

# National Geothermal Resource Assessment and Classification

Project Officer: Tim Reinhardt Total Project Funding: \$2.89M  
May 11, 2015

Colin F. Williams  
**US Geological Survey**

Systems Analysis (Resource Assessment)

- Overall Objectives
  - Develop new Geothermal Resource Classification standards
  - Expand Resource Assessment scope to include  $T < 90\text{ }^{\circ}\text{C}$
  - Improve assessment methodologies for EGS and undiscovered resources incorporating results from targeted field and modeling studies
  - Work with NGDS to provide data and USGS report access
- DOE Identified Barriers
  - Lack of Available and Reliable Resource Information
  - Resource Assessment and Data Needs
  - Key issue is for the geothermal community, public, and government agencies to have access to comprehensive, up-to-date, logically organized information on geothermal resources
- Relevant GTO Goals
  - Systems Analysis – Resource Assessment
  - Enhanced Geothermal Systems (EGS)
  - Hydrothermal Resource Confirmation
  - Low Temperature, Co-Produced and Geopressured Demonstration Projects

## Significant and Innovative Aspects of Project

- Resource Classification – Define resources from a systemic perspective with inherent thermal, hydrologic, and geologic features that span the full spectrum of resource types and utilization practices.
- Low-Temperature (<90 °C) Assessment – Application of revised approach to determining temperature, reservoir volume, and potential thermal energy recovery as developed for 2008 assessment of resources (>90 °C) by Reed and Mariner (2008) and Williams et al. (2008)
- EGS Assessment Methodology – Develop models for EGS thermal energy recovery that accurately anticipate reservoir performance, by applying a quantitative understanding of the relative roles of tectonic stress, depth, lithology/mineralogy, temperature, fluid chemistry, and alteration.

## Significant and Innovative Aspects of Project

- EGS Assessment Methodology – Improve knowledge of potential EGS resources through characterization of upper crust in regions of significant EGS potential
- Assessing Undiscovered Resources – A critical, but as yet unquantified, factor in the occurrence of hydrothermal systems is the creation and evolution of fracture permeability. Coupled modeling studies are providing the tools to quantify rates of permeability changes with deformation and mineral precipitation/dissolution
- Assessing Undiscovered Resources – Targeted geological and geophysical field studies, generally conducted in conjunction with industry drilling projects, are providing critical data on the nature of hydrothermal systems that can be used to inform modeling efforts described above

## 1. Conventional Geothermal Resource Characterization and Assessment

- Conduct geophysical, geological and geochemical surveys for evaluation of identified and undiscovered geothermal resources. (e.g., Pilgrim Springs, Warner Valley, Long Valley/Mono Basin, NE Nevada)  
**Key issue – Use targeted field studies to inform assessments**
- Update the low-temperature (<90 °C) geothermal resource databases, report on revisions to the low temperature geothermal resource assessment, and produce online databases and summaries of the results. Revisions applied using USGS methodology developed for 2008 assessment of resources >90 °C. **Key issue – What are the geothermal resources of the US across entire temperature range?**
- Utilize coupled thermal-mechanical-chemical-fluid flow models to investigate the evolution of hydrothermal systems and to develop life cycle models for the creation and evolution of these systems that can be utilized in improved resource assessment methodology. **Key issue – Can numerical models replicate observed characteristics and be used to quantify resource occurrence statistics?**

## 2. Enhanced Geothermal Systems

- Develop a provisional comprehensive geothermal resource classification system incorporating EGS and other “unconventional” geothermal resources. Revise and update the classification system based on community feedback and collaboration with IGA Resources and Reserves committee. **Key issue – How best to describe and classify geothermal resources?**
- Conduct regional studies of in situ stress, fault and fracture permeability, geologic structure, seismicity and heat and fluid transport in areas with potential for future EGS development. **Key issue – Is there more resource than indicated by shallow heat-flow measurements?**
- Incorporate the results of these investigations into improved methods for assessing potential EGS resources. **Key issue – Can we improve existing simple approaches to predict EGS resource exploitation by calibrating physical models with new and existing field data?**

## 3. Geothermal Resources in Sedimentary Basins

- Compile data on subsurface temperatures, lithologies and reservoir characteristics for sedimentary basins and identify regions of significant geothermal potential.
- Conduct focused studies on the basins with greatest potential to determine the geologic constraints on geothermal development.
- Incorporate the results of these investigations in an expanded resource assessment, publish the results of the assessment and place the supporting data and reports online. ***Key issue – What resource contributions can be expected from diverse geothermal production approaches (e.g., shallow thermal aquifers, petroleum coproduction, geopressured geothermal) in sedimentary basins across the US?***
- Combine results of assessment and classification work conducted in Tasks 1, 2 and 3 with previous assessment results in summary report on the full spectrum of geothermal resources in the United States.

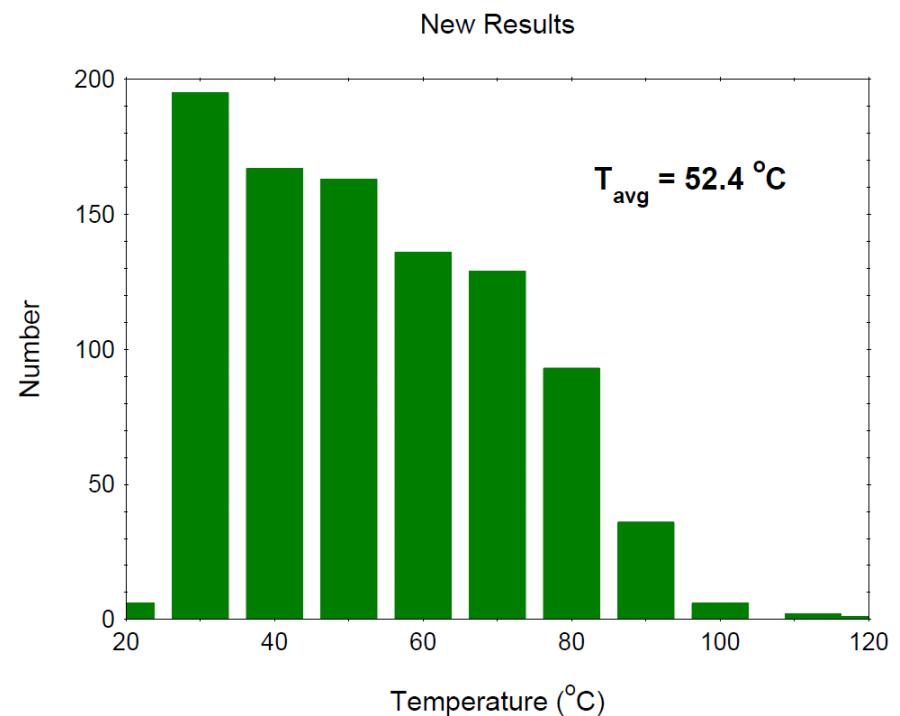
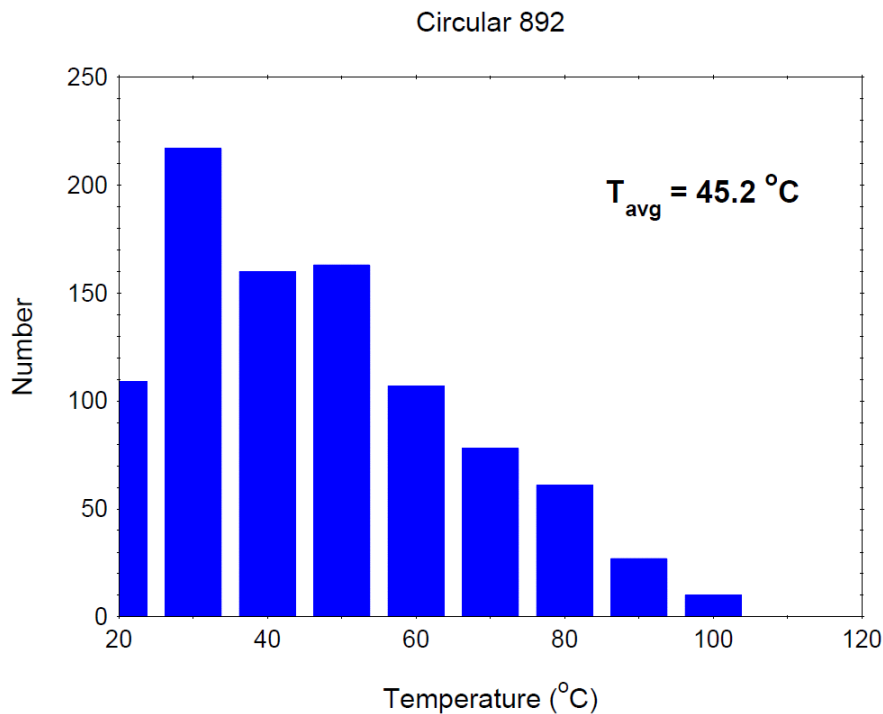
## 4. USGS Geothermal Data and NGDS Collaboration

- Complete compilation, review and publication of relevant geothermal databases assembled as part of the national geothermal resource assessment project (e.g., Long Valley thermal data - <http://pubs.usgs.gov/ds/523/>)
- Work with NGDS staff to identify database requirements, place USGS data in formats compatible with those requirements, and transfer to the National Geothermal Data System.
- Consult with and advise the center staff on the format, structure and accessibility of geothermal databases.
- Continue to provide new data to the center from the results of new and ongoing field projects and industry collaborations.

***Key issue – Provide effective access to both new and existing USGS data as well as interpretive assessment results.***



- $T < 90\text{ }^{\circ}\text{C}$  Assessment
  - Geothermometer and in situ temperature revisions to 1982 low-temperature data, with geothermometer approach as specified by Reed and Mariner (2008).  
Results –

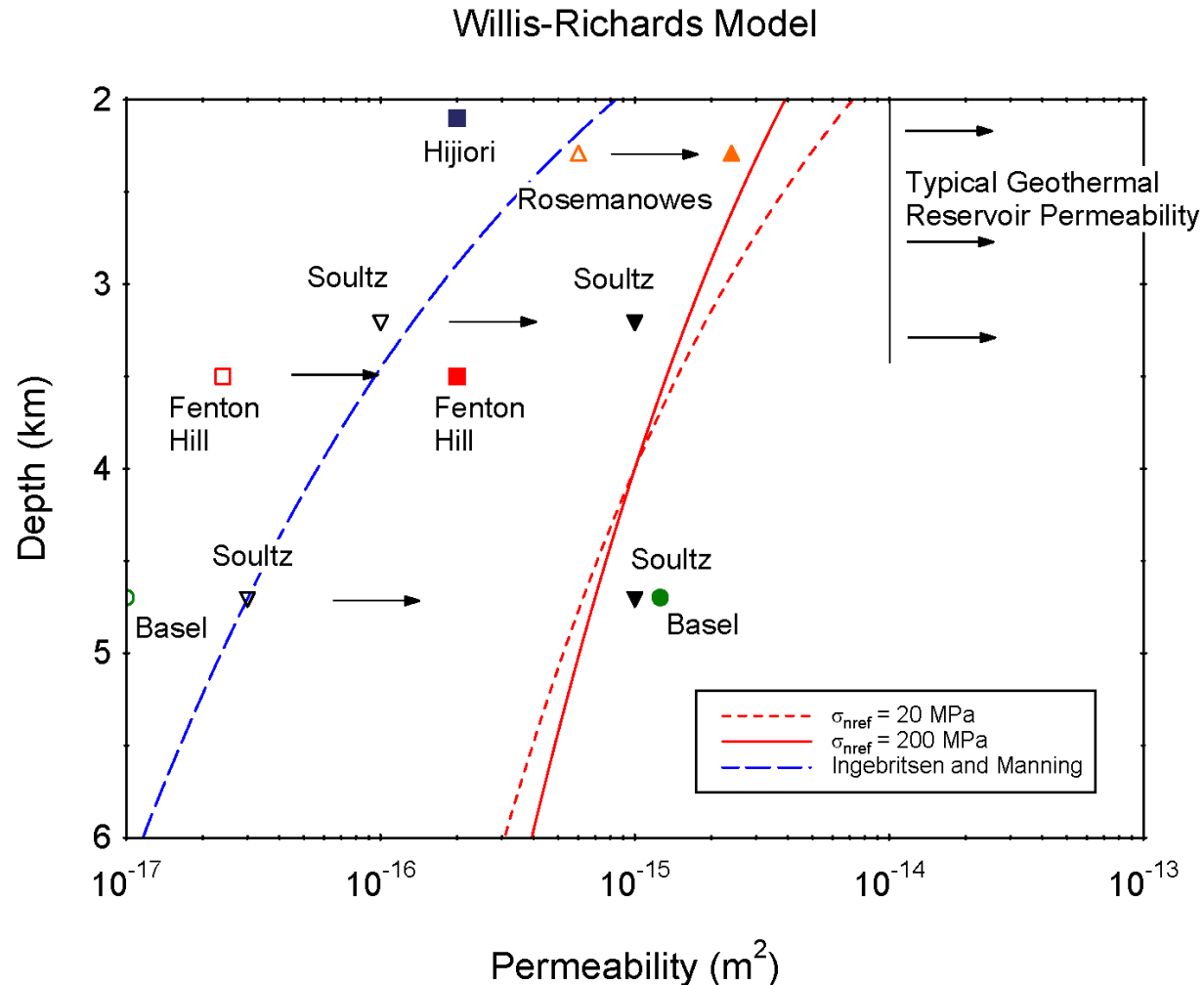


## Summary T <90 °C Assessment Results

- Improved system, chemistry and temperature database
- For entire United States totals represent modest increase over past assessments
  - Beneficial Heat = 44,300 MWt
  - Thermal Energy =  $90 \times 10^{18}$  J
  - Wellhead Exergy =  $7.25 \times 10^{18}$  J
- Potential electric power ~400 MWe in T range from 50 to 90C (Compared to 1640 MWe for  $90 \leq T \leq 150$  and 7420 MWe for  $T > 150$  in 2008 assessment)
- Working on deeper, higher T sedimentary resources to capture entire range of temperature

- Earlier comparison of models with data from EGS experiments indicated that reservoirs created by shear stimulation in crystalline rock are relatively insensitive to stress but that shear stimulation alone may not be consistently capable of achieving permeability equivalent to natural geothermal reservoirs.
- An update including new data indicates higher sensitivity and that stimulations achieve permeability equivalent to natural geothermal reservoirs at relatively shallow depth.
- Ongoing developments suggest that limited stimulation permeability at depth can be compensated for by increasing permeability-thickness through multi-zone stimulation.
- The most promising targets for EGS development in crystalline bedrock will be areas of both high conductive heat flow and extensional to strike-slip faulting.

## Evaluating EGS Permeability Creation (Stanford 2015)



- NGDS Data Contributions – Results from this project

BETA VERSION - UNDER ACTIVE CONSTRUCTION

[Issue Tracker](#)



Home Browse Collections Find Resources

Collections

Online Availability

- Geophysical studies in the vicinity of Blue Mountain and Pumpernickel Valley near Winnemucca, north-central Nevada

Resource Location



Standard Metadata

- USGIN ISO 19139
- Atom Feed
- GeoJSON

Site Information

- About this Repository
- Terms of Use
- About Metadata

## Geophysical studies in the vicinity of Blue Mountain and Pumpernickel Valley near Winnemucca, north-central Nevada

Geophysical, Blue Mountain, Pumpernickel Valley, Nevada

Basic Information

**Author:** Ponce, David A.  
**Description:** Abstract: From May 2008 to September 2009, the U.S. Geological Survey (USGS) collected data from more than 660 gravity stations, 100 line-km of truck-towed magnetometer traverses, and 260 physical-property sites in the vicinity of Blue Mountain and Pumpernickel Valley. Gravity, magnetic, and physical-property data were collected to study regional crustal structures and understand the geologic framework of the Blue Mountain and Pumpernickel Valley areas, which in general, have implications for mineral- and geothermal-resource investigations throughout the Great Basin.  
**Publication Date:** Jan 01, 2012

Author Contact Information

**Name:** Ponce, David A.  
**Organization Name:** U.S. Geological Survey  
**Street:** 345 Middlefield Road, MS989  
**City:** Menlo Park  
**State:** CA  
**Zip:** 94025  
**Email:** [ponce@usgs.gov](mailto:ponce@usgs.gov)

Distributor Contact Information

**Organization Name:** U.S. Geological Survey  
**Street:** 345 Middlefield Road, MS989  
**City:** Menlo Park  
**State:** CA  
**Zip:** 94025  
**Email:** [nothing@notreadyvet.com](mailto:nothing@notreadyvet.com)

Geographic Extent

**North Bounding Latitude:** 41  
**South Bounding Latitude:** 40  
**East Bounding Longitude:** -117  
**West Bounding Longitude:** -118



USGS Publications Warehouse - Citation View



### Geophysical studies in the vicinity of Blue Mountain and Pumpernickel Valley near Winnemucca, north-central Nevada

2012, Ponce, David A.  
 USGS Open-File Report: 2012-1207

The document and additional supplemental information are available at the index page for this publication

[Full-text PDF](#)

A print version of this publication is not available from the USGS Store

[Tweet](#) 0

**Abstract:**

From May 2008 to September 2009, the U.S. Geological Survey (USGS) collected data from more than 660 gravity stations, 100 line-km of truck-towed magnetometer traverses, and 260 physical-property sites in the vicinity of Blue Mountain and Pumpernickel Valley, northern Nevada (fig. 1). Gravity, magnetic, and physical-property data were collected to study regional crustal structures and understand the geologic framework of the Blue Mountain and Pumpernickel Valley areas, which in general, have implications for mineral- and geothermal-resource investigations throughout the Great Basin.

#### Additional Publication Details

Publication Type	USGS Numbered Series
Title	Geophysical studies in the vicinity of Blue Mountain and Pumpernickel Valley near Winnemucca, north-central Nevada
Author	Ponce, David A.
Year	2012
Series	Open-File Report
Series Number	2012-1207
Language	English
Publisher	U.S. Geological Survey
Publisher Location	Reston, VA
Contributing Office	Minerals, Energy, and Geophysics Science Center- Menlo Park
Description	Report: vi, 14 p.; Metadata txt; 3 Tables: XLS files
Online Only	Y
Lat Bound N	041.5000
Lat Bound S	040.6666
Lon Bound E	-117.0000
Lon Bound W	-118.7500
Country	United States
State	Nevada
Additional Location Information	Blue Mountain

Sponsored by the U.S. Department of Energy under award DE-EE0002850 to the Arizona Geological Survey acting on behalf of the Association of American State Geologists.

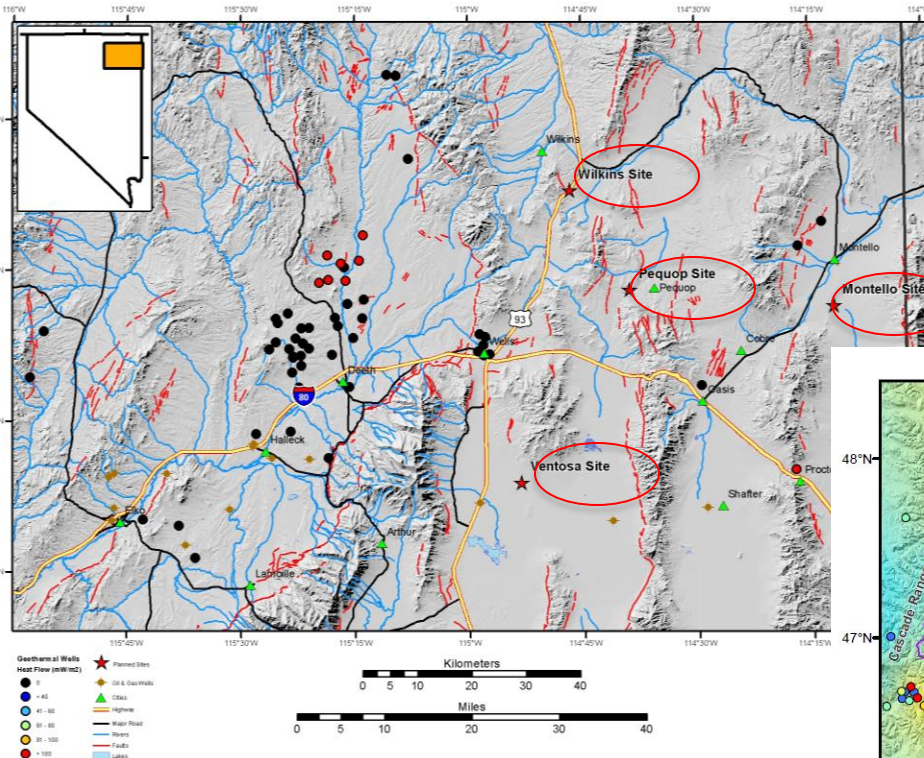


U.S. DEPARTMENT OF  
**ENERGY**



**AASG**  
Association of American State Geologists

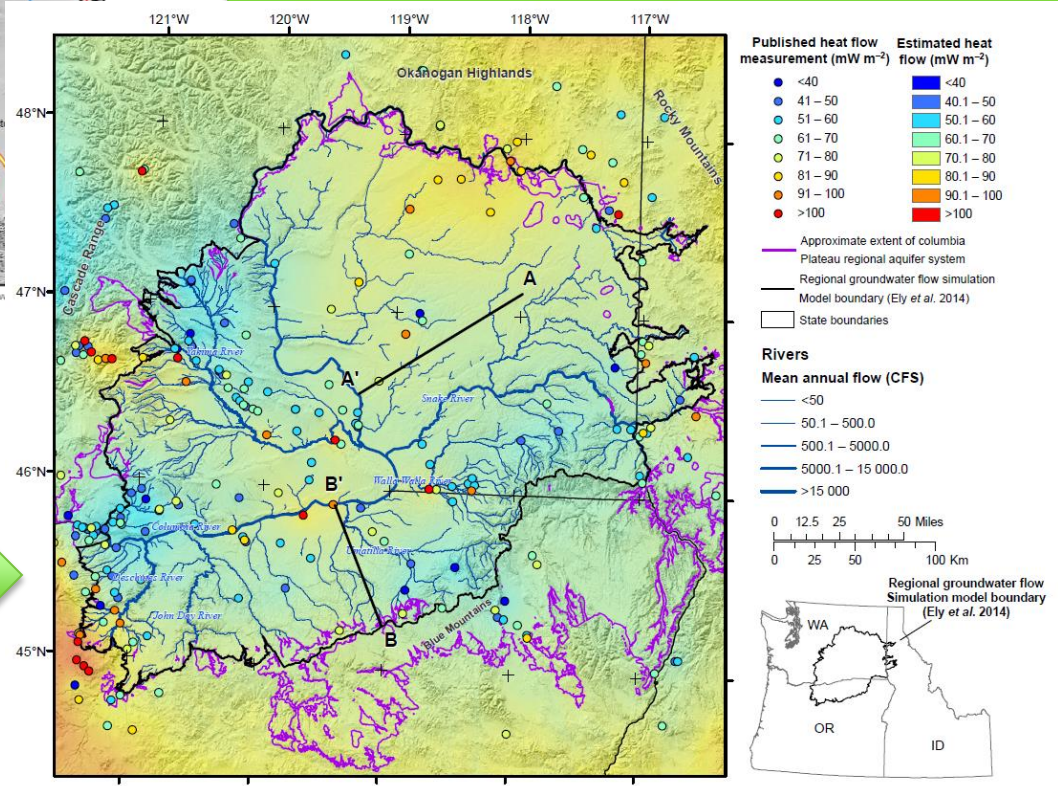
# Accomplishments, Results and Progress



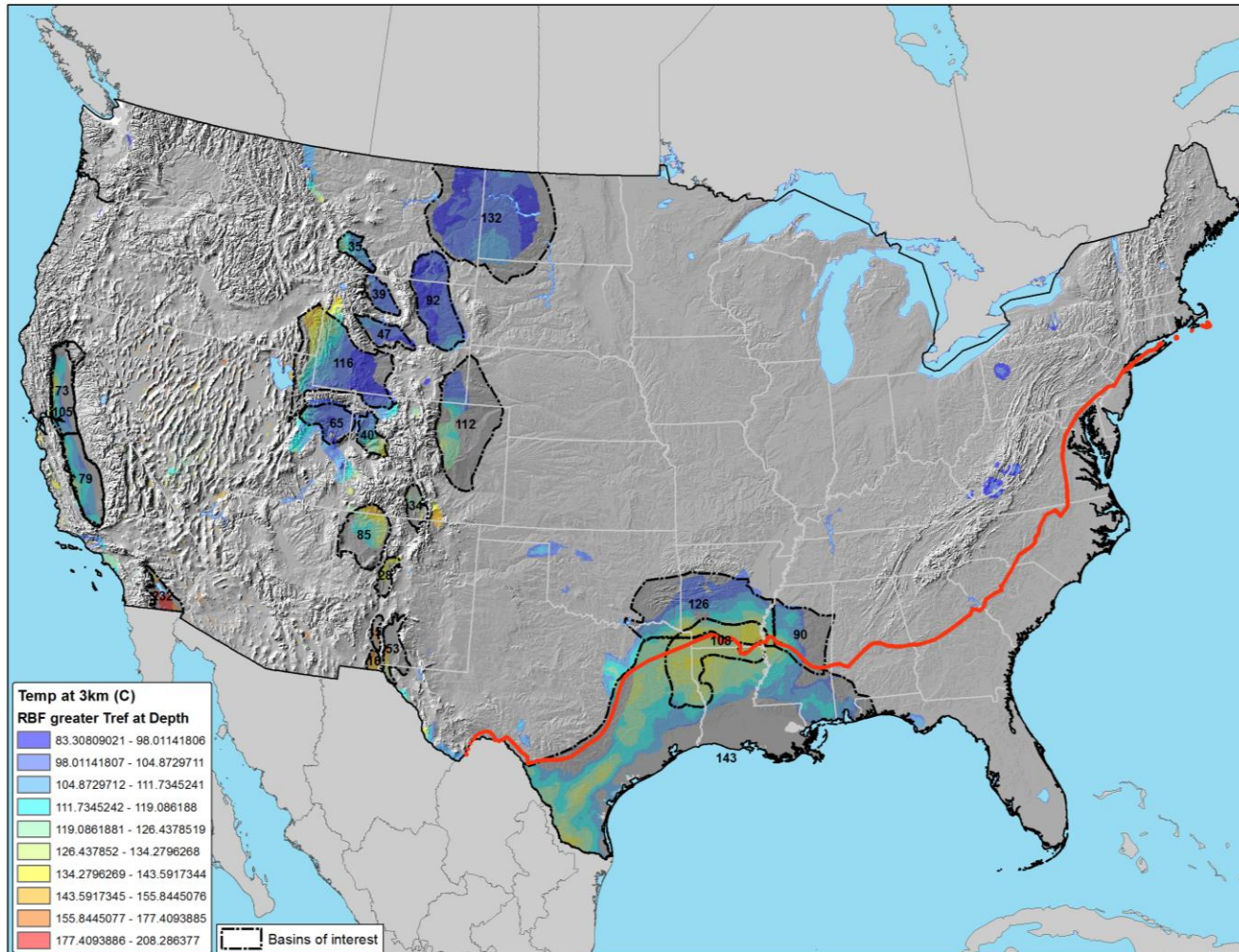
Confirming Deep Temperatures –  
New Heat Flow Measurements in  
Areas with Significant Data Gaps

Main focus in Northeastern Nevada

New data also being collected in  
Northeastern California (Surprise  
Valley). Regional fluid and heat  
transport modeling in Columbia  
Plateau also revising thermal  
picture (Burns et al., 2015).



- Sedimentary Basin Assessments – Completing temperature models for major sedimentary basins



# Accomplishments, Results and Progress

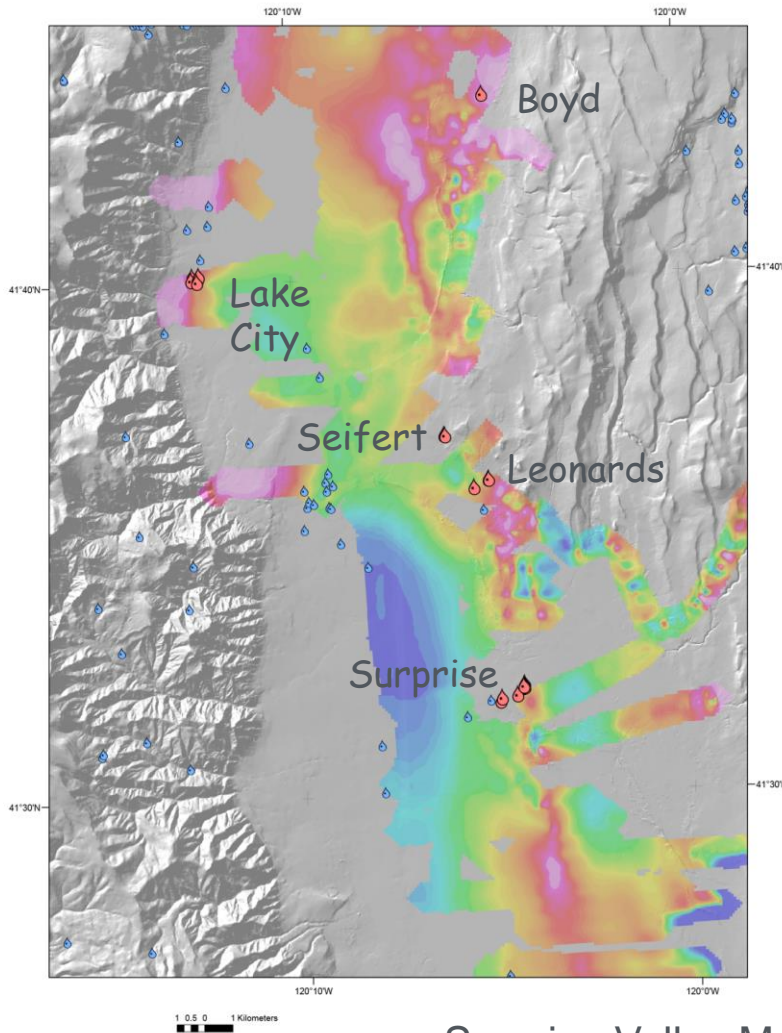
Original Planned Milestone/ Technical Accomplishment	Actual Milestone/Technical Accomplishment	Date Completed
Circulate Provisional Geothermal Resource Classification Definitions - 2011	Circulate Provisional Geothermal Resource Classification Definitions - 2011	February, 2011
Complete metadata for online USGS geothermal publications and deliver to NGDS along with legacy USGS GEOTHERM data - 2013	Complete metadata for online USGS geothermal publications and deliver to NGDS along with legacy USGS GEOTHERM data - 2013	March, 2014
Assessment of geothermal resources from low-temperature (<90 C) hydrothermal convection systems - 2013	Assessment of geothermal resources from low-temperature (<90 C) hydrothermal convection systems -2013	Completed 2013. Talk at Stanford, 2014. In press to GRC Meeting, 2015
Update EGS assessment methodology - 2014	Update EGS assessment methodology - 2014	February, 2015
Sedimentary basin resource assessment and comprehensive summary	Sedimentary basin resource assessment and comprehensive summary	In progress, anticipated December, 2015

- **Low-Temperature Geothermal Resources**
  - Assessment analysis complete. Finish digital release of data and addition of electric power estimates.
- **Geothermal Resource Classification System**
  - Work with IGA on report relating USGS and other geothermal classification systems to UN Framework Classification for mineral and petroleum resources
- **Improved EGS Assessment Methodology**
  - Direct USGS geothermal resource assessment project to initiate new national EGS assessment
- **Sedimentary Basin Resource Assessment**
  - Complete and integrate with other assessment components by December, 2015.



- USGS work under this project is providing a comprehensive portfolio of geothermal resource assessments for the entire United States, covering conventional and unconventional resources from low-temperature to high-temperature applications.
- Field and modeling studies are supporting new and revised assessment methodologies that will be applied in developing progressively more reliable assessment results.
- In addition to stimulating geothermal development, results can be incorporated into latest series of energy and market penetration modeling.

Innovative Airborne Geophysical Data Collection with NASA-USGS collaboration is an example of how DOE-supported effort expanding tools and techniques available for exploration and resource characterization. The result is high-resolution, cost-effective data collection.



Surprise Valley Magnetic Map from UAS Survey (J. Glen, USGS)