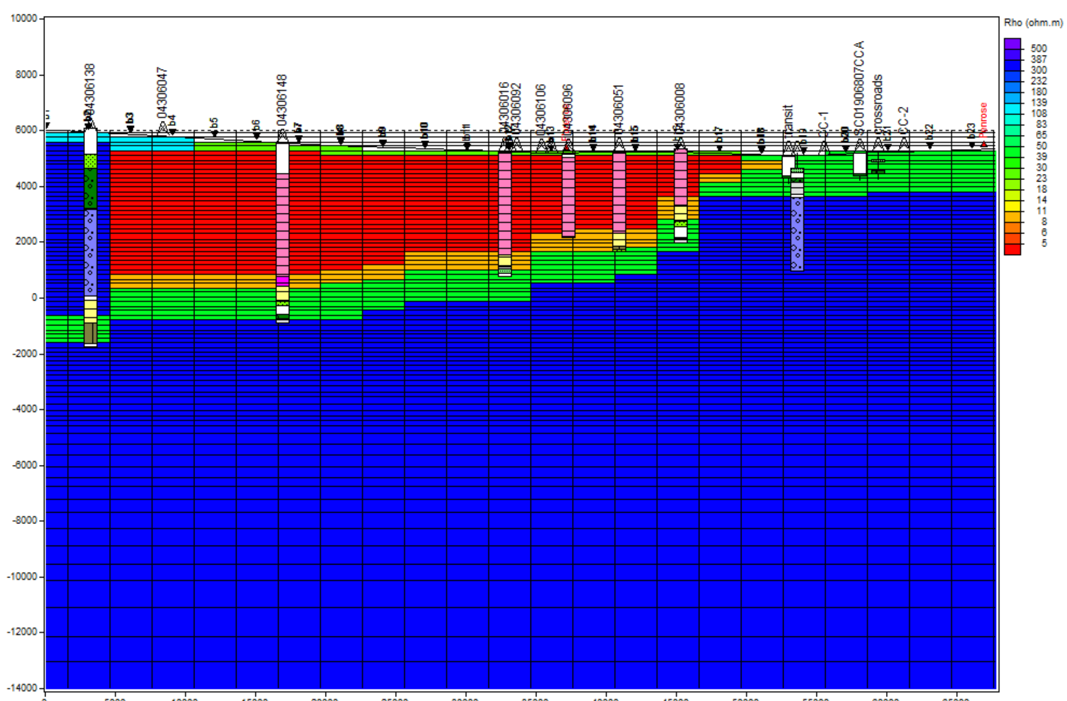


Figure 15: Forward MT model showing blocked resistivities for formations

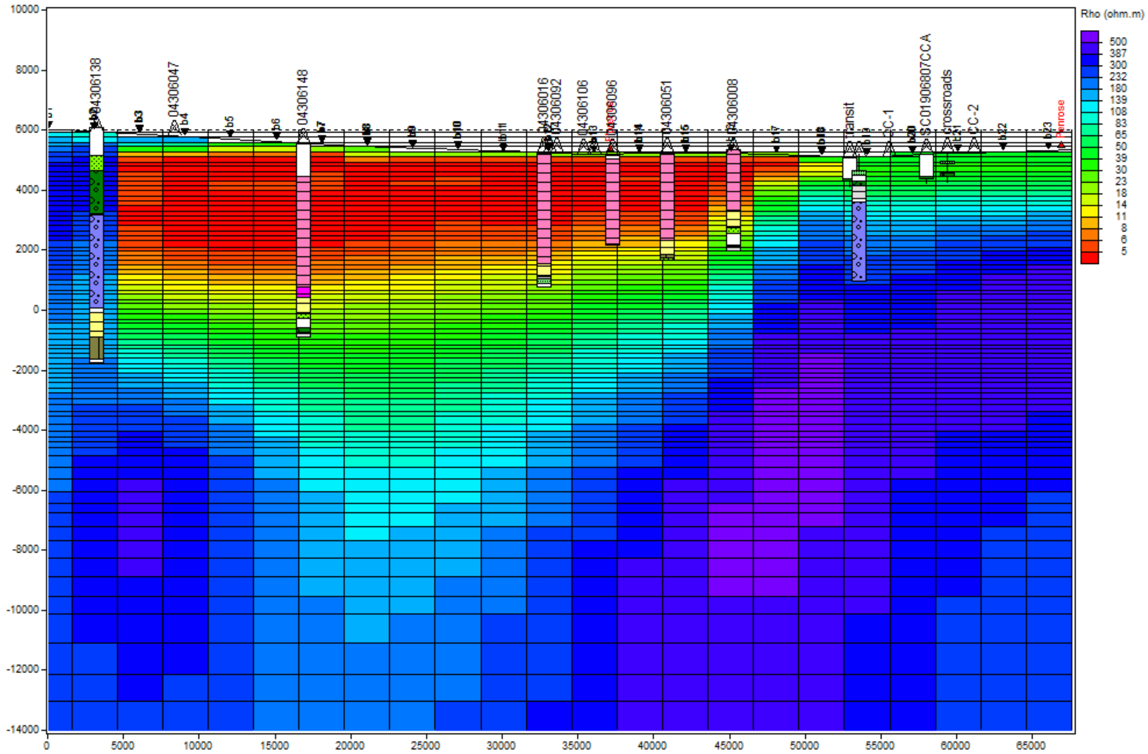


Figure 16: Inverse MT model showing the result of interpreting that data from the forward MT model

OTHER DATA

We performed exhaustive literature and online searches in an effort to locate any other geophysical data. Other than what we have included or referenced in this report, we could find no data useful to our study.

We did thoroughly review the CGS report on Canon City (Zacharakis, 1982). That report includes results from seismic, resistivity, Audio-Magnetotelluric, and Telluric Profiling studies done by the USGS in the 1970's. Although these surveys were small in areal scope, they all seem to confirm the presence of one or more of the larger structural features (faults or fractures) that we have mapped.

GEOPHYSICS SUMMARY

- Further ground-based gravity and/or magnetic may be useful for identifying major faults, fractures or contacts in our area. We have a possible program designed and quoted
- Existing seismic may be useful, if the data have been re-processed
- Contacts within the oil/gas community may allow review of their 2D or 3D seismic surveys
- Magnetotellurics is not deemed advantageous

LIDAR

Holcim (US) Inc., the owner of a limestone quart and a significant land position in the Penrose area, commissioned a geothermal study of the CCE in 2012 which was conducted by Meridian Power (MP) and Geologica. One component of the study was a LIDAR (Light Detection and Ranging) survey. Although the imagery MP used in their study was unavailable, Holcim provided the raw data files to Flint. A digital elevation model (DEM) was constructed from the LIDAR data with a 2 meter cell size and a vertical resolution of approximately 0.3 meters. Hillshade grids were then produced from the DEM at 60^o angles around the compass with a "virtual sun angle" of 20^o above the horizon. This in turn allowed the identification of lineaments that presumably correspond to low fault scarps.

The results of one such hillshade grid, together with observed lineaments, is shown in Figure 17. Our hillshade analysis identified many lineaments not mentioned in the MP survey. The lineaments seem to occur along several specific directions: north-northwest, northeast, and east-northeast. The north-northwest lineaments (and one east northeast lineament) are parallel to some of the mapped faults in Figure 2, and several correspond spatially with them.

STRUCTURAL CONTROLS TO THE PENROSE GEOTHERMAL SYSTEM

The geothermal systems of the CCE occur at a spot where the Rocky Mountain escarpment takes an easterly jump from the Wet Mountains to the Front Range. This could be related to a so-called structural "stepover" which creates dilatant zones that are associated with many of the geothermal systems in Nevada.

As mentioned previously, the Penrose geothermal system occurs in a structural zone that previous geologists have called the 'Brush Hollow Anticline'. Presumably, this was interpreted as an anticline (with inferred compressional regime) because bedding on the east side of the BHA dips gently to the east, and bedding on the west side dips gently to moderately to the west. However, later geologists (Zacharakis et al., 1982, and Meridian Power, 2012) have interpreted the BHA as a small horst block (with an inferred extensional regime) created by north-striking normal faults. Perhaps this structure would be better named as the 'Brush Hollow Horst'.

The NNW and NE lineaments of the Penrose area closely parallel normal fault features in the San Luis Valley some 70 km to the southwest. We agree with these interpretations and suggest that the LIDAR lineaments are in fact Tertiary extensional features related to late Tertiary to Recent normal faulting of the Rio Grande Rift.

Joe Lamanna, Manager and geologist of the Holcim limestone cement operation, confirms that NNW and ENE structures are present in the pit walls and have normal offset. In the pit, the NNW structures dip at about 60^o to the NE and have displacements on the order of 40-80 feet (some NNW structures outside the pit have are reported to have a definite down to the SW movement). The ENE structures dip to the southeast with dips on the order of 70^o. Thus, direct field data seems to corroborate the fault nature of the LIDAR lineaments.

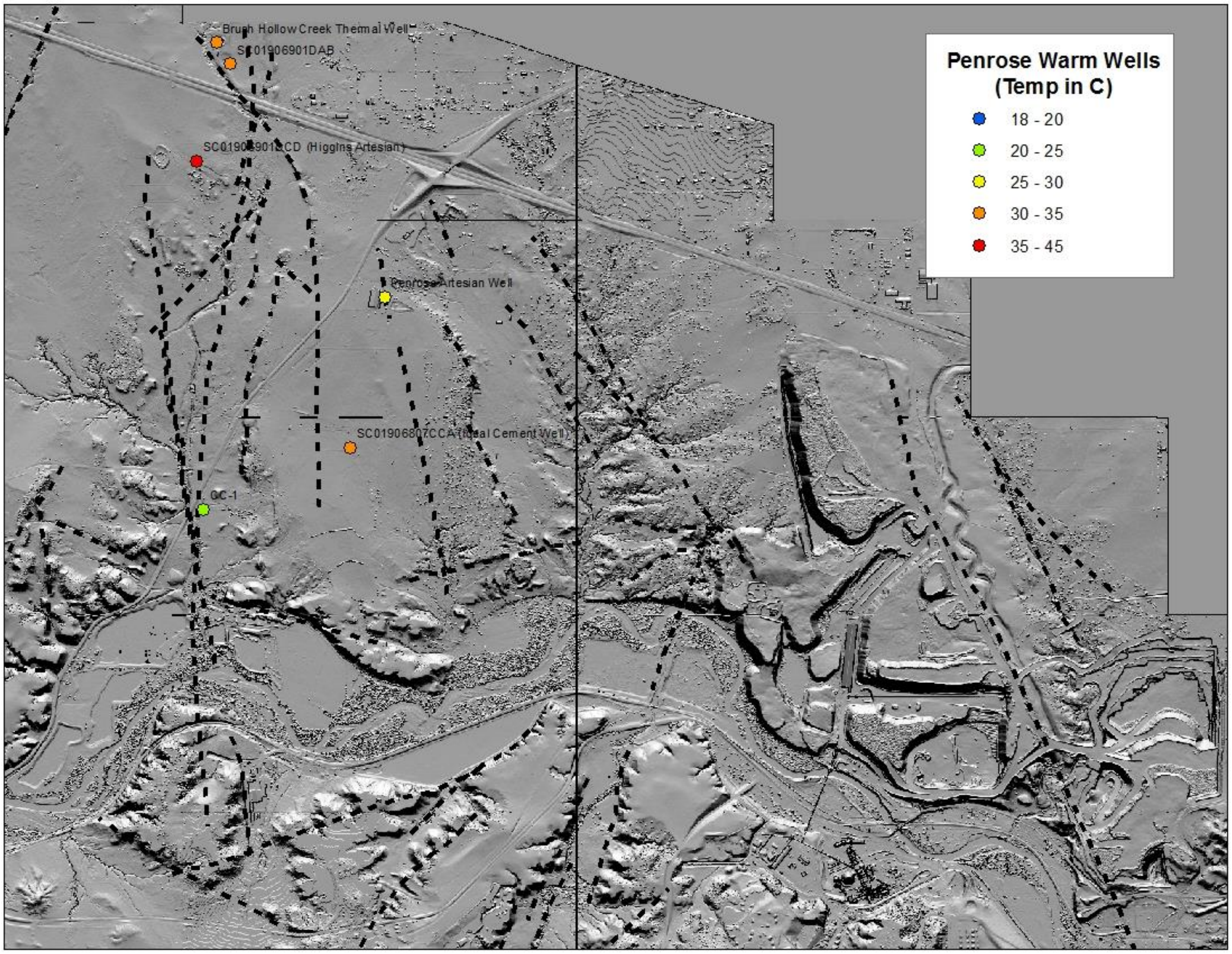


Figure 17. Hillshade map of the Penrose geothermal area from the Holcim LIDAR data. Thermal wells are shown as colored dots corresponding to measured temperature. Lineaments derived from this and other hillshades are shown as dotted lines. The pit and dumps of the Holcim cement operation are visible at middle right.

Since the thermal waters of the Penrose geothermal system do not seem to be related to any formational aquifer, it seems more likely that geothermal fluid flow is occurring along the normal faults that constitute the BHA. Given the gravity evidence that suggests basement involvement with this normal faulting, it is likely that geothermal fluids are traveling directly from Precambrian crystalline rocks towards the surface, traveling (and perhaps interacting chemically) through the thick Paleozoic and Mesozoic section.

CONCLUSIONS

From our studies it looks like there are two primary geothermal targets in the CCE. The first is the deeper +70^{o}C temperatures in portions of the Florence oil and gas field (e.g. 32-29 Patti well). Because of the depth to these temperatures, shallow temperature techniques and even 1000’ temperature gradient drilling would not be effective in follow-up work. Flint is having discussions with the well and lease owners to determine if there is an efficient way of testing this potential resource. The second and more reachable target is the Penrose geothermal area.

The Penrose geothermal area appears to be a structural target where the thermal fluids are rising up late Tertiary to Recent normal faults associated with the Brush Hollow Anticline (or Horst). Most if not all of the data sets we've amassed support a model of geothermal flow up a normal fault or fracture zone related to the BHA.

There are not enough surface exposures to measure structural fabrics sufficiently to delineate which structural orientation affords the highest dilatency. The geochemistry and geothermometry of the thermal waters do not suggest a high-temperature system at depth; however, there is evidence of contamination and/or dilution by surface waters that could explain the low geothermometer estimates. This contamination would presumably occur when high Mg surface water encountered the fractured conduit and mixed with the thermal waters.

All previous drilling greater in the area was conducted for purposes other than geothermal exploration; they can be envisioned as random pierce-points in this context. Because an MT survey is thought not to be effective in this geologic environment, perhaps the only effective next step would be temperature gradient drilling.

Figure 18 shows the location of a set of proposed sites for a shallow (800 foot deep) temperature gradient drill program in the Penrose geothermal area. The exact hole locations attempt to maximize the following geologic and logistical variables:

1. Stepping out an appropriate distance to known thermal wells, particularly the two with the highest temperatures and/or temperature gradients.
2. Proximity to down-dip direction to LIDAR structures/lineaments, including those oriented NNW and ENE.
3. Location on land controlled by owners amenable to geothermal development.
4. Location away from environmentally sensitive areas.

In a favorable drilling outcome, temperatures much higher than those previously measured would be encountered. Careful geochemical sampling of thermal fluids would help establish evidence for higher reservoir temperatures (through geothermometry) than previous samples. A second round of TG drilling would target the warmest area and could be designed to intersect a specific structure near TD. This program, possibly augmented by a close-spaced gravity survey, would then provide the information necessary to make the "Go or No-Go" decision prior to deeper drilling.

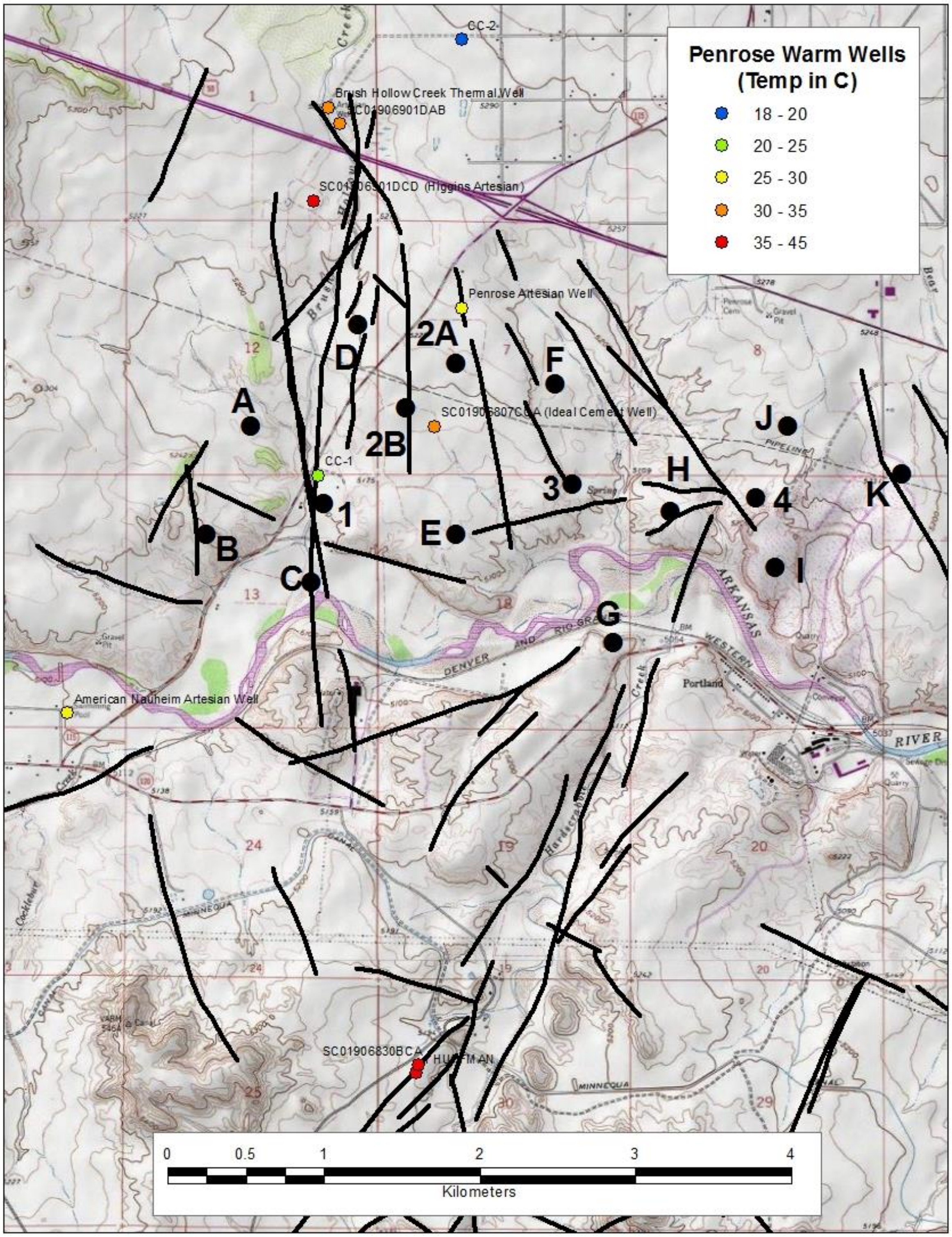


Figure 18. Proposed drill targets in the Penrose geothermal area. Thermal wells are shown as colored dots corresponding to measured temperature. LIDAR lineaments and mapped faults are shown as solid black lines. First round temperature gradient drill sites are designated by numbers; possible second round drill sites are shown as letters.

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