Abstract

The Great Basin Center for Geothermal Energy (GBCGE) was established at the University of Nevada, Reno in 2000, to work in partnership with the geothermal industry to increase the uptake and development of geothermal resources in the western United States. Mechanisms to achieve this include conducting innovative research, pursuing collaborative projects with industry, student projects, outreach activities and training. Research conducted at the GBCGE aims to better understand the geothermal resource potential of Nevada and the broader Great Basin, by investigating geological factors that control where geothermal resources are located in the region, and by developing new approaches for geothermal exploration to increase our discovery of ‘blind’ geothermal systems. In addition, we seek to understand the characteristics of geothermal reservoirs in terms of their temperature, volumes of fluid, permeability, fluid geochemistry, and fluid flow pathways, which are important factors for optimizing the development and management of geothermal resources. Notable achievements since the establishment of the GBCGE include:

- The compilation and release of geothermal datasets for the Great Basin (such as the geochemical groundwater database, geothermal favorability maps, and the Great Basin Geothermal GIS);
- development of new methods to explore for blind geothermal systems (e.g. shallow temperature surveys, remote sensing to map geothermal alteration minerals, structural favorability mapping, mercury soil gas studies);
- establishment of the National Geothermal Academy (NGA), to run annual educational courses to train the next generation of geothermal scientists and engineers (over 130 students have participated in the program to date), and
- Publication of over 50 peer reviewed articles and presentation of over 200 conference papers.
Future activities within the Center will include the ongoing release of data and products useful for geothermal explorers and resource operators, focused research to address the key challenges facing the geothermal industry in the Great Basin, community outreach, and training through the NGA. Anticipated future research directions include a focus on reservoir characterization and modeling, to better understand the dynamics of geothermal reservoirs in the Great Basin. In addition, the Center is currently involved in the US Department of Energy's FORGE (Frontier Observatory for Research in Geothermal Energy) initiative that aims to develop a site for operation and testing of Engineered Geothermal System technologies. In Phase 1 of FORGE, the Center has been involved in two of the five candidate sites: West Flank of Coso (California) and Fallon (Nevada). Both projects are being led by Sandia National Laboratories. Phase 1 is to be completed in June 2016, and the sites that will continue into Phase 2 of FORGE will be selected and announced in the following months.

References Cited


The Great Basin Center for Geothermal Energy: Past, Present and Future

Dr. Bridget Ayling; Director, Assoc. Prof.
Talk outline

• Geothermal in Nevada and the Great Basin:
  • Current use, Potential and Challenges

• GBCGE – What? Where? When? Who are we? What do we do?

• Achievements of the Center:
  • Research
  • National Geothermal Academy
  • Datasets

• Current projects the Center is involved in:
  • Nevada Play Fairway Project
  • FORGE at Fallon
Geothermal potential in the Great Basin

- Transtensional-extensional setting
- Characterized by elevated heat flow
- Significant geothermal potential: USGS estimated 30,000 MWe of undiscovered hydrothermal resources in the Western USA

Geothermal electricity in the Great Basin

- 26 geothermal systems being utilized
- Total installed capacity: 1100 MWe
- Resource temperatures: 140-270°C
- Hydrothermal systems
- Dominantly binary power plants
Geothermal electricity in Nevada

- 16 geothermal systems being utilized (with 25 power plants)
- Total installed capacity: 674 MWe
- Resource temperatures: **150-270°C**
- Hydrothermal systems
- Dominantly binary power plants

![Geothermal power plants map](image)

**Diagram:**
- Binary Cycle Power Plant
  - Turbine
  - Generator
  - Electricity
  - Injection Well
  - Production Well
  - Geothermal Reservoir
  - Heat Exchanger

**Map Overview:**
Geothermal energy in Nevada

Geothermal energy = renewable, baseload source of energy:

- an attractive option for meeting renewable energy targets
- Nevada's Energy Portfolio Standard requires that 25% of electricity sales come from renewable energy resources by 2025
- in 2014, 18.6% of Nevada’s net electricity generation came from geothermal, solar, wind, and hydroelectric power sources.
Current challenges for the Great Basin

Most existing known high-temperature geothermal resources were discovered via obvious surface indications (thermal features), and/or accidentally when drilling for petroleum or mineral exploration

• How can we find the currently-undiscovered geothermal resources that are likely to be ‘blind’?
• How can we find new areas with sufficient temperature and permeability to host an economic geothermal system (hydrothermal)?
• Can we develop Engineered Geothermal Systems (EGS)?
The Great Basin Center for Geothermal Energy

• Currently sits within the Nevada Bureau of Mines and Geology, at the University of Nevada, Reno (within the Mackay School of Earth Sciences and Engineering, and the College of Science)

• Established in 2001

• Mission: to work in partnership with U.S. industry to establish geothermal energy as a sustainable, environmentally sound, economically competitive contributor to energy supply in the western United States

• http://www.gbcge.org/
GBCGE Affiliates

Dr. Bridget Ayling  Dr. Jim Faulds  Dr. Bill Hammond  Dr. John Louie  Dr. Mark Coolbaugh  Andrew Sadowski

Dr. Wendy Calvin  Nick Hinz  Dr. Clay Cooper  Emma McConville  Holly McLachlan  Chris Sladek
GBCGE Activities

• Conducting innovative, applied research:
  • Investigation of the geological factors that control where geothermal resources are located in the Great Basin
  • Development of new approaches for geothermal exploration to increase discovery of ‘blind’ geothermal systems
  • Sub-surface characterization to optimize the development and management of geothermal reservoirs

• Collaborative projects with industry to address current challenges

• National Geothermal Academy: summer short courses to train the next generation of geothermal scientists and engineers

• Data dissemination, student supervision and outreach activities
Research achievements: 2001 - present

• Geodetic measurements and strain calculations
• Remote sensing of geothermal alteration minerals
• Soil mercury studies
• Detailed structural mapping studies
• Aqueous geochemistry database
• Shallow temperature surveys
• Geothermal potential maps

In preparation: a review document collating the Center’s work since it was established (lead author Lisa Shevenell)
Structural analysis

• Structural analysis and categorization of favorable structural settings in Great Basin settings and extensional settings worldwide

→ Enhanced our ability to predict where blind geothermal systems may be located

Figure courtesy of J. Faulds
Geodetic crustal strain measurements

- GBCGE initiated one of the first regional applications of geodetic crustal strain to geothermal studies – tool to map geothermal favorability
- Initial GCBGE funding helped to build the MAGNET GPS Network → improved our ability to map crustal extension on a regional scale

Kreemer et al., 2012
Shallow temperature surveys

• Improved and revitalized the approach applied at over 30 sites
• Provided a key role in the discovery of 7 blind geothermal systems in NV

Photos courtesy of A. Sadowski, and B. Tobin
Remote sensing techniques

- Hyperspectral image processing techniques used to identify alteration minerals and hydrothermal deposits on a regional and borehole scale
- GBCGE pioneered work using LiDAR and low sun angle photography to identify fault scarps and association with geothermal systems

Calvin et al., 2010
Regional aqueous geochemistry

- Great Basin Groundwater Geochemical Database
- Version 3.0 contains data for 47,500 samples from 16,855 sites in 15 data tables.
- Geochemical signatures demonstrated as a viable exploration tool
Student support and research outputs

• Over 75 undergraduate students supported on GBCGE-funded projects
• 33 MSc and 5 PhD students
• Nearly $18M awarded to 148 projects proposed and completed by GBCGE researchers
• 56 peer-reviewed papers; 242 conference publications; 5 book chapters; 11 geological maps generated from these projects
National Geothermal Academy

• The first national geothermal education program
• Initiated in 2010; training offered 2011-2014
• Several modules offered
• 138 students attended from 23 countries
• Instructors from industry, national labs and academia to help train the students in multiple disciplines.
• Funded by DoE grants in the early years. Self-supporting in final year. This model will be explored for the 2017 NGA
National Geothermal Academy 2017

- Geothermal drilling engineering
  - Bill Rickard (Geothermal Resource Group)
  - 1 week module, 18-23\textsuperscript{rd} June 2017

- Geothermal reservoir engineering:
  - Prof. Roland Horne (Stanford University)
  - 1 week module, 26-30\textsuperscript{th} June 2017
About

The National Geothermal Data System (NGDS) is a catalog of documents and datasets that provide information about geothermal resources located primarily within the United States (although information from other parts of the world is also included).

This complete and current catalog of available data, which is funded by the Department of Energy’s Geothermal Technology Office, is designed to accelerate the development of U.S. geothermal resources and can be used by the public, private industry, and the scientific community.

Contributors & Web Developers

NGDS exchange methods and metadata
Data Exchange Models
Learn how to submit data to the NGDS
For more information, visit

www.geothermaldata.org
National Geothermal Data System

56,381 datasets found

Geologic Map of the Grimes Point Quadrangle, Churchill County, Nevada, NBMG M173
1:24,000 scale Geologic Map of the Grimes Point Quadrangle, Churchill County, Nevada. Nevada Bureau of Mines and Geology Map 173. Detailed geologic mapping by John W. Bell and...

Geologic Map of the Austin quadrangle in Lander County, Nevada, USGS GQ-1307
1:62,500-scale, full-color Geologic Map of the Austin 7.5' quadrangle in Lander County, Nevada, with 4 cross sections and description of 30 units. The GIS work was in support of...
National Geothermal Data System

• UNR is the **western regional data hub** for the NGDS. We store, host and deliver Tier 3 geothermal datasets for NV, UT, ID, MT, SD, CO and WY.

• Data is categorized in one of three interoperability tiers; the higher the tier, the greater the level of interoperability. Tiers roughly conform to whether data can be accessed through a web service or must be downloaded or viewed as a file.

  - **Tier 1**: Unstructured data (text, images, or sound)
  - **Tier 2**: Structured data that does not conform to an NGDS schema
  - **Tier 3**: Structured data that conforms to an NGDS schema
Current projects
Geothermal Play Fairway Analysis

• Funded by the US Department of Energy

• Ultimate goal: improve the success rate for exploration drilling and reduce the development risk and capital cost

• Individual project aim: identify areas with high potential for hosting blind geothermal systems
  
  • **Phase 1**: Develop a workflow involving the synthesis of geological, geochemical and geophysical data to identify/predict locations that have the most favorable intersections of heat, fluid and permeability (11 sites)
  
  • **Phase 2**: collect new geological, geochemical and geophysical data for identified sites with potential to reduce uncertainty: identify drilling targets (6 sites)
  
  • **Phase 3**: drill sites that have greatest demonstrated potential to host a blind geothermal system, thus validating methodology
UNR’s Play Fairway Project – Phase 1

Figures courtesy of Jim Faulds
UNR’s Play Fairway Project – Phase 2

Figures courtesy of Jim Faulds
Frontier Observatory for Research in Geothermal Energy

The Energy Department envisions FORGE as a dedicated site where scientists and engineers will be able to develop, test, and accelerate breakthroughs in enhanced geothermal system (EGS) technologies and techniques.

• Ultimate goal: make EGS **commercially viable**
EGS potential in the USA

• USGS estimates we could have >500 GWe if we can unlock the potential of EGS (total power generation capacity in the USA is ~1100 GWe)

• Prior EGS projects funded by Department of Energy:
  • Raft River, ID (1979, 2010-present) Baca, NM (1981)
  • Desert Peak, NV (2009-?) Bradys, NV (2010 - ?)
  • Newberry Volcano (2010- ?) Geysers, CA (1981, 2011-2013)

• R&D challenges: how do we safely create and maintain permeability in an engineered reservoir? Can we make it economic?
FORGE timeline

• **Phase 1:** Sites are evaluated for their suitability to host FORGE (5 sites evaluated: Snake River Plain, ID; Newberry Volcano, OR; Milford, UT; Fallon, NV; Coso, CA) (2015-2016) $2M

• **Phase 2:** Down-select to 2 sites; set up and further site characterization (Fallon, NV and Milford, UT) (2016-2018) $29M

• **Phase 3:** FORGE is operational as an R&D test site (~2018/2019)
Fallon, NV: FORGE Team

- PI: Sandia National Laboratories
- 10 organizations
  - National labs
  - Academia
  - Industry
  - Geological Surveys
- Diverse team
- Several decades of collective experience in geothermal research
FORGE Phase 1 at Fallon

Demonstration of Fallon meeting the FORGE site criteria:

• Temperature (175 – 225 °C)
• Depth (1.5 – 4 km)
• Low permeability rocks (< 10^{-16} m²)
• Crystalline lithology
• Appropriate stress regime
• No hydrothermal system
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Data assimilation and synthesis

- FORGE Parameters – Data Constraints
  - Stratigraphic – Surface, wells, petrographic
  - Structural – faults, stress regime
  - Thermal Data
  - Fluid Geochemistry Data
  - Alteration Data
  - Well Flow Testing Data
  - Geophysical Data
    - Gravity and magnetic
    - MT
    - Seismicity
    - Seismic reflection
FORGE Phase 2a and 2b at Fallon

- Securing required environmental permitting (NEPA etc.)
- Additional site characterization to address data gaps, related to:
  - Obtaining baseline data sets for evaluating stimulation – including installation of a micro-seismic monitoring array
  - Precisely locating EGS targets – drilling a core hole
  - Establishing mechanical properties of potential targets
  - Selecting future drilling sites with minimal geological risk
  - Minimizing geological uncertainties

→ Watch this space
Thank you