EMD Geothermal Energy Committee Mid-Year 2012 Report

Richard J. Erdlac, Jr., Ph.D., P.G., Chair

Vice-Chairs:

- David Blackwell, Ph.D., (Vice-Chair: University), Southern Methodist University, TX
- Richard J. Erdlac, Jr., Ph.D., P.G., (Acting Vice-Chair: Industry), Calnetix, Inc.
- Tom Anderson, P.G., (Vice-Chair: Government)
- TBA, (Vice-Chair: Representative of DEG)
- TBA, (Vice-Chair: Representative of DPA)

Advisory Committee:

- Paul Morgan, Ph.D., Colorado Geological Survey, Golden, CO
- Michael D. Campbell, P.G., P.H., I2M Associates, LLC, Houston, TX
- Steven Tischer, P.G. Arcadis, Midland, TX
- Cenk Yardimcilar, Ankara, Turkey

Special Consultant:

- Joel Renner, Inver Grove Heights, MN

Committee Activities

2012 AAPG Annual Meeting - Long Beach

The April 22-25, 2012 AAPG Annual Convention and Exhibition held two themes that included presentations involving geothermal energy production. Theme 7: Geothermal Energy (EMD) was the oral presentation held Tuesday afternoon, with attendance reaching a maximum of around 70 people. Eight oral papers were presented during this session. The first three presentations were more generalized and discussed the challenges for geothermal from sedimentary basins, estimates on the energy resource within sedimentary basins, and how hydrofracked reservoirs can be converted to thermal energy production.

After the break discussions were focused in specific geographic areas, starting with Saudi Arabia. This paper presented the need for electrical power in the country and projected that without other forms of electrical power generation, greater amounts of produced oil would be needed for internal electrical production. This was followed with updated information about

ongoing geothermal production at RMOTC. The final three papers focused on geothermal production from a gas well in Louisiana, the geopressured resource across the Texas and Louisiana Gulf Coast, and finally geothermal energy from mature gas reservoirs in the Frio and Vicksburg Formation of South Texas.

Poster presentations on geothermal energy were given Tuesday morning in Theme 7: Alternative Energy: Gas Hydrates and Geothermal (EMD). A total of 16 poster presentations were available for viewing, with 11 of the posters focused on geothermal energy. These posters had topics covering drilling and production techniques for EGS reservoirs, the national geothermal data base and geothermal resource estimates involving sedimentary basins, determination of formation temperature, and low-grade geothermal power in association with shale gas. Also presented were seismic survey work in igneous and metamorphic environments for geothermal and mineral resources, and a presentation involving geothermics of Phanerozoic strata of Saskatchewan.

U.S. Geothermal Data Base

For the last couple of years an effort has been underway to create a publically available data base containing geothermal information. This effort encompasses all 50 states with, with the DOE being one of the providers of funding for this effort. Geological surveys, NREL, universities, and several companies are involved with this project. The data includes a variety of information such as well name, location, depth, BHT, and other pertinent site information. Also, various maps such as gravity and magnetic maps are available.

The oldest and presumably the first national geothermal data base was codeveloped in the 1970's by the USGS, the AAPG, several universities, and a number of oil and gas companies who were a primary source of data. This data base covered all of North America, with data from the U.S., Canada, and Mexico along the Gulf Coast. Some 18,467 wells came from the lower 48 states, with Canada providing around 4,888 and Mexico providing 464. Of this number, Texas wells number 3,776 within this data base, which was and presumably is still available for purchase through the AAPG. The available wells with temperature data in Texas alone and at the present time is numbered at 12,715, nearly four times the number originally available through the USGS study of the 1970's. Data exists or is being made available by other states as well.

Two websites are available for entry and data recovery. The first website is through the NGDS, or the National Geothermal Data System (http://geothermaldata.org/). Although numerous participants are involved, this site appears to be managed through Boise State University. Interconnected to this site is the USGIN or the United States Geoscience Information Network and the AASG (Association of American State Geologists). The website for this group is at http://catalog.usgin.org/geoportal/catalog/main/home.page . Both websites appear to access the same data though in slightly different ways. For example, the second website requires you to login as a user. Internal online maps are apparently available for usage through the websites though well data with location information is available to download in Excel spreadsheet form. The data can then be displayed in other interpretation packages such as Petra, Geographix, or Surfer to name just three geoscience oriented software packages. Both websites are still being updated as new data is provided.

TGS and Geothermal

In October, Pete Dotsey from TGS gave a presentation at the West Texas Geological Society in Midland. His topic was entitled "MaxG Basin Temperature Modelling" and used BHT data collected from log headers from the well data available at TGS for the oil and gas industry. The geothermal temperature studies were undertaken not only for interest in geothermal as a potential future energy resource, but also because a good understanding of subsurface temperature involving its distribution and history is important for understanding rates of chemical reactions in rocks, such as kerogen transformation in source rocks, cementation in reservoirs, and permeability development, along with many borehole management procedures. The first basin that was studied in this manner was the Delaware Basin of West Texas, with discussion on their approach to analyzing BHT data for temperature modeling.

SEDHEAT Group Activities

An announcement was sent out in October by John Holbrook from TCU to many of the interested parties involved with geothermal energy, especially as related to geothermal from sedimentary basins. The full announcement is reproduced below for archival purposes.

We would like suggestions for the first workshop of the SEDHEAT RCN

A key element of the SEDHEAT effort is to host workshops where we have an opportunity to put our heads together and focus on a particular research issue related to sediment-sourced geothermal energy. It is time to get the first effort moving. I'm sure each of you are brimming with ideas and have many burning questions you would like the group to tackle. Please give us your suggestions. From these suggestions, the steering committee will choose a topic for the first workshop. The workshops will be in the spirit of a Penrose, Chapman, SPE Forum, etc. type gathering. Topics should address some fundamental science and engineering question related to the SEDHEAT area. We have a particular strength in this community in that science and engineering researchers are both so well represented. This gives us a great opportunity to address questions at the intersection of these disciplines that we should certainly use to our full advantage. Use your imagination. The purpose of these workshops is to share information and generate ideas for how best to tackle some particular research problem. This evolves of course into individual proposals and projects from each of you which ultimately make advances happen. So what do you think is the question we should tackle first?

We will be taking your suggestions over the month of November, and then the Steering Committee will get to the business of picking a priority and turning it into a workshop plan. We have funds to supplement the cost of the workshops through the RCN grant. To help out on choosing topics, I've attached the executive summary of the first workshop report with the research priorities we set last fall in the italic text.

<u>A brief report from the Steering Committee:</u>
The Steering Committee of the SEDHEAT group held its first meeting this past Tuesday at TCU, where we talked goals and logistics for moving the ball on geothermal research in sedimentary basins. In attendance were (Walter Snyder, Derek Elsworth, Herbert Einstein, Karen Block, Dave Black, Joe Moore, and myself). Harriet Burrow, our new web manger, also attended and provided valuable input. We

discussed the logistic of implementation of the various parts of the proposal as initially stated. We agreed that the first priority was to initiate the first workshop, and that these workshops should have a format much like a research conference. The above call for topics reflects this effort. We also began logistics for the first student short courses. Dave Blackwell and Joe Moore are working on this effort. Walt Snyder is currently working on several efforts related to best options in cyberinfrastructure. Derek Elsworth and Herbert Einstein are examining options for sponsorship of sessions and other interaction within the engineering community, and Karen Block suggested several good ideas regarding student involvement that we are currently exploring. We spent much of the afternoon discussing the web plan. Harriett Burrow is a new hire at TCU who as part of her efforts at the TCU Energy Institute will be building and managing the SEDHEAT web page. We discussed several ideas for the web page, including automatic updates, information pages for the RCN members, web interaction formats, and portals to other geothermal information sites. These are in the development plans, and we hope to have the new website up and running by the beginning of next semester. In the interim, we are in the process of transferring the existing URL to TCU, after which we will do some updates on the existing site within the existing format. We also talked extensively regarding outreach plans. We intend to make efforts to interface with NSF and Congress in DC in near-future and recurring visits to communicate and forward RCN efforts, and discussed best efforts to toward this goal.

TRACKING AN ENERGY ELEPHANT: SCIENCE AND ENGINEERING CHALLENGES FOR UNLOCKING THE GEOTHERMAL POTENTIAL OF SEDIMENTARY BASINS

Executive Summary

On November 6-9, 2011, a group of 71 scientists, engineers, educators, practitioners and planners gathered in Salt Lake City, Utah through an NSF-SEES Workshop to address one central question.

"What are the basic science and engineering questions that need to be addressed in order to make geothermal energy production from sedimentary basins practical?"

The consensus of the group was that large stores of heat energy are available from sedimentary basins, but advances in basic science and engineering are needed in order to economically extract this heat for large-scale electrical generation.

For geothermal resources to be viable, water of sufficient volume and temperature are required along with reservoir rocks with similarly sufficient porosity and permeability to store and allow the movement of water through them to the well bore. The western US is dominated by hydrothermal systems that reflect the structure and high heat flow of this tectonically active

area. But these western resources tend to me small, generating from 10-30 MW per site, are generally localized, and lack the collective resource capacity to have a significantly large impact on U.S. electrical supply. Enhanced Geothermal Systems (EGS) systems are those that attempt to extract heat by fluid circulation through induced fractures in otherwise non-porous and permeable crystalline basement rock. But generating sufficient reservoir capacity to accept injected water of sufficient volume, and flow connectivity between injection and production wells has been an insurmountable challenge to date. In contrast, the strata in deeper portions of sedimentary basins have the native porosity and permeability, can hold large volumes of water, and can be enhanced to hydrologically connect fractures induced by EGS. High subsurface temperatures coupled with effective flow and heat sweep between injection and extraction wells that offer the potential for geothermal resources from sedimentary basins that can yield 100's MW per site. Heat at drillable depths of 3-6 km in sedimentary basins could generate 1+ MW of sustained power per square kilometer with negligible impact to surficial systems. The large areas of deep sedimentary basin in the conterminous U.S. house an estimated 100,000 EJ of power resource (Tester, et al, 2006). The potential for sedimentary-basin geothermal to replace a sizeable proportion of the current carbon-rich (100EJ/year at approximately 50% coal; DOE/EIA, 2010) energy consumption is thus high. In addition, being able to tap geothermal resources of sedimentary basins opens up areas of the US, and indeed the world, that have no other viable source of geothermal energy.

Tapping the large energy resources of sedimentary basins will require a meaningful effort in basic research geared directly to overcoming current applied challenges. Better understanding of the native sedimentary basin and better engineering and geophysical technologies are needed to provide the breakthroughs that will advance geothermal energy to its potential role as a primary contributor to the U.S. energy portfolio. The high up-front costs associated with large-scale geothermal energy systems make this industry particularly vulnerable to uncertainty in proper placement and development of power plants and the related acceptance of financial risk. Lowering of financial risk to acceptable levels, and organic expansion of this industry, must start with a concerted effort to address the basic science and engineering questions that underpin the risks of applied-research unknowns. This will necessarily require advancements in workforce development and educational infrastructure as well. The diversity of science and

engineering and social sciences needed to address these problems also require advanced vehicles for informational exchange and interdisciplinary cooperation addressed by cyberinfrastructure and other scholarly exchange. The primary basic questions identified by the workshop group that need to be surmounted are summarized below.

Questions Pertaining to the Native Sedimentary Basin

How does heat move within sedimentary basins at large scales and how does this impact the renewability of the resource?

How is heat stored and released on the local and micro scales and how does this impact efficiency of heat sweep?

What are the fundamental sedimentary processes that control the filling of sedimentary basins across all scales, and how do they impact permeability, connectivity, and heterogeneity of deep-basin flow paths?

What are the diagenetic processes that operate in deep sedimentary basins and how do they increase or reduce permeability as they evolve?

What controls the natural processes whereby fractures form and evolve within basin sediments, and what is the impact of these fractures on the transmission of fluid flow?

Geophysics

How can discrete geophysical methods be integrated to identify basin properties critical to geothermal development (e.g. permeability pipes, thermal distribution, etc.)?

What are the critical advances needed to better predict and measure changes in thermal properties of fluids and solids in deep-Earth settings during development and production?

How can geophysical aspects of deep-Earth settings be effectively simulated within the lab?

Engineering of Geothermal Systems

What new or improved well technologies can make drilling and developing large boreholes possible and practical at very high temperatures?

What new techniques can be defined that permit us to predict, control, and monitor stimulated fracture systems in deep, hot, and heterogeneous media?

How can we effectively monitor the evolution of fractures, heat regime, and stress conditions induced by geothermal extraction?

What are the relationships and thresholds between modified fluid pressures and induced seismicity?

Can numerical decision models be generated that effectively predict geothermal operational risk?

Education and Cyberinfrastructure

What short-term and long-term efforts will prove most effective toward tempering workforce shortages expected of an emerging geothermal industry?

What efforts would prove most effective at raising the current low profile of geothermal energy in the mind of the public and policy makers?

What are the positive and negative feedbacks tied to relationships between the geothermal and oil and gas industries as it relates to perceptions, workforce development, and educational infrastructure?

What are the most effective forms of cyberinfrastructure that may be used to promote sharing of data and education materials to best aid the development of geothermal curricula?

What are the best vehicles for fostering cross-disciplinary education and scholarship between engineering and science disciplines?

What are the best processes for building an educational and workforce pipeline from K-12, though undergraduate, to graduate, to professional in the geothermal sciences, and how can we best assure that women and minorities are not leaked from this system?

What can be done to retain underrepresented groups in the educational and career pipeline toward potential geothermal positions?

What are the cyberinfrastructure platforms that will best facilitate effective exchange of ideas and data and foster greatest participation for the SedHeat community, and what is the best approach for constructing this platform?

Williston Basin Geothermal Project

The geothermal project in the Williston Basin is continuing to move forward. This project, managed by the University of North Dakota, involves funding support from the DOE along with equipment provided by Calnetix Technologies. The project is in the Cedar Creek Field in the southwestern part of North Dakota and involves 210^{o}F water flowing at 875 gpm (30,000 bbls/d) from multiple wells as part of a water flood. Continental Resources, Inc. operates the field and is providing access to the water for power generation. At the time of this writing the project was awaiting the delivery of two 125 kW turbines from Calnetix.

2013 SMU Geothermal Conference

On March 12-14, 2013 Southern Methodist University in Dallas will hold its geothermal conference entitled “Geothermal Energy and Waste Heat to Power: Utilizing Oil and Gas Plays”. Upwards of 200 people have attended past conferences. The conference focuses on using oil and

gas wells for geothermal power instead of abandoning them. Information on the event can be obtained from Maria Richards (mrichard@smu.edu) or at the website (http://smu.edu/geothermal/Oil&Gas/GeothermalEnergyUtilization.htm).