REGIONAL ASSESSMENT OF EXPLORATION POTENTIAL FOR GEOTHERMAL SYSTEMS IN THE GREAT BASIN USING A GEOGRAPHIC INFORMATION SYSTEM (GIS) – Part II

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ABSTRACT

A geothermal GIS covering the state of Nevada was developed last year using DOE funding at the Great Basin Center for Geothermal Energy (GBCGE). The currently proposed research will expand that GIS to cover the entire Great Basin. The objectives are fourfold: 1) integrate and evaluate new geothermal data developed by the GBCGE and other sources, 2) regionally assess the potential for geothermal energy throughout the Great Basin, 3) evaluate and quantify regional relationships between geothermal activity and geological, geochemical, and geophysical features, and 4) make digital geothermal data of the Great Basin accessible to industry, researchers, and the public.

By including the entire Great Basin, it will be possible to evaluate both magmatic and extensional-type geothermal systems and identify the most prospective areas for future exploration of each. The research will include a regional assessment of southern Idaho, where potential for both magmatic and extensional high-temperature systems exists but where laterally-flowing groundwaters may prevent the formation of hot springs that would otherwise reveal their locations.

Geothermal-related data will be integrated into a GIS using ArcView® and related software, and evaluated quantitatively using weights-of-evidence, logistic regression, and other statistical measures. In conjunction with a companion research project "Geopowering the West", GIS data will be posted on the web site of the GBCGE for public access. The data will be presented in a format allowing for selective extraction, overlaying, and viewing of data using ArcExplorer® or similar "freeware" and data will be available for downloading in ArcView and other database formats.

DESCRIPTION OF PROJECT

Introduction

Last year the geothermal GIS project was the first research started at the Great Basin Center for Geothermal Energy (GBCGE), since it began before new funding was received in 2002. The primary goal was to use the GIS to clarify relationships between geothermal systems and geological, geochemical, and geophysical features, and subsidiary goals were to visualize and analyzing the data to find gaps in information and identify potential new research projects. After one year of DOE-supported work, the project has performed better than anticipated. Two new research projects have been spawned as a result of the GIS analysis, one involving the use of global positioning system (GPS) crustal strain measurements as a tool for geothermal exploration (Blewitt et. al, 2002), and the other using trace elements in geothermal fluids to distinguish types of geothermal systems in the Great Basin (Arehart et. al, 2002). The analysis is also beginning to identify areas warranting more detailed geothermal exploration interest, including the Buffalo Valley and Fairview Peak/Gabbs Valley areas of Nevada and the China Hat dome in southeastern Idaho. More details on the accomplishments of last years' program are described below in the section titled "Previous Years' Results".

Background

The Geothermal GIS was initially described (in the first proposal submitted to the GBCGE last year) as a three-year, three stage project. The first year would focus on the state of Nevada, the second year

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would expand the GIS to cover the Great Basin, and the third year would focus on posting GIS data on the web. In reality, pursuing all three "stages" simultaneously provides more timely information to the geothermal industry, and consequently last year significant progress was been made on all three fronts. Some digital coverage of the entire Great Basin has already been added to the database, including the locations of geothermal systems and hot springs, volcanic age dates, and regional heat flow. Much initial preparation has gone into web site development (see section below titled "Previous Years' Results").

Project Rationale

Towards the goal of increasing geothermal utilization, a GIS of geothermal systems of the Great Basin serves several purposes:

1) it makes diverse types of data on geothermal systems readily available digitally to industry to facilitate their exploration and development efforts,
2) it allows integration of new research data into the GIS so that relationships with other variables can be assessed,
3) it facilitates statistical exploration of relationships among the data to help identify new cause and effect relationships and identify potential new exploration tools,
4) it allows regional assessments to be made of undiscovered geothermal resources, which in turn can be used to help focus exploration efforts.

Two types of high-temperature geothermal systems are recognized in the Great Basin: the "magmatic-type" which occur on the margins of the Great Basin (e.g., Long Valley caldera), and the "extensional-type", which are "amagmatic" and occur within the interior of the Great Basin (e.g., Dixie Valley; Koenig and McNitt, 1983; Wisian, et. al., 1999). The location of known "magmatic" type geothermal systems are currently confined to the margins of the Basin and are associated with young silicic volcanics. In contrast the extensional type systems occur over large areas both inside and marginal to the Great Basin.

Many disparate types of evidence can be used to help signal the location of a geothermal system. These include the location and orientation of Quaternary faults, regional heat-flux anomalies, anomalous groundwater chemistry, earthquakes, young volcanism, and hydrothermal alteration. A GIS can be used to draw these diverse types of information together and assess which types of evidence correlate best with geothermal activity on a regional basis. Ultimately, this evidence can be integrated to identify regions of greater exploration potential, based not only on where geologic conditions are favorable, but also on a determination of which areas have not been fully explored.

By expanding GIS coverage over the entire Great Basin, it becomes possible to quantitatively explore factors responsible for the formation of magmatic-type and extensional-type geothermal systems. This is not just an academic question: because magmatic-type systems are much more likely to support a power plant than extensional systems, and because the power output of magmatic-heated systems tends to be greater than that of extensional systems. Less than three percent of geothermal systems in the Great Basin are believed to have magmatic heat sources, but they account for 2/3rds of the geothermal power produced. Although magmatic-type systems in the Great Basin are closely associated with young silicic volcanism, there are a number of places where the distribution of young silicic volcanic rocks does not provide clear answers and more information is needed to assess geothermal potential. Those places include the Cascade Range, the area between Bodie and Mammoth, California, and a broad area in southeastern Idaho.

The region in southeastern Idaho is particularly interesting, because geothermometer temperatures and the occurrence of young rhyolite domes suggest good potential for high-temperature systems of both the magmatic and extensional types. Nevertheless, no geothermal power plants exist in southeastern Idaho; there has been speculation that laterally-flowing groundwaters in young basalts may be concealing underlying geothermal activity in some places. The GIS can be used to develop a broader repertoire of favorable characteristics associated with magmatic-type geothermal systems, so that the potential for magmatic-type geothermal systems in southeastern Idaho can be compared more directly with counterpart regions on the western margin of the Great Basin. Ultimately, maps of geothermal favorability for southeastern Idaho (and the rest of the Great Basin) will be generated to help focus exploration efforts.

Proposed Research and Methods

Four primary objectives, restated here, will guide the research: 1) integrate and evaluate new geothermal data developed by the GBCGE and other sources, 2) regionally assess the potential for both magmatic and extensional-type geothermal systems throughout the Great Basin, 3) evaluate and quantify regional relationships between geothermal activity and geological, geochemical, and geophysical features, and 4) make digital geothermal data of the Great Basin accessible to geothermal developers, researchers, and the public.

In pursuing these objectives, specific target goals have been identified. They include:

1) Incorporation of up-to-date digital geologic maps for each state covered by the Great Basin. An emphasis will be placed on documenting the distribution and composition of Quaternary volcanic rocks.
2) Incorporation of regional crustal thickness maps and seismic velocity models developed by Louie (2002). The ability of crustal thickness and seismic velocity maps to predict geothermal potential will be explored both visually and statistically.
3) Incorporation of a new Great Basin-wide database on Quaternary faults and their slip rates. This database is in the process of being published (Craig DePolo, personal communication) and hopefully will be available by the end of 2003. Relationships between slip rates, earthquake distributions, GPS-derived inter-seismic strain rates, and geothermal systems will be analyzed. This work would be completed in the second year of the proposal.
4) Development of a Great Basin-wide map of depth to groundwater. Last years' GIS research documented an inverse relationship between depth to groundwater and the occurrence of *known* geothermal systems (Coolbaugh et. al, 2002). Known high-temperature geothermal systems are more likely to occur where water tables are shallow, suggesting that deep groundwater tables may make it difficult for hot springs to form at the surface, and that hidden geothermal systems may occur where groundwater tables are deep. Last year a water table depth map was produced for the state of Nevada, and this year it is proposed to expand the groundwater modeling to include the entire Great Basin. Tim Minor of the Desert Research Institute will manage this work by way of a sub-contract (see below).
5) Incorporation of new geothermal fluid geochemical data into the GIS. An agreement has been reached with the Geo-Heat Center of Klamath Falls, OR. to share regional geochemical data and make it available on the web. This will allow geothermal fluid geochemical data from all states of the Great Basin to be readily accessed in a single file, together with geothemometer-based estimates of subsurface reservoir temperatures. In addition, new major, minor, and trace element data on geothermal systems are being generated by Arehart et. al. (2002) and Shevenell et. al. (2002). This data is directly relevant to predicting the location of magmatic vs. extensional-type geothermal systems and will be added to the database. Finally, many major, minor, and trace element distributions in the NWIS (National Water Information System) database have not been fully incorporated into the GIS. This work needs to be done, and relationships of these elements with geothermal activity investigated. This is a second year project.
6) Acceleration of web site development. Although progress has been made in laying the foundations for an interactive web site (see section below titled "Previous Years' Results"), more work needs to be done. Consequently, 50% of the manpower in the current proposal will be dedicated to posting geothermal data on the GBCGE web site, and the efforts of Don Sawatzky and Gary Oppliger in this proposal are fully committed towards that work. Additional support for construction of the overall GBCGE web site is provided under the parent DOE research proposal. Ultimately the geothermal data will be presented in a format allowing for selective extraction, overlaying, and viewing of data using ArcExplorer® or similar "freeware" and data will be available for downloading in ArcView and other database formats.

Geothermal data in the GIS will be analyzed using spatial statistical methods including weights-of-evidence and logistic regression. Relationships among the data will be explored and predictive maps of geothermal potential or favorability will be generated, to help identify areas most likely to host undiscovered geothermal systems. Besides helping to focus exploration efforts for finding geothermal systems, the investigative process will yield clues as to how and why geothermal systems occur where they do.

DRI Subcontract – Groundwater Table Modeling

The Desert Research Institute (DRI) will develop a database of ground-water levels (depth to water table) that can be used to augment the geothermal database and GIS modeling efforts described in the overall project description. Specifically, DRI will extend the database of ground-water levels it developed for the state of Nevada to cover the entire Great Basin. The task descriptions for the water table/aquifer database development subcontract are as follows:

1.) DRI shall integrate NWIS and well driller's data provided by Mark Coolbaugh for areas of the Great Basin outside of Nevada. These areas shall include those portions of California, Oregon, Idaho, Utah and Arizona found in the Great Basin.
2.) DRI shall integrate selected lake boundaries (lakes to be selected by DRI and Mark Coolbaugh) with the water level data using ArcView GIS software. The lake data shall be obtained from either DRI's spatial data archive or from Mark Coolbaugh's GIS database.
3.) Geology data sets for the states listed above will be required to develop masks of non-alluvial areas in volcanic aquifers. These data will be provided by either Mark Coolbaugh, obtained from the UNR USGS office, or acquired from entities within the respective states.
4.) DRI, together with Mark Coolbaugh, will select individual or aggregated basins from the Great Basin water level data set to generate a water level interpolated surface for these basins. An appropriate interpolation algorithm for surface generation will be chosen and applied to the selected subbasins in the Great Basins.

DRI will integrate the resultant raster model of water levels for the above-described states with the completed water level model of the state of Nevada. An appropriate method for combining these raster grids will be developed by DRI. The combined data models will be mosaicked as an Arc/Info grid.

DRI Deliverables:

The resultant depth to water table gridded data set shall be delivered to Mark Coolbaugh in Arc/Info grid format, for integration into the geothermal database. This deliverable shall be provided to Mark Coolbaugh no later than January 1, 2004 (assuming a start date of July 1st, 2003) or six months from the initiation of this subcontract.

Available Resources

Personnel and resources of the Great Basin Center for Geothermal Energy, the University of Nevada, Reno (UNR), the Nevada Bureau of Mines and Geology (NBMG), the United States Geological Survey (USGS), and the Desert Research Institute (DRI) will participate in the study. (The budget summarizes the role of each individual researcher.) As the scope of the project is expanded to include the entire Great Basin, assistance from other state and federal organizations will be sought. Other regional databases, including those of the Geo-Heat Center in Klamath Falls, Oregon and Southern Methodist University, will be employed.

DELIVERABLES

Deliverables will include:

1) Predictive maps of geothermal potential for the entire Great Basin. These maps will separately model the favorability for magmatic-type and extensional-type geothermal resources, and will be available for downloading at the GBCGE web site.

2) A map of the depth to the groundwater table for the entire Great Basin shall be provided in Arc/Info grid format and other formats for integration into the geothermal database (see above).

3) As much of the geothermal GIS database as is possible will be posted on the web site of the GBCGE. Some data will be proprietary and can't be posted (data generated by other research organizations or industry), and for some data, links will direct the public to other web sites, such as, for example, the Southern Methodist University site for heat flow data. However, the majority of the data can be uploaded. Where possible, agreements will be made with sister research organizations to allow sharing and posting of geothermal data. One such agreement was recently made with the Geo-Heat Center.

4) Papers discussing results of the geothermal GIS research will be submitted to the Geothermal Resources Council (GRC) for publication in their annual proceedings in 2003 and 2004. Other talks and papers may be presented as appropriate.

5) A final report describing the significant results of the geothermal GIS research will be submitted for publication at the end of each research year and posted on the web.

6) All required quarterly and annual reports would be submitted to the GBCGE and/or Department of Energy.

PREVIOUS YEAR'S RESULTS

Project Objectives: The overall objective of last years' research was to develop a geographic information system (GIS) of geothermal systems. The first year of research focused on developing a database for the state of Nevada. Included in this GIS are co-registered geological, geochemical, hydrological and geophysical maps useful in defining geothermal potential. These databases are being assembled in collaboration with other PIs working on Center projects. The objectives of the research are to: 1) better define regional relationships between geothermal activity and geologic, geochemical, and geophysical features, 2) produce regional maps of geothermal energy potential, and 3) post the database and maps on the web to make it available to other researchers and the public.

Project Metrics: The following data acquisitions and analyses have been made:

- The locations, temperatures, and chemistries of geothermal systems in the Great Basin have been added (sources include the NBMG, the Geo-Heat center, and state maps of geothermal potential).
- Using geochemistry data, geothermometer-based estimates of reservoir temperatures have been made.
- An updated and improved model of depth to the water table in Nevada has been created by the DRI.
- Regional maps of crustal inter-seismic strain rate for Nevada, provided by the Blewitt et. al. research project, have been integrated into the model for the state of Nevada.
- A Great Basin database of geologic age dates compiled by the USGS has been added.
- Maps of Quaternary volcanic activity have been added for the states of Nevada and Utah.
- A digital catalog of earthquake activity for the state of Nevada has been incorporated, and a moment release map based on seismic activity has been provided by the John Louie research project.
- Digital maps of heat flux and temperature gradients covering the entire Great Basin have been provided by Southern Methodist University.
- Quaternary faults from Nevada and Utah have been added to the database.
- Digital geologic maps at various scales covering the Great Basin have been included.
- Mineralization and alteration maps of most of the Great Basin, interpreted from Landsat satellite imagery, have been provided by the USGS and statistical relationships with geothermal systems computed.
- Regional gravity and magnetic geophysics have been added to the database.

- ♦ Water geochemistry data from the USGS National Water Information System have been synthesized and added to the database.
- ♦ Digital maps of crustal seismic wave velocity and crustal thickness derived from deep seismic analysis (John Louie research study) have been added to the database.
- ♦ Spatial analyses have been conducted on the above data using weights-of-evidence, logistic regression, and fuzzy logic methods.
- ♦ Preliminary predictive maps of geothermal potential have been generated for the state of Nevada.

Research Benefits: Major accomplishments during the year are listed below.

1) Prediction of Geothermal Favorability in "Concealed" Terrains: Some geothermal systems in the Great Basin may remain undiscovered because they don't have surface expressions such as hot springs or fumaroles to attract attention. Statistical analysis conducted as a part of this study helped demonstrate that the current inventory of geothermal systems is biased towards areas where groundwater levels are shallow and where deep aquifers are not present. Maps of regional geothermal potential were created that are independent of groundwater phenomena by using geologic and geophysical evidence unaffected by water table depth or aquifers. These maps can be used to assess geothermal potential in areas where groundwater tables and aquifers are deep, such as the deep carbonate aquifer in south-central Nevada.

2) Quantification of Link between Geothermal Activity, Quaternary Faulting, and Rates of Crustal Extension: With the help of a companion DOE research project (the Blewitt GPS-Strain study), spatial analysis was used to demonstrate that young faults with high rates of extension are more likely to host geothermal resources than faults with low rates of extension. Because crustal extension in much of Nevada is currently oriented northwesterly, northeast-striking faults will tend to have higher rates of normal extension than northwest-striking faults. This explains why northeast-striking faults in Nevada correlate more strongly with high-temperature geothermal resources (≥160°C) than northwest-striking young faults. Strain rate maps derived from GPS station measurements provide valuable information to help define regional geothermal potential.

3) Correlations between geothermal activity and Quaternary silicic and mafic volcanism: A very strong correlation between magmatic-type geothermal systems and Quaternary silicic volcanism was demonstrated statistically. The only Quaternary silicic volcanic centers without known high-temperature geothermal resources in the Great Basin occur in south-central and southeastern Idaho, where laterally flowing groundwaters in young basalt flows could be concealing underlying geothermal activity. This suggests that southern Idaho has a strong potential for hosting high-temperature geothermal systems hidden beneath volcanic-hosted groundwater aquifers.

Extensional-type geothermal systems in Nevada were found to correlate with vents of Quaternary basalt, even though extensional-type systems are not believed to have magmatic heat sources. The basalts may be indicative of high rates of crustal extension. High rates of extension could permit circulating meteoric fluids to penetrate to greater depths in the crust, and be heated to relatively high temperatures.

4) Web Database Development Progress**:** Three PowerPoint presentations with 94 color slides have been posted on the web site of the Great Basin Center for Geothermal Energy. These slides document the development of the geothermal GIS and the results obtained. In conjunction with a sister web-development project led by Don Sawatzky, considerable progress has been made in developing a sophisticated interactive search engine to allow web users to access, sort through, evaluate, and download data of interest. Software compatibility issues have delayed full implementation, but in the meantime the GIS databases and maps are being prepared for uploading. It is anticipated that by the end of September 2003 (the extension of time granted for completing all 1st-year research) a significant portion of the geothermal GIS will be on-line and available to the public.

Reports & Articles Published During the First Year of Research:

Coolbaugh, M., and R. Bedell, 2003, A Simplification of weights of evidence using a density function and fuzzy distributions: a comparison of probability modeling techniques in the designation of geothermal systems in Nevada; Geol. Assoc. Canada Special Volume "GIS applications in the Earth Sciences.", *in press*.

Coolbaugh, M., J. Taranik, G. Raines, L. Shevenell, D. Sawatzky T. Minor, and R. Bedell. 2002. A Geothermal GIS for Nevada: Defining Regional Controls and Favorable Exploration Terrains for Extensional Geothermal Systems. Transactions Geothermal Resources Council 26: 485-490. (Won GRC session best paper award)

Coolbaugh, M., 2003, Regional Geologic Controls, Geochemical Characteristics, and Thermal Infrared Signatures of Geothermal Systems of the Great Basin: GSN Newsletter (Geological Society of Nevada), v. 17, n. 1, p. 3.

Presentations Made in During First Year of Research:

Coolbaugh, M., at the *Geothermal Opportunities in Nevada*, January 11, 2002, meeting; titled "Regional Controls on the Distribution of Geothermal Systems in Nevada": a Powerpoint file with added text is posted http://www.unr.edu/geothermal/meetingsandpresentations/geooppsnv1_11_02.html

Coolbaugh, M., at the *Annual Geothermal Resources Council Meeting*, Reno, NV, September 23-25, 2002; titled "A Geothermal GIS for Nevada: Defining Regional Controls and Favorable Exploration Terrains for Extensional Geothermal Systems": a Powerpoint file with added explanatory text is posted at the web site http://www.unr.edu/geothermal/meetingsandpresentations/meetings_grc.html

Coolbaugh, M., at the *January meeting of the Geological Society of Nevada*, in Reno, NV, January 17, 2003; titled "Regional Geologic Controls, Geochemical Characteristics, and Thermal Infrared Signatures of Geothermal Systems of the Great Basin". An abstract has been published in the January 2003 newsletter of the Geological Society of Nevada (see above).

Coolbaugh, M., at the *2003 Nevada Geographic Information System Conference* in Reno, NV., April 30, 2003; titled: "Defining Regional Controls on the Distribution of Geothermal Systems in Nevada using a GIS with Spatial Analysis, including Weights-of-Evidence".

Coolbaugh, M., (talk and poster will be given) at the *Vancouver 2003 Geological Association of Canada-Mineralogical Association of Canada-Society of Economic Geologists Meeting* in Vancouver, Canada May 28, 2003; titled "A Simplification of weights of evidence using a density function and fuzzy distributions: a comparison of probability modeling techniques in the designation of geothermal systems in Nevada; Geol. Assoc. Canada Special Volume "GIS applications in the Earth Sciences."

LIST OF REFERENCES

Arehart, G.B., Coolbaugh, M.F., and Poulson, S.R., 2002, Geochemical characterization of geothermal systems in the Great Basin: implications for exploration, exploitation, and environmental issues: Proceedings, Annual Meeting, Reno, NV., Sept. 22-25, 2002, Geothermal Resources Council Transactions, v. 26, p. 479-481.

Blewitt, G., Coolbaugh, M.F., Holt, W., Kreemer, C., Davis, J.L., and Bennett, R.A., 2002, Targeting of potential geothermal resources in the Great Basin from regional relationships between geodetic strain and geological structures: Proceedings, Annual Meeting, Reno, NV., Sept. 22-25, 2002, Geothermal Resources Council Transactions, v. 26, p. 523-525.

Coolbaugh, M.F., Taranik, J.V., Raines, G.L., Shevenell, L.A., Sawatzky, D.L., Minor, T.B., and Bedell, R., 2002, A geothermal GIS for Nevada: defining regional controls and favorable exploration terrains for extensional geothermal systems; Proceedings, Annual Meeting, Reno, NV., Sept. 22-25, 2002, Geothermal Resources Council Transactions, v. 26, p. 485-490.

Koenig, J.B. and McNitt, J.R., 1983, Controls on the location and intensity of magmatic and non-magmatic geothermal systems in the Basin and Range province: Geothermal Resources Council Special Report No. 13, May 1983, p. 93.

Louie, J., 2002, Assembly of a crustal seismic velocity database for the western Great Basin: Proceedings, Annual Meeting, Reno, NV., Sept. 22-25, 2002, Geothermal Resources Council Transactions, v. 26, p. 495-499.

Shevenell, L., Garside, L., Arehart, G., van Soest, M., and Kennedy, B. M., 2002, Geochemical sampling of thermal and non-thermal waters in Nevada to evaluate the potential for resource utilization: Proceedings, Annual Meeting, Reno, NV., Sept. 22-25, 2002, Geothermal Resources Council Transactions, v. 26, p. 501-505.

Wisian, K.W., Blackwell, D.D., and Richards, M., 1999, Heat flow in the western United States and extensional geothermal systems: Proceedings, 24th Workshop on Geothermal Reservoir Engineering, Stanford, CA., p. 219-226.

MILESTONES

Submission of paper for annual GRC meeting 2003:	May 7, 2003
Posting of Geo-Heat Center geochemical data on web:	July 31, 2003
Presentation of preliminary results, GRC annual meeting:	Oct. 15, 2003
Creation of preliminary predictive maps of geothermal potential for Great Basin:	Oct. 15, 2003
Completion of Great Basin map of depth to water table:	Jan. 1, 2004
Posting of geothermal GIS data on web:	ongoing
Updating GIS with new GIS data:	ongoing
Submission of paper for annual GRC meeting 2004:	May 7, 2004
Completion of final reports discussing 1st year research results:	Sept. 30, 2004
Creation of 2nd year predictive maps of geothermal potential for Great Basin:	Oct. 15, 2004
Completion of Quaternary fault slip rates, integration with seismic	Dec. 31, 2004
Completion of NWIS major, minor, and trace element analysis	July 31, 2005
Completion of final report discussing 2nd year research results	Sept. 30, 2005

BUDGET EXPLANATION AND JUSTIFICATION

Salaries: M. Coolbaugh will provide overall project management, coordinate with other researchers and organizations, and will generate statistical analyses and maps of geothermal resource potential. Half of Mark Coolbaugh's time will be devoted towards preparing data and maps for posting on the web. Lisa Shevenell will provide interpretive guidance with geochemical geothermometers and other geochemical issues. Gary Raines of the USGS will provide an advisory role in GIS spatial statistics and will help provide digital geologic maps of the Great Basin. Gary Oppliger and Don Sawatzky will provide expertise in the construction of web-based databases and posting of data. A graduate student in the second year will study either the NWIS database or the integration of Quaternary fault slip rates with seismic activity and strain rates. This could provide the subject of a M.Sc. thesis.
Field Work: Vehicle mileage and per diem will cover the costs of checking one or more anomalies generated by the predictive maps of geothermal potential. Total costs are low in this category because the PI is involved with other field research projects that permit more regular field access.
Meeting Registrations/Travel: These funds will help defray the costs of presenting results of the geothermal GIS research at two meetings in addition to the annual GRC meetings, which are covered by the main GBCGE budget.
Publications: These funds will help defray printing costs, such as for color figures.
Subcontracts, Desert Research Institute: A detailed breakdown of DRI subcontract costs is provided in a second worksheet in the Excel budget file. A description of the work to be completed is provided in the previous section titled "DRI Subcontract – Groundwater Table Modeling".