Application for a 2008 GSA Research Grant

Name: Kjos, A. R.

Project Title: Tracing fluid sources and distinguishing between deep and shallow processes in the Salton Sea, South-Eastern California, USA: a temporal and spatial analysis

Project Supervisor: Kimbrough

Academic Info (Department Address): SDSU – Dept. of Geological Sciences

Clearly state the problem(s) to be addressed, the hypothesis or hypotheses to be tested, and the overall objectives of your proposed project. **(1,200 character limit):**

Previous bore hole data, associated with exploitation of the geothermal field in the Salton Sea has revealed an interface between deep saline rich brines and there shallower, likely, meteoric counterparts (Williams and McKibben, 1989; Williams, 1997). How these two bodies interact and migrate with respect to each other and there seasonal variations are the primary focus of this study. The temporal and spatial geothermal variations within the Salton Sea field are not fully understood. Spatially and temporally distributed halogen (chloride) water analysis of the Salton Sea geothermal field is required to better characterize subsurface mixing processes of segregated brine layers and temporal variation in this unique geological environment. This study can provide significant insight into processes in the Guaymas and other basins in the Gulf of California, by providing a temporal framework for the subsurface geothermal mixing model first proposed by Williams (1997) and later adapted by Svensen (2007) (fig. 1).

Discuss the previous work on your problem(s) that (1) places the project in a disciplinary and, if appropriate, regional context and (2) documents the importance of your project. (2,500 character limit):

The Salton Sea geothermal field represents a major economic and geopolitical resource. To make sure the Salton Sea geothermal field remains a sustainable energy resource it must be properly characterized to prevent play-out (depletion) of the field. The field was produced in association with pull-apart basins linked with step-over in the San Andreas Fault Zone and short spreading center segments in the Gulf of California leaky transform system. This geotectonic regime extends approximately more than 1,200 km along strike to the south. Helgeson (1968) first characterized the Salton Sea field in association with its exploitation as a geothermal power source. The field encompasses an approximately twelve square mile area on the southeastern shore of the Salton Sea, denoted by a distinct gravitational and electromagnetic anomaly. It is hosted dominantly in lacustrine and fluvial arkosic sediments two to three thousand meters thick and is capped by several thousand meters of shale, creating a “pressure-cooker” type system. A model for the system was first developed by Williams (1997) after discovery of the interface between shallow saline-poor and deep saline-rich brines. Near-surface fluid migration has been associated with subsidence structures and calderas and the high levels of CO_2 (>98% by volume) resultant from the dissolution of sub-surface calcareous rocks (Svensen, 2007; Helgeson, 1968). Recent discovery of petroleum on the eastern edge of the principal Davis-Scrimpf seep has lead to its characterization by Svensen (2007). The seasonal variation of this system has been noted but not examined. This area has the potential for accelerated hydrocarbon production and maturation (Svensen, 2007). Recent work by Svensen (2007) has established a direct analytical approach for the evaluation of the seeps within the field and the questions being addressed in this study. Using the Davis-Scrimpf seep field as the template for analysis of the entire field, chlorine concentration has been shown to delineate fluid source region and correlates to fluid density (high fluid density = low chlorine values). No systematic variation in pH relative to fluid density has yet been demonstrated, but Svensen’s (2007) study was restricted to a single seep. Study of the entire field over the course of a year may show a variation in pH.

Concisely state how you plan to address your problem(s) and test your hypothesis or hypotheses (2,500 character limit):

A year long, systematic water sampling and monitoring regime is the best way to develop a temporal and spatial analysis of the Salton Sea geothermal system. An initial geologic investigation and mapping of the field area will provide a spatial framework. Water sampling is planned for an approximately twelve-month period at one-month intervals. Temperature, TDS (total dissolved solids) and pH monitoring will also be conducted to further understand seasonal variations within the geothermal field and will be carried out on-site due to potential variations as a result of transportation and sampling practices (Hem, 1989). Primary halogen analysis will be conducted using an anion analyzer (column separation technique), available at San Diego State University. Additionally, select samples will be analyzed for TOC (total organic content) if they display petroliferous field characteristics. Previous complexities associated with using a single seep site due to sub-surface heterogeneity and spatial availability, as noted by Svensen (2007), may be resolved by the increased scope of this study. An extensive sampling program of this terrestrial field can help constrain brine source regions and may distinguish between deep and shallow geothermal processes.

Duration of investigation (dates): June 2008 - May 2009

Budget: LIST IN ORDER OF PRIORITY AND JUSTIFY IN DETAIL, for example, funding of chemical and isotopic analysis, equipment, technicians and expendable laboratory supplies is necessary for consideration. Grants are made for one year only. Total: 3,832

- Travel ($832)
  - 200 mi (round-trip) @ $0.32 per mile = $64 per trip
  - 13 round trips (1 site evaluation and discovery trip; 12 monthly monitoring trips)
- Analytical Costs ($3000) **-** $10 per sample
  - An estimated 300 samples over the course of 1 year
  - Field Sample Bottle – 4 oz. polypropylene ($2)
  - Analyzer Vile – ($0.50)
  - Lab supplies and fees – includes solution and equipment costs for sample processing ($7.5)

Budget justification (1,200 character limit):

This study will establish spatial and temporal characteristics of the Salton Sea geothermal Field. This study expands the scope of an already well establish technique and has the potential to be applied to similar environments in this type of tectonic setting. The Salton Sea field is highly accessible. The costs of this study are relatively low for the quantity of data that will be collected and extent of time and area of sampling. The geothermal field has already seen significant investment and through characterization will become economically more viable. By characterizing temporal and spatial variations associated with fluid circulation patterns, in this geothermal field, the study can contribute significant information to the Salton Sea geothermal model. This model could apply to similar sub-oceanic fields in the Gulf of California (Guaymas Basin), but due to the inaccessibility and the nature of sampling for these areas direct characterization is cost-prohibitive. The added potential to further exploit the basin for hydrocarbon resources strengthens its economic longevity and may provide insight into processes associated with the geothermal production of hydrocarbons. The spatial long-term characterization of the Salton Sea geothermal field will allow it to remain and potentially grow as an economic and energy resource in the region.

Amount and nature of other available funds, facilities, materials, etc. (1,200 character limit):

Additional costs (approx. $500) associated with maintenance and care of the anion analyzer will be covered by San Diego State University in accordance with laboratory protocols. On-site Temperature, TDS, and pH monitoring equipment is available on loan from San Diego State University and would cost approximately $100-250 per meter if the study was required to purchase them. Any additional costs associated with travel or accommodations, including food will be covered by the individual.

Other grants that (a) have supported this project, (b) are currently supporting this project, and (c) are being applied for. This list should include funds available to or applied for by the thesis supervisor, if these can support the proposed work: None to date.

If you have received a previous GSA graduate student research grant, please copy and paste your progress report form below. Click here for Progress Report Form (Word Format – copy attached to end of document). (4,000 character limit): n/a

Abbreviated resume. List education, major positions held, and significant accomplishments. Provide information relevant to your qualifications to undertake proposed research. List up to 5 of your publications and presentations (2,500 character limit):

Education: Bachelor of Science Degree, Geology (comprehensive): University of Wisconsin Eau Claire, 2007

Major Positions and Accomplishments:

Regional Geologic Mapper, Archer, Cathro & Associates (1984) Limited, Yukon, June-August 2007

Field Assistant to Geological Survey of Canada (GSC) and UWEC Faculty, British Columbia, June-August 2004, July-August 2005, and June-August 2006

Geologic Mapper USGS EDMAP Project, Montana, May-July 2005 and May-June 2006

Research Assistant, University of Wisconsin, Eau Claire, 2004-2006

University of Wisconsin Eau Claire Teaching Assistantships: Geological Field School, Boulder, Montana, June 2006; Geological Field School, Kingston, New Mexico, January 2006; Earth History, Fall 2005; Sedimentology and Stratigraphy, Spring 2005; Introduction to Geology, Fall 2004

San Diego State University Teaching Assistantships: Dynamics of Earth Laboratory, Fall 2007 and Spring 2008; Mineralogy, Fall 2007 University of Wisconsin Eau Claire Geology Department Award for Excellence, 2007 Regional

Publications:

Kjos A.R., MacLaurin, C.I., Kohel, C.A., Nawikas, J.M., Stoltz, J.M., Mahoney, J.B., and Ihinger, P.D., 2006, Reassessment of the Belt Supergroup: a stratigraphic analysis of the Devil's Fence Anticlinorium, Southwest Montana [an EDMAP project]; Geological Society of America Abstracts with Programs, vol. 37, no. 7, p. 500.

Kjos, A.R., MacLaurin, Catherine I., Mahoney, J.B., Hooper, R.L., Snyder, Lori D., Haggart, J. W., and Woodsworth, 2006, G. J., Geologic Evolution and Economic Mineralization Potential of the Whitesail Lake map area, west-central British Columbia; 7th Annual UW-System Symposium for Undergraduate Research and Creative Activity—Poster Session, Menomonie, WI.

Kjos, A.R., Suzanne Reed, Lori D. Snyder, J. Brian Mahoney, R. G. Anderson, Vicki McNicoll, and Simpson, Kirstie, 2006, Stratigraphy of John Peaks, Iskut River area, Northwestern British Columbia: Illuminating the Geologic History and Mineral Potential; 7th Annual UW-System Symposium for Undergraduate Research and Creative Activity—Poster Session, Menomonie, WI.

Nawikas, J.M., Kohel, , C.A., Stoltz, John M., MacLaurin, Catherine I., Kjos, Adam R., Mahoney, J.B., Ihinger, P. D., 2005, Structural and Magmatic Evolution of the Helena Salient: New Geologic Mapping in the Devils Fence Anticlinorium; Geological Society of America Abstracts with Programs, Vol. 37, No. 7, p. 76.

****References cited in proposal (2,500 character limit):***

- Helgeson, H.C., 1968, Geologic and thermodynamic characteristics of the Salton Sea geothermal system: American Journal of Science, v. 266, p. 129–166.
- Hem, J. D., 1989, Study and Interpretation of the chemical characteristics of natural water: USGS Water Supply Paper 2254.
- Svensen, H., D. A. Karlesn, A. A. Sturz, K. Backer-Owe, D. A. Banks and S. Planke, 2007, Processes controlling water and hydrocarbon composition in seeps overlying the Salton Sea Geothermal System, California, USA. Geology Vol 35: 85-88.
- Williams, A.E., 1997, Fluid density distribution in a high temperature, stratified thermohaline system: Implications for saline hydrothermal circulation: Earth and Planetary Science Letters, v. 146, p. 121–136.
- Williams, A.E., and McKibben, M.A., 1989, A brine interface in the Salton Sea geothermal system, California: Fluid geochemical and isotopic characteristics: Geochimica et Cosmochimica Acta, v. 53, p. 1905–1920.

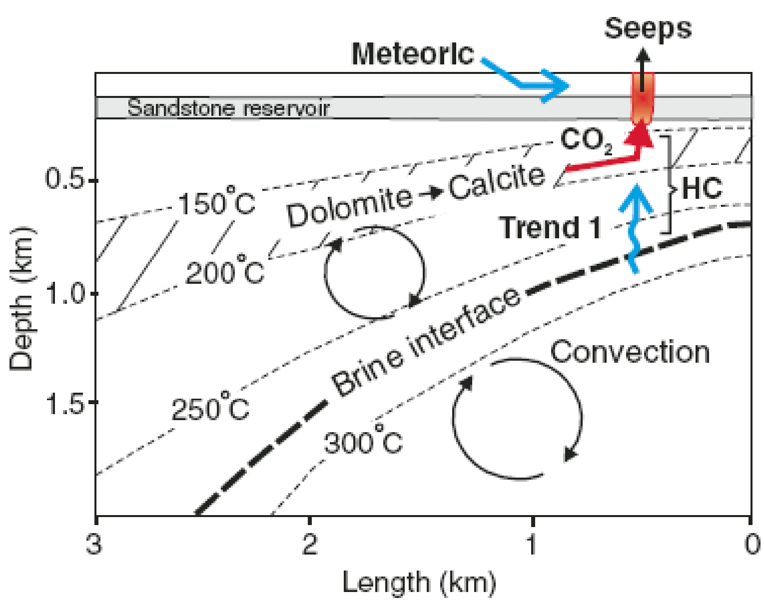

Figure 1 – Generalized geothermal model of the Salton Sea Field. “Trend 1” and “Seeps” refer to the Dacis-Scrimpf seep field. General model is taken from Williams (1997). (Svensen, 2007)