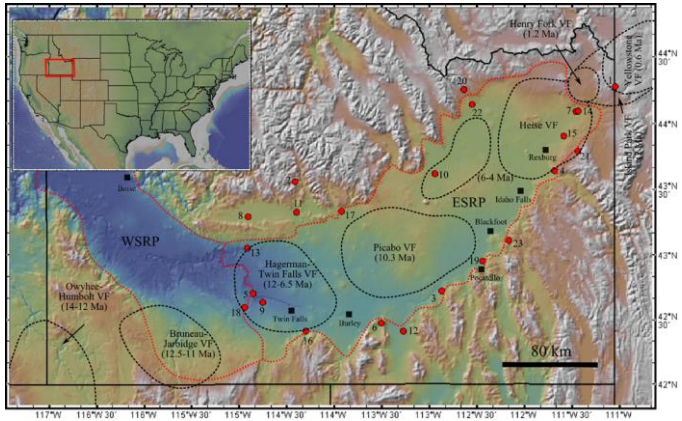

Geothermometry Mapping of Deep Hydrothermal Reservoirs in SE Idaho

Project Officer: Eric Hass, Holly Thomas

Total Project Funding: $700K

May 14, 2015

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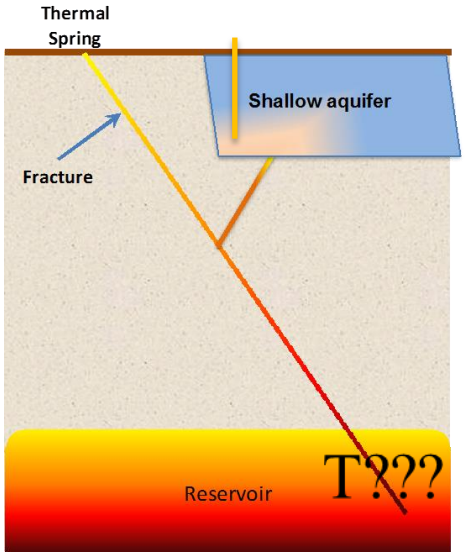
Mark Conrad LBNL

AOP 3.1.2.1

Track 2 HRC

Relevance/Impact of Research

- Reducing the risk and cost of hydrogeothermal exploration is a major challenge for the geothermal industry and DOE
- This project addresses this challenge by collecting and analyzing water and gas samples from geothermal expressions and calculating the equilibrium reservoir temperature using geothermometry/isotopic techniques.
- Exploration costs can be minimized if geothermal prospects with high temperatures can be identified prior to exploration drilling
- Project combines the use of multi-component geothermometry, and isotopic geothermometry to assess the hydrogeothermal potential of the Eastern Snake River Plain.



Relevance/Impact of Research

- Consistent results from the two geothermometry techniques of indication of high geothermal reservoir temperatures will lower the perceived risk of geothermal exploration impacting the Geothermal Technologies Office's goal of **Accelerated Near Term Hydrothermal Growth**
- Multiple samples are being collected from geothermal expressions and being analyzed by different techniques to calculate the geothermal reservoir temperature. Consistent results imply more certainty of the reservoir temperature.
- Result are being shared with:
  - LBNL project "Use of He isotopes for Geothermal Resource Identification in the Cascades and Snake River Plain"
  - Utah State led Snake River Plain play fairway project

Scientific/Technical Approach

- Obtain samples from thermal expressions, analyze samples for chemical concentrations, use INL's geothermometry tool (RTEst) and LBNL isotopic methods to estimate reservoir temperature.
  - Collection and assessment of existing data for wells and hot springs
  - Coordinated with local universities and water related personal to provide access to sampling areas.
  - Field sampling thrust efforts with all research parties participating.
  - Sharing of samples between institutes
  - Multicomponent and isotopic geothermometry analysis
  - Integration of data to examine consistency of results

Scientific/Technical Approach

- Key Issues

– Is existing water chemistry of sufficient quality to assess potential geothermal prospect?

– Can well and spring water data be used in combination to assess geothermal prospects?

– Can isotopic signatures of trace components (e.g., dissolved CH_4) be relied upon to indicate the existence of deep thermal reservoirs?

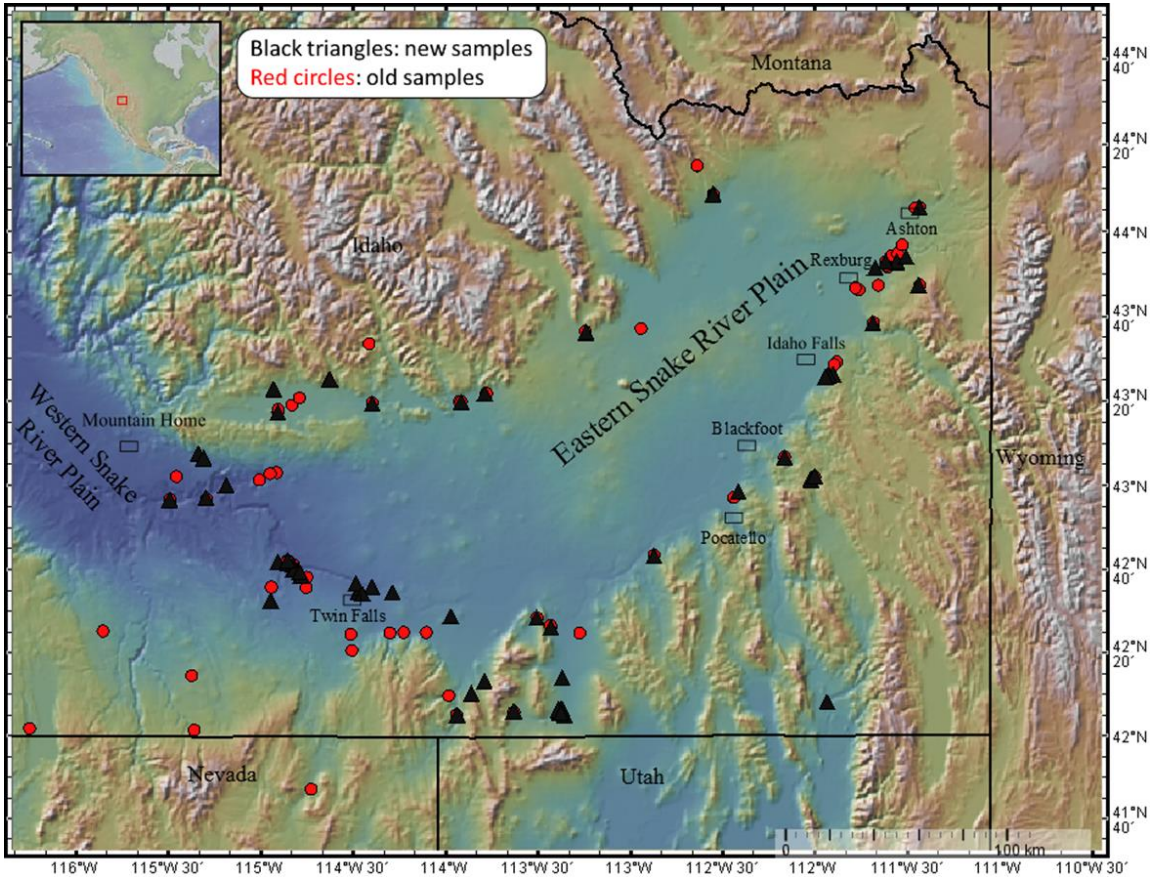
– Does aluminum need to be measured and/or what are the appropriate proxy minerals to use?

– How does one integrate calculated reservoir temperatures from disparate results?

– How many samples are needed to identify a geothermal prospect? How big (geographically) should clusters of wells and springs be? Do they represent a single prospect, or a collection of similar prospects?

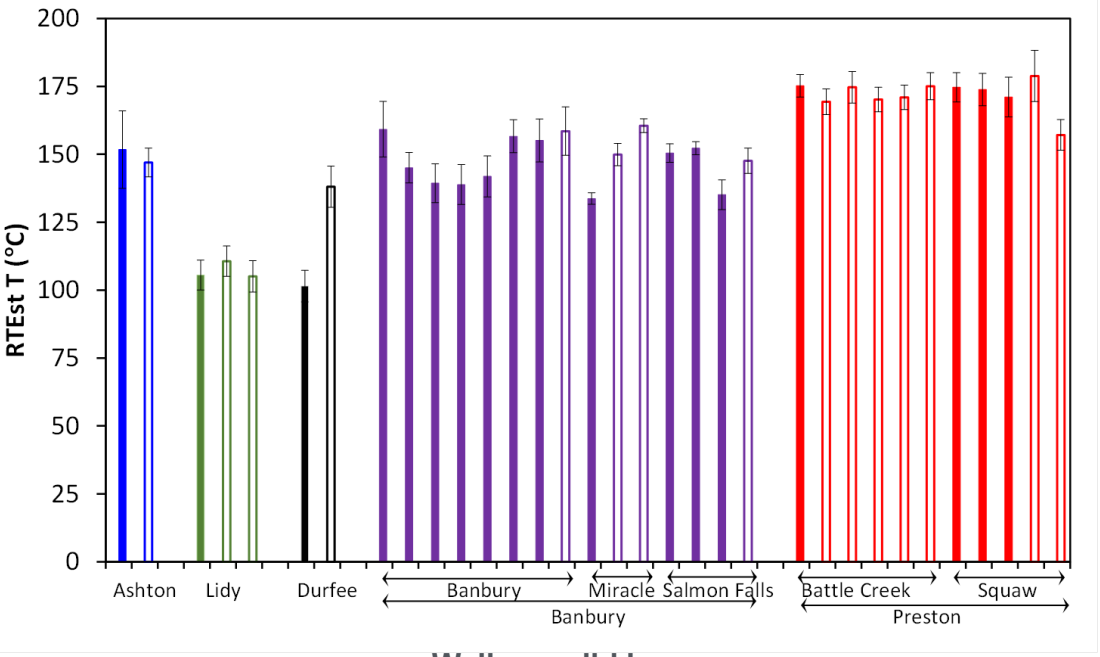
Accomplishments, Results and Progress

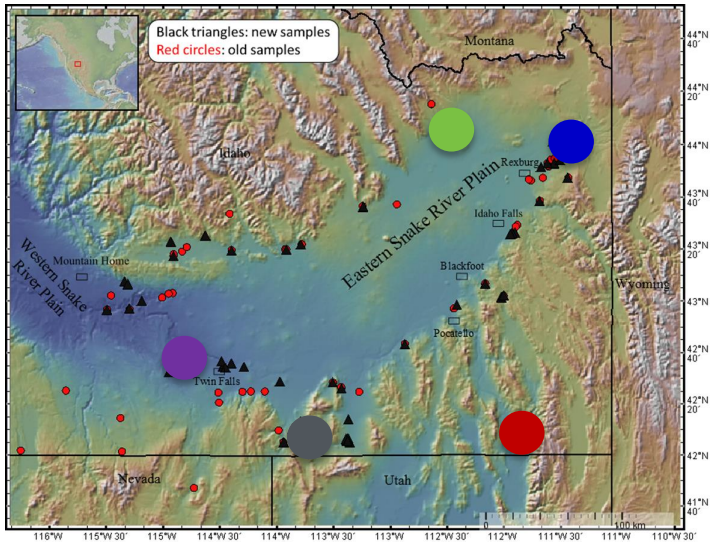
- Thermal expressions water samples have been collected
  - More than 70 water samples have been evaluated using RTEst.
  - More than 40 samples have been calculated using LBNL's isotopic techniques.



Accomplishments, Results and Progress

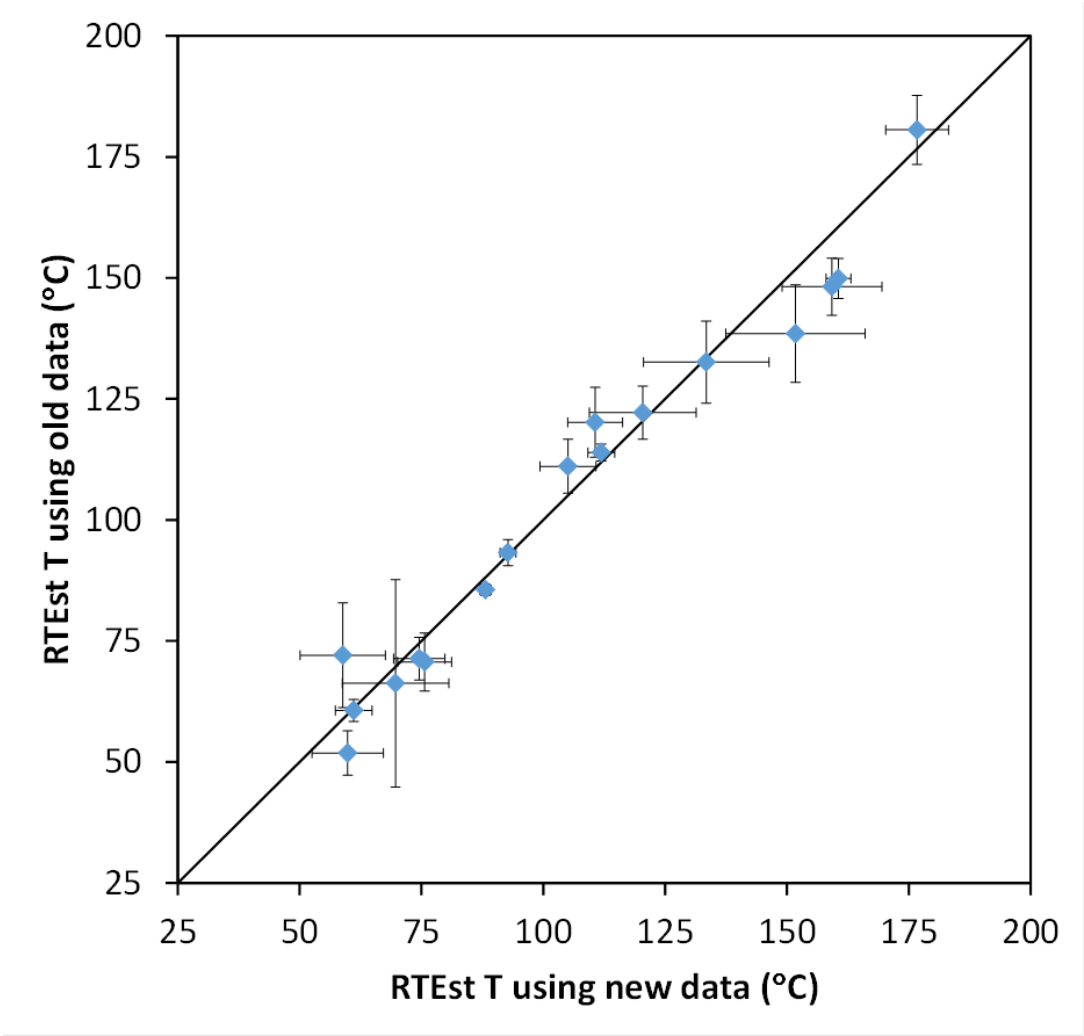
- Preliminary cluster analysis of wells and springs to assess the consistency of obtaining similar temperatures from different types of thermal expressions suggest that the two thermal expressions can be combined.





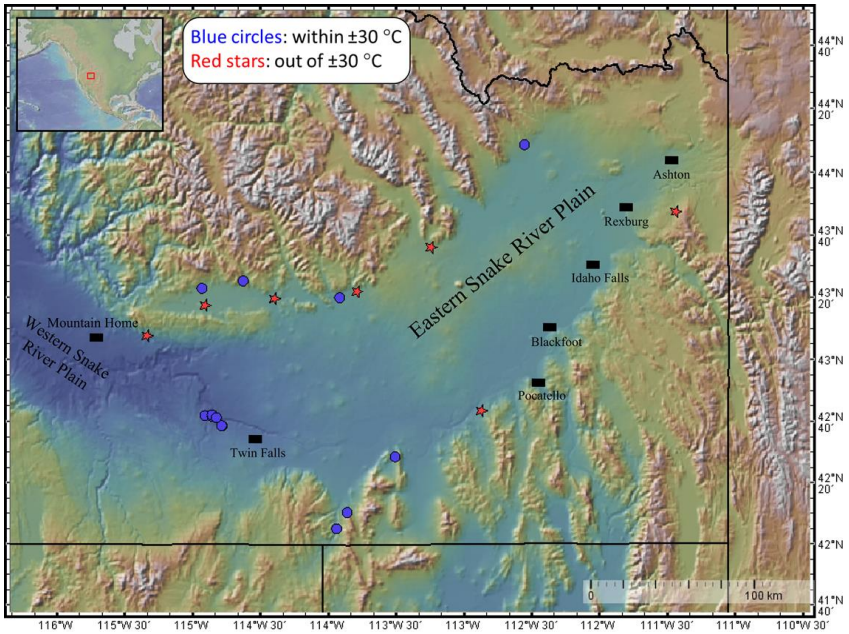
Accomplishments, Results and Progress

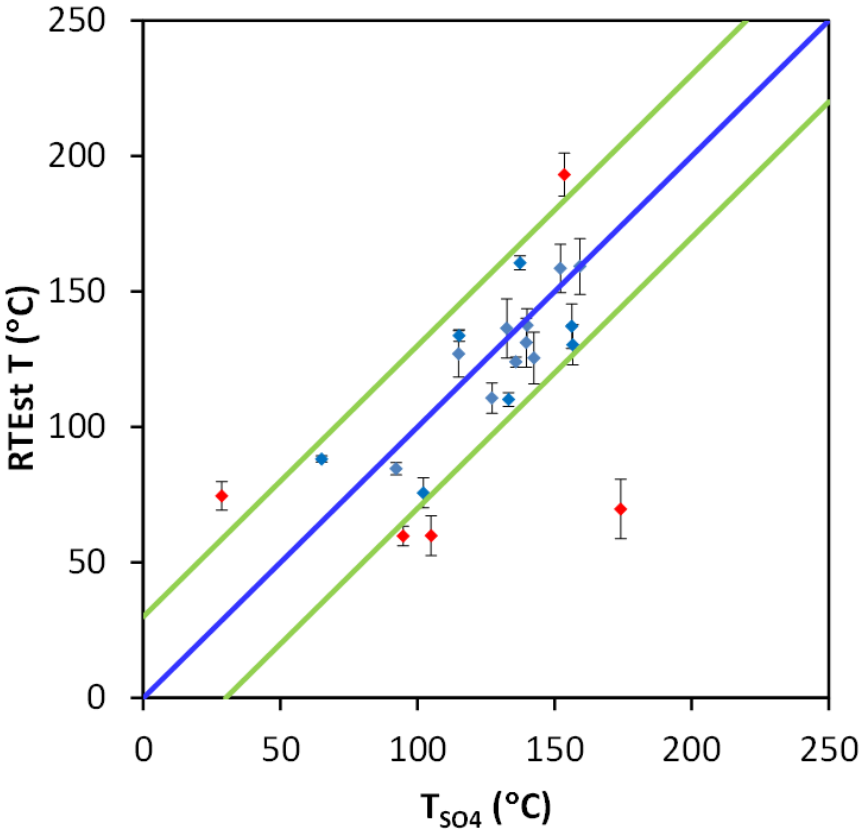
- Historical chemical analyses are generally valid to estimated thermal temperatures using RTEst (at least in SRP).
- However, the mineral proxy selected to substitute for the missing component (such as Al) should be validated.



Accomplishments, Results and Progress

- INL's RTEst and LBNL's isotopic temperatures calculated using the sulfate-water oxygen isotope geothermometer generally agree with in 30˚ C for the SRP system.
  - Agreement => confidence.
  - Differences => further evaluation

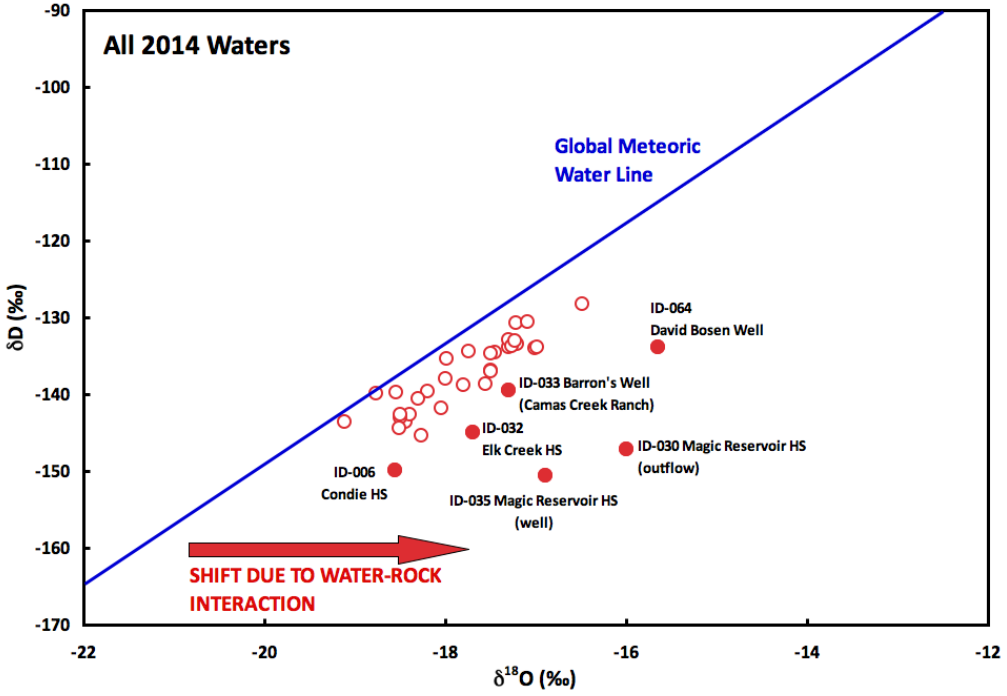




Water Isotope (δD, $\delta^{18}O$) Analyses

- Shifts from the local meteoric water line can indicate processes including boiling and/or high temperature water-rock interaction are occurring at depth. Note that these signals can be diluted by mixing with shallower non-thermal waters.

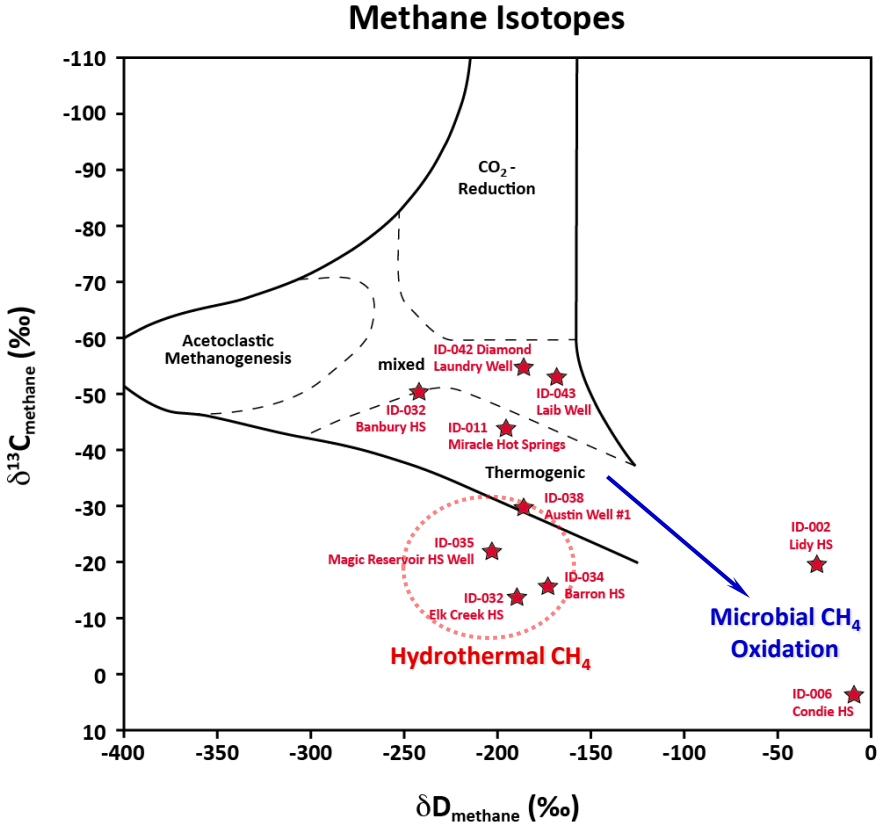
- Most samples fall along a line close to the Idaho local meteoric water line (offset to the right of the global meteoric water line
- Some samples (highlighted on figure to right) are shifted to the right of the meteoric water line by 1‰ to 3‰.
- These samples coincide with many with high calculated temperatures.



Dissolved CH_4 (δD, $\delta^{13}C$) Analyses

- The isotopic composition of methane can offer clues as to it's formation environment and post-formation history. It can also be used to calculate temperatures, but only if the actual reservoir fluids are available.

- The isotopic compositions of samples for which we were able to analyze both the hydrogen and carbon isotopic composition of CH_4 are plotted on the figure to the right.
- Several samples fall in the thermogenic ± biogenic CH_4 field, but there is also a group that falls in the range of high-temperature hydrothermal CH_4 defined by Welhan (1988).
- There are a couple of samples with clear evidence of microbial CH_4 oxidation.



modified from Whiticar et al. (1986)

Accomplishments, Results and Progress

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Original Planned Milestone/ Technical Accomplishment	Actual Milestone/Technical Accomplishment	Date Completed
Finish chemical analysis of water samples collected in FY14 and upload data into GTO's NGDS.	Chemical analyses complete Data compiled but not loaded to NGDS w/ agreement from DOE	12/31/14
Present geothermometry validation analysis of thermal expression at existing power plants results at the Stanford Geothermal Workshop	Completed	3/31/15
Initiate FY15 summer sampling campaign that includes finishing the cluster analysis sites in southern SRP, the remainder of the sampling locations in the northern SRP	Wells/springs are being identified Sampling scheduled for week of June 15th	NA
Complete report describing the chemical analysis of FY15 samples and prepare SRP map of the RTEst estimated thermal temperatures using spring/ wells data	70 locations sampled Cluster and additional sample for map in summer FY15	NA

Future Directions

- Results from this study will be available for Utah State University's Snake River Plain Play Fairway project and LBNL's He isotope project.
- Describe deployment strategy or expected outcome of this effort. Discuss future research, development or deployment needs.
  - Finish analysis, and publish results on; historical/new data analysis, well/spring data analysis, RTEst/^{18}O/He data integration
  - MS geology summer intern to develop x-sections/conceptual model of hydrogeothermal flow at RTEst/^{18}O discrepancy locations and geothermal prospect locations
  - Added a laboratory re-equilibrium task to provide preliminary kinetic information of solute re-equilibrium effects on calculated temperature.

Milestone or Go/No-Go	Status & Expected Completion Date
Present project results to peer review panel	On track, 05/14/15
Complete the chemical and isotopic analyses of FY15 samples to evaluate geothermal temperature of potential resources in this area.	Due to delay in FY15 funding, We will be requesting no cost extension to 12/31/15 to complete analyses and final report.

Summary

- We expect ~100 thermal expressions to be sampled in the SRP area by the end of the project.
- Water samples being shared for multi-component geothermometry, isotopic analyses and rare earth element analyses.
- Integration of multiple temperature estimates result in more confidence of the thermal analysis results or lead to zones for further investigations.
- A ‘map’ of the thermal temperatures is being prepared describing the calculated thermal water reservoir temperatures.
- Results being integrated with other GTO projects (i.e. He interpretations and Snake River Play Fairway).

Possible Areas of Interest

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