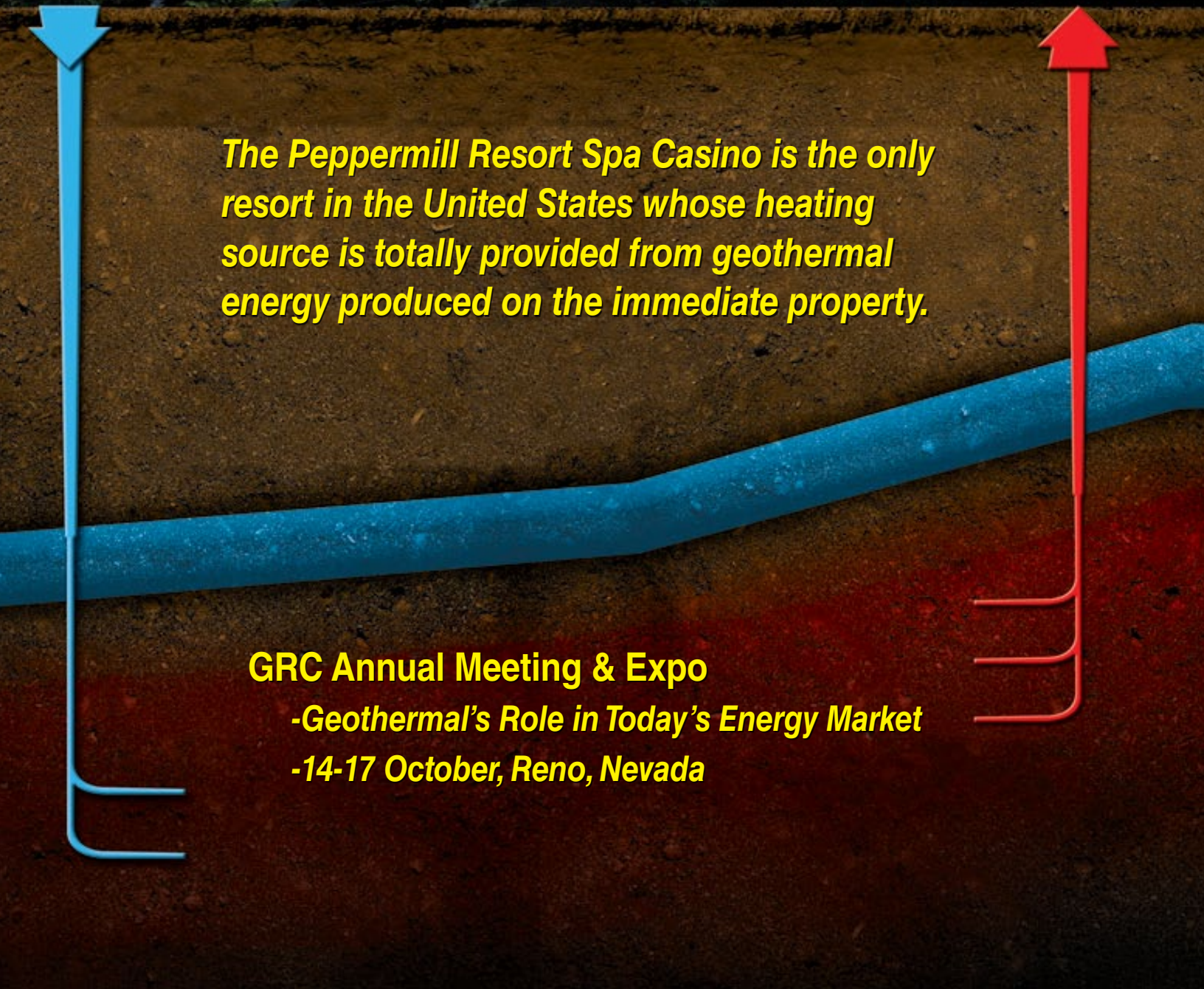
GEOTHERMAL RESOURCES COUNCIL

Bulletin

Vol. 47, No.5
September/October 2018



The Peppermill Resort Spa Casino is the only resort in the United States whose heating source is totally provided from geothermal energy produced on the immediate property.

GRC Annual Meeting & Expo

-Geothermal's Role in Today's Energy Market

-14-17 October, Reno, Nevada

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The Geothermal Resources Council (GRC) *Bulletin* (ISSN No. 01607782) is published as a service to its members and the public, with six issues per annual volume. The GRC is an international, non-profit educational association whose purpose is to encourage research and environmentally sound exploration, development, and utilization of geothermal-energy resources worldwide through cooperation with governmental agencies, academic institutions, and the private sector. The GRC *Bulletin* provides a forum for information transfer to the public and among professionals in many fields related to geothermal resources, including geology, exploration, development, electric-power production, and direct-use technologies. The views and opinions expressed by authors in this publication do not necessarily reflect those of the GRC or its members. For changes of address or membership information, please contact us.

COVER: *All the events and accommodation at the GRC Annual Meeting & Expo are in one location, the luxurious Peppermill Resort Spa Casino.*

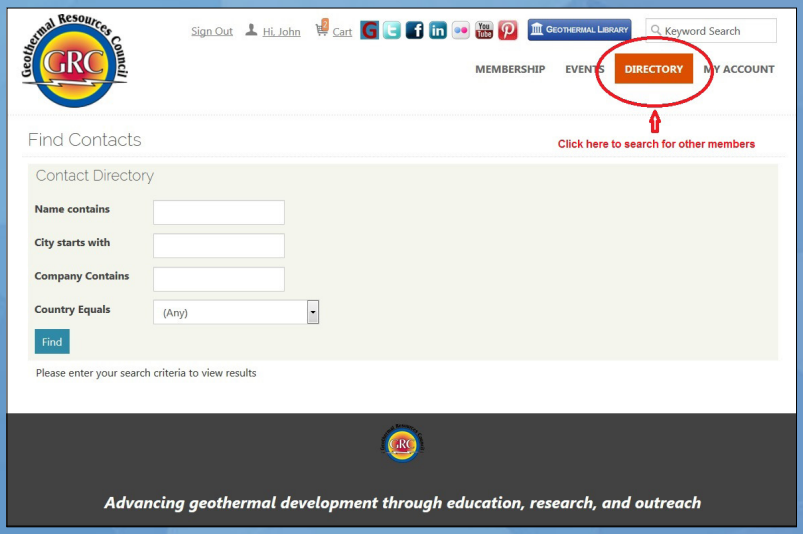
The GRC Membership Directory At Your Fingertips

www.my.geothermal.org

The online membership directory provides the most up to date contact information for all GRC members at your fingertips.

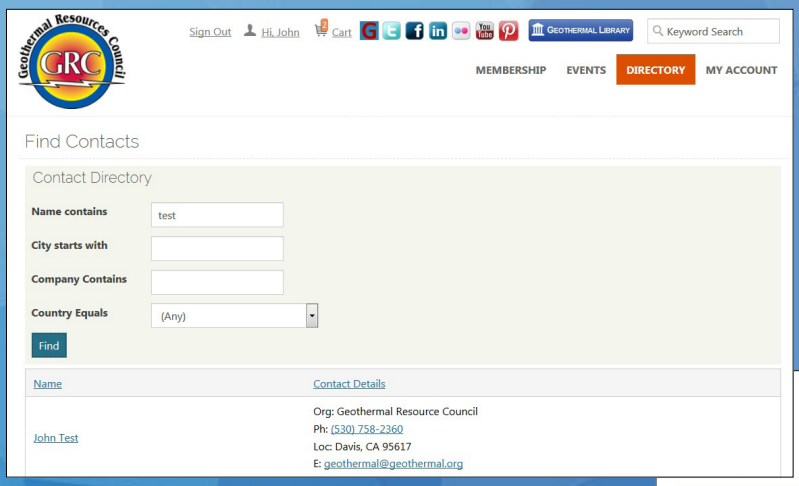
Step 1

Login to the GRC Membership website: my.geothermal.org
(Tip: Bookmark this webpage on your smart phone for easy access)



Step 2

Click on the Directory Tab

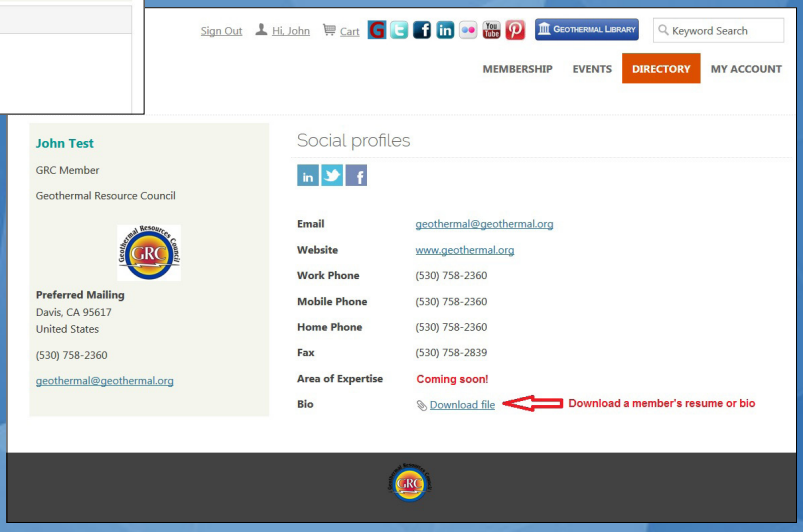


Step 3

Search by Name, City, Company, or Country
(Coming soon: search by Expertise)

Step 4

Click on the name of the person and view their public profile.



This feature is only available to current GRC members. If you have not renewed, please contact Anh Lay at alay@geothermal.org to renew your membership and update your profile!

President's Message

by Maria Richards

Making a List

Are you someone who wakes up in the middle of the night with a list of items running through your head? I've read that if you write down everything you need to accomplish, you achieve more in life. Last night I found myself writing a list of lists: list of GRC Award winners, list of GRC student scholarship recipients, list of Annual Meeting Committee members, list of nominations for Board, technical sessions to attend, booth representatives to meet, etc. Then I realized that every list was related to people, people who were important in my life and I expect in your life too, because we, as GRC Members, are really one big geothermal family who support each other. We can be competitors and good friends.

Instead of listing all the names of the people in my lists, it's more fun to give you the ability to see how many faces you can name in the collage. The lists mentioned above are all in the GRC Annual Meeting app, which by the way, you can download ahead of time before arriving in Reno. Look forward to seeing you soon! ■

Executive Director's Message

by Will Pettitt, PhD

The 2018 Annual Meeting Steams Ahead (and so does the 2019 one!)

The 2018 Annual Meeting & Expo in Reno is nearly upon us. Like its predecessors, it will be the largest annual gathering, and premier technical program, of the geothermal community in the world. I would first like to thank all the volunteers and staff that contribute to our conference. It takes a small army of people to organize the meeting and all the activities that are planned. Each of you know what you have contributed. I speak on behalf of the GRC and geothermal community to say that everything you do is really appreciated and we are all very grateful for your efforts. For all our volunteers, please know that the GRC could not function without you, and that the staff, management, and Board are grateful for every moment of time you donate.

Our conference is organic and simply could not survive and flourish without everybody's contribution. At the meeting this year, we will have almost 200 technical papers presented over three days in five tracks of oral sessions running sequentially, along with a poster session. We all understand how much work has gone into each and every one of these papers. As well as the time in performing the original research and analysis, there is the commitment to writing the paper, putting together the presentation or poster, and attending the conference to present it. The Annual Meeting truly highlights the width and breadth of the community we have in geothermal energy spanning science, engineering, social-economics, and government, and highlights the eclectic mix

Worldwide locations of the 1,176 GRC members, as of the end of 2017.

of people that are involved: students, corporate entrepreneurs, politicians, professionals and researchers. The extent of that mix can be seen by browsing the preliminary technical program found on the website or downloading the conference app.

The conference will have three technical workshops, including a "101" to which the general public is invited, four fieldtrips, and numerous social events (including a student-led trivia contest where we hope to see the likes of ORMAT and Schlumberger face off against their corporate competitors!). The meeting is also a large business affair, with over 70 booths lined up in the Expo*, where companies gather to promote their products and services, and take advantage of the opportunity for a meeting of clients with vendors. The conference is well known for high-level, big-budget, side meetings with many projects signed and sealed within our walls. There's also the social networking of everybody together across our community (industry, academia, government, and public) where some of those big project ideas are initially discussed, or research ideas are born. This year, these meetings of folk include both the GRC and International Geothermal Association (IGA) Board Meetings that will occur ahead of the published program. The corporate flavor not just contributes through the Expo, but also through our many sponsors that help make the conference financially viable, and through the mix of attendees knowledge, experience and personalities from across the geothermal industry.

Our conference attendees also highlight the international flavor of the GRC as a whole. Although based in the USA, we are an international organization by definition due to the globalized nature of our community, with 1,176 members from 44 different countries, as at December 2017 (see figure above from our website). The GRC should be an outward facing, collaborative organization, that partners with other international associations to speak for our community with one voice and work in the best interest of all our members (the GRC was pivotal in the original creation of the IGA as described in an article later in this *Bulletin*). The GRC's international outreach and activities will only get greater through necessity as our industry becomes more globalized. In my view this is the same for every country association in the world. Our organization can continue to contribute by helping to build networks of stakeholders across the globe to help geothermal energy become more recognized and accepted, and in doing so, help all of us working for the same cause to have a consistent message and be more effective at communicating that message globally.

The Annual Meeting is a gathering of our community and our membership. It's an opportunity for everybody to network, to learn, to do business, and to contribute to the direction of the geothermal industry. Please let us know how the GRC can help you in your work and how we can together help elevate our industry. As we enter a successful 2018 meeting we also have our eyes on the future. The GRC has many ongoing activities and new initiatives that we are starting; you can learn more at our booth in the Expo hall or talk with any of the staff or Board. Preparations have also begun for our conference in 2019 in Palm Springs, California, September 15-18, where there are fantastic facilities lined up at the conference center and hotels, situated in a beautiful part of the world. So, you have 12 months to put on your thinking caps, sharpen your pencils, develop some geothermal power, and we'll see you there!

* as of publication

If you want to talk about our association and the geothermal energy community you can contact me at wpettitt@geothermal.org or 916.758.2360 ext. 103. ■

The 2019 GRC Annual Meeting & Expo will be in Palm Springs, California, September 15-18. GRC staff **Anh Lay, Will Pettitt** *and* **Estela Smith** *paid a visit to Palm Springs during the summer.*

Communication from the GRC

by Ian Crawford
Director of Communications

Geothermal Energy Awards Announced

The GRC has announced awards honoring the best and brightest of the global geothermal energy community. These prestigious awards have been a highlight of the geothermal calendar since the late 1970's.

The GRC will present the prestigious Aidlin, Pioneer, Henry J Ramey Jr., and Geothermal Special Achievement awards at the GRC Annual Meeting in Reno, Nevada, October 14-17.

The recipients of these awards have a lifetime of achievement in the geothermal academic, scientific and commercial communities. The GRC Awards recognizes the contributions of these individuals to educational institutions and the geothermal community around the world.

This year's award winners are:

- *Joseph W. Aidlin Award* - **Ron Barr**
  For your early and long-standing service to the GRC, your active promotion of the use of geothermal energy, and your participation in the development of numerous projects over more than 40 years.
- *Geothermal Pioneer Award* - **Zvi Krieger**
  For contributions to the development and enhancement of binary plant technology, integration of facilities and reservoir characteristics leading to successful projects, and for leadership in the advancement of geothermal development around the world.
- *Henry J. Ramey Jr. Award* - **Peter Rose**
  For developing and commercializing the high temperature geothermal tracers that now make tracer returns one of the most insightful tools available to reservoir engineers.
- *Geothermal Special Achievement Awards*
  Recognizes special or outstanding achievements in any aspect of geothermal energy development and related areas:
  - **Roy Baria** - For your outstanding work in the worldwide development of Enhanced Geothermal Systems.
  - **Virgil Welch** – In recognition of a long and distinguished career in providing project management and drilling solutions to the geothermal industry, dealing effectively with challenging wells, and mentoring a generation of drilling professionals.
  - **Kasumi Yasukawa** – For her contributions to the use of geophysics in geothermal exploration, her tireless support of geothermal development in Asia, and her selfless service to the Fukushima Renewable Energy Institute after the Fukushima Daiichi nuclear disaster.

2018 Geothermal Scholarships

Last year's scholarship winners.

The GRC is pleased to announce the recipients of eight GRC Scholarship Awards.

The selection was based upon a variety of factors, including the individual's academic record, student activities, geothermal industry experience, and career goals.

The **Undergraduate Award** winners are:

- **John Grill** (Montana Tech University);
- **Christ Quinicot** (Negros Oriental State University, Philippines) and
- **Estefanía Ramírez Restrepo** (University of Medellin, Colombia).

The winners of the Graduate Awards are:

- **Estefanny Dávalos-Elizondo** (Oklahoma State University);
- **Jonathan Ogland-Hand** (The Ohio State University);
- **Arna Palsdottir** (Cornell University);
- **Jared Smith** (Cornell University) and
- **Yuran Zhang** (Stanford University).

The scholarship winners will be acknowledged at the GRC Annual Meeting & Expo, to be held in Reno, Nevada, USA, from October 14-17.

Register Online and Save $50

The biggest geothermal energy event of the year is almost upon us! It's not too late to make last minute arrangements!

The latest information is available on the GRC website at: geothermal.org/meet-new.html, a *Program* is available to view, download and print-out if you wish. Though we strongly urge you to save paper by viewing all the information on your computer or mobile device.

However, the best way to experience the GRC Annual meeting & Expo is through the Event App. See the instructions below.

After the early-bird deadline of September 30 **GRC members** pay **$1,030** for a three-day registration and **non-members** pay **$1,280.**

The non-member registration includes GRC membership through 2019. The cost includes lunches on all three days and a USB stick containing all the Technical Papers.

Students with a current identification card from an accredited institution **pay just $175** for a three-day registration which also includes GRC membership through 2019.

Registering at the event in Reno incurs an additional USD 50 fee.

5 Easy Ways To Register:

1. my.geothermal.org
2. Fax: 530.758.2839
3. Phone: 530.758.2360 ext. 100
4. Email: alay@geothermal.org
5. Mail: GRC, PO Box 1350, Davis, CA 95817

Reserve your Room for the Geothermal Event of the Year

https://aws.passkey.com/event/49537648/owner/7268/home

All the events and accommodation are in one location, the luxurious **Peppermill Resort Spa Casino.**

The Tuscany Foyer at the Peppermill.

There is a choice of three room styles in the **Peppermill North and West Wings** the more luxurious **Tower Rooms** offering panoramic views of the majestic Sierra Nevada mountains and at the top of the line, the lavish accommodations in the **Tuscan Tower.**

Attendees can make their reservations on a secure website prepared specially for the GRC. The links are available from the GRC Annual Meeting website at: www.geothermal.org/meet-new.html.

Geothermal Event? We've got an app for that!

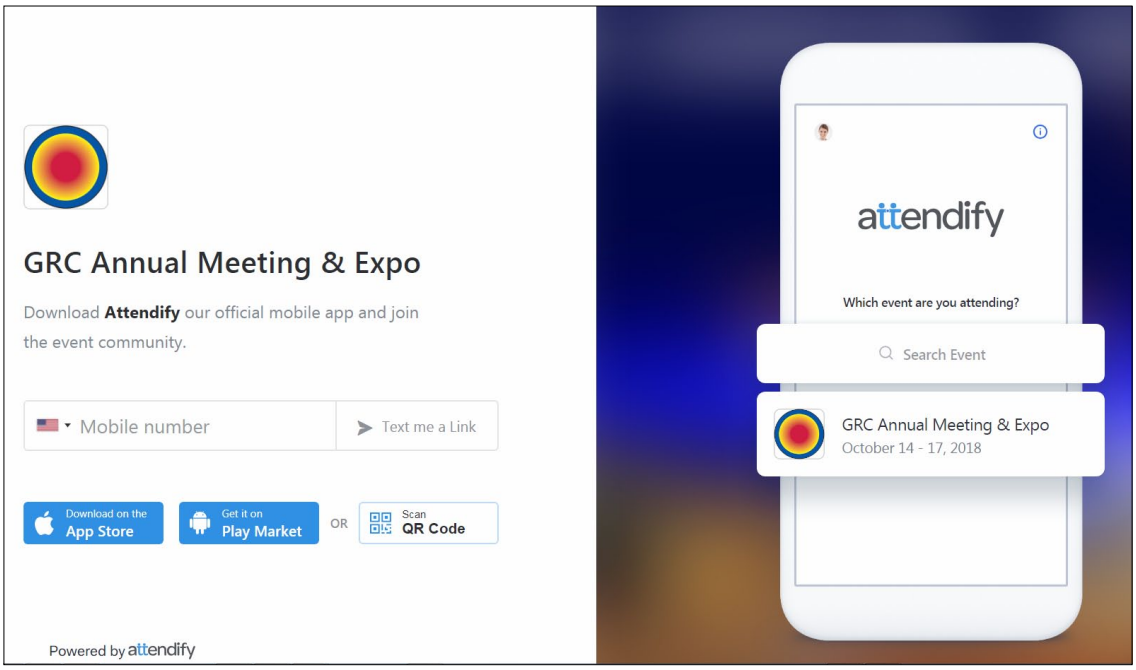
Due to popular demand we are again providing a mobile app for the GRC Annual Meeting & Expo for use on a Smartphone, tablet or desktop. This is the best way to keep up-to date with news and information at your favorite geothermal energy event. Are you going to Reno to network? The app will help you find old friends and connect with new ones.

The app can be downloaded from a dedicated website at https://attendify.com/app/o2gnls/ - the instructions are a little different to last year - you have to first download a "container app".

1. Download the "Attendify - Network at Events" app from the App Store or Google Play.
2. Open the app and sign up by tapping the corresponding button at the top or bottom of the page, or log in if you already have a profile. To create an account, we recommend using the email address you registered for the event with.
3. Search for "**GRC Annual Meeting**".
4. If you already joined an event, it will be visible on the home screen of the Attendify App under "Your Events" section, or you can quickly open the list of all events you joined from the side menu.
5. On the event card, you can find the GRC Annual Meeting's date, location, and description. Tap join to access the event, see the full, up-to-date information and start interacting with other users.

Have Your Say!

If you would like to comment on any column or article in the *GRC Bulletin* or have an opinion on a topical subject that will interest our readers, please email the editor, **Ian Crawford** at icrawford@geothermal.org or mail to Geothermal Resources Council P.O. Box 1350, Davis, CA 95617-1350.



Download the app at https://attendify.com/app/o2gnls/

REGISTER NOW FOR THE FIRST ANNUAL GRC

TRIVIA NIGHT & MIXER!

PRESENTED BY THE GRC STUDENT COMMITTEE

Challenge Your Colleagues In A Game Of Knowledge!

How Much Do You Know About Geothermal Energy?

WHO: You and up to 5 colleagues against teams (plus a student paired by the GRC) from all over the world representing every sector of the industry.

WHAT: An intense game of team trivia, complete with prizes for the top finishing teams.

WHEN: Monday, October 15th 2018 @ 6pm - 9pm

WHERE: The Edge Night Club at the Peppermill Resort Spa Casino, Reno NV, USA

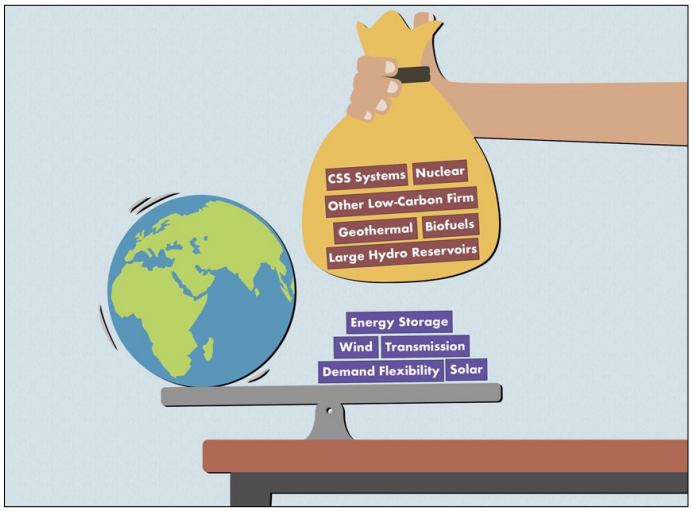
WHY: Enjoy friendly academic competition while contributing to the development of geothermal students across the glove! All proceeds will go to the GRC Student Committee to fund future student events and activities.

HOW: Register TODAY at my.geothermal.org. Cost is $700 for a team of up to five (5) or $140 for an individual (will be placed in a team of 5), and $75 to watch the competition. Student are free wit ha GRC Annual Meeting registration. Registration includes free hors d'oeuvres and up to three (3) drinks.

1. 10x10 booth for the 2019 GRC Annual Meeting, picture in the GRC Bulletin & bragging rights!
2. $50 gift card to each person.
3. 2019 GRC Individual membership for each person.

Inside Geothermal

New Report Suggests Categorizing Geothermal as a "Firm" Energy Resource



In looking at options for new power generation in different scenarios, a new report from the **Massachusetts Institute of Technology (MIT) Energy Initiative** finds that the traditional way of describing different types of power sources in the electrical industry — **"baseload," "load following," and "peaking" resources** — is outdated and no longer useful, given the way new resources are being used.

Rather, they suggest, it's more appropriate to think of power sources in three new categories: **"fuel-saving" resources**, which include solar, wind and run-of-the-river (that is, without dams) hydropower; **"fast-burst" resources**, providing rapid but short-duration responses to fluctuations in electricity demand and supply, including battery storage and technologies and pricing strategies to enhance the responsiveness of demand; and **"firm" resources**, such as nuclear, hydro with large reservoirs, biogas, and **geothermal**.

The new findings are described in a paper published in the journal *Joule*, by MIT doctoral student **Nestor Sepulveda, Jesse Jenkins, Fernando de Sisternes**, and professor of nuclear science and engineering and Associate Provost **Richard Lester**.

In conclusion, the authors of the report recommend "**an electricity system that uses firm low-carbon resources** together with solar, wind, and storage that can achieve zero emissions with only modest increases in cost even under pessimistic assumptions about how cheap these carbon-free resources become or our ability to unlock flexible demand or expand the grid." **The addition of firm low-carbon resources "is an effective hedging strategy that reduces both the cost and risk" for fully decarbonizing power systems.** *Global Geothermal News*

NORTH AMERICA

DOE Announces Funding for Projects Researching Reliable Zonal Isolation Tools and Technologies for EGS

The **U.S. Department of Energy (DOE)** has announced nearly **USD 4.45 million** for four projects supporting early-stage research and development of tools and technologies for **enhanced geothermal systems (EGS).** The projects seek to improve the performance and increase the cost-effectiveness of EGS through **research in zonal isolation.**

The selected projects will focus on researching and developing reliable zonal isolation tools and technologies that present low risk to wellbore integrity or the conductivity of fractures; operate at high temperatures in corrosive, hard rock environments for extended periods of time; and withstand large pressure differentials.

The selected projects include:

• **C-Crete Technologies, LLC** (Stafford, Texas): Developing graphene nanoribbons embedded in high performance polymers that can be cured and isolate zones downhole through targeted high-energy microwaves.

• **Fervo Energy Company** (San Francisco, California): A collaborative effort with Schlumberger to upgrade their most popular zonal isolation technology ("Copperhead") with high-temperature components (elastomers) to enable deployment in geothermal environments.

• **Hotrock Research Organization (HERO)** (Seattle, Washington): Developing a high temperature packer system based on thermally-degradable expanding materials for zonal isolation, including expandable elastomers and foams to temporarily isolate zones downhole.

• **Welltec, Inc.** (Katy, Texas): Designing an all metal, elastomers-free zonal isolation tool to enable use in higher-temperature, EGS environments.

Global Geothermal News.....

DOE Announces Funding for Projects to Utilize Geothermal Energy to Create A Modern Grid of the Future

The U.S. Department of Energy's **Geothermal Technologies Office (GTO)** has announced the selection of eight projects to receive up to **USD 2.4 million** in funding via the **Beyond Batteries Lab Call: Geothermal Energy Applications for Storage Alternatives.**

These projects will explore opportunities for integrating geothermal energy into various functions in support of the Beyond Batteries objectives. These include dispatchability, co-production, and hybrid operations to improve grid reliability, resilience, and security.

The selected projects include:

- **Brookhaven National Laboratory**: Advanced Thermal Shock-Resistant Cement (TSRC) Suitable to Withstand Frequent Thermal Cycling
- **Idaho National Laboratory**: Dynamic Earth Energy Storage: Terawatt-Year, Grid-Scale Energy Storage using Planet Earth as a Thermal Battery
- **Idaho National Laboratory**: Geo-Solar Hybrid Power Plant with Subsurface Thermal Energy Storage to Increase Geothermal Plant Dispatchability
- **Lawrence Berkeley National Laboratory**: Analysis of Curtailment of Geothermal Power Generation in the California Electricity Market and Beyond – Temporal Variability and Future Trends
- **National Renewable Energy Laboratory**: Exploring the Role of Geothermal in Enhancing Cold-Climate Net Zero Communities
- **National Renewable Energy Laboratory**: Alternative CAES Technology Using Depleted Unconventional Gas Wells and Subsurface Thermal Energy Storage
- **Oak Ridge National Laboratory**: A Mobile Sorption-Based Thermal Battery for Harvesting Geothermal Energy
- **Oak Ridge National Laboratory**: Novel Heat Pump Integrated Underground Thermal Energy Storage for Shaping Electric Demand of Buildings

These projects support the objectives of the DOE **Grid Modernization Initiative (GMI)** by exploring approaches to utilize geothermal energy in order to create the modern grid of the future.

The GMI works across DOE with the goal of developing the tools and technologies that measure, analyze, predict, protect, and control the grid of the future. As part of the GMI, the Beyond Batteries Initiative considers energy storage holistically. It focuses on opportunities for flexible generation, controllable loads, and new approaches to the broader concept of energy storage to effectively mimic many of the benefits of large scale batteries and to increase the reliability and resilience of the U.S. energy systems. *Global Geothermal News.....*

ENERGY.GOV
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ENERGY EFFICIENCY & RENEWABLE ENERGY
Geothermal Technologies Office

The Geothermal Technologies Office will be attending and exhibiting at the GRC Annual Meeting & Expo from 14-17 October in Reno, Nevada, USA.

Opportunity for Geothermal Energy Industry to Influence Production of Hydrogen

The DOE Office of **Energy Efficiency & Renewable Energy (EERE)** has announced the release of a *Request for Information* (RFI) soliciting stakeholder feedback on opportunities to enable **high volume production and multi-sector use of hydrogen. Responses are due October 31, 2018, at 5:00 PM Eastern Time.**

Hydrogen is an energy carrier and a feedstock used in industrial applications today including petroleum refining, ammonia production for fertilizers, and steel production, and can also be used in fuel cells to generate power for homes or to drive cars, buses or trucks. With the help of this RFI, hydrogen use could be expanded and made more affordable across multiple applications such as energy storage, running large turbines at power plants, supporting grid flexibility and enabling baseload operation of nuclear plants, as well as **increased renewable power generation.**

The *GRC Bulletin* has reported before on a couple of projects in **Iceland** and **New Zealand** where hydrogen is produced as a by-product of geothermal power plants. The *Request for Information* should be seen as an opportunity for the geothermal industry to influence future production of hydrogen in the USA. *Global Geothermal News.....*

Inside Geothermal

California Legislation Requires all Retail Electricity be Generated from Zero-Carbon Resources by 2045

California Governor Jerry Brown has signed a bill that would require **all retail electricity** to be generated from **Zero-Carbon Resources by 2045**. The 2045 goal may be met with not only Renewables Portfolio Standard (RPS)-qualifying renewable energy (**including geothermal**), but also technologies such as large hydro, nuclear, and natural gas with carbon capture and storage that do not emit carbon into the atmosphere.

Despite objections from utilities and oil companies, **Senate Bill 100**, introduced by **Sen. Kevin de León**, would revise interim RPS goals along the way. The bill bumps up an existing target by four years to hit **50 percent renewable energy in 2027** and sets the state on track to meet the **60 percent threshold by the end of 2030.**

In addition, Gov. Brown also announced an executive order at the signing ceremony directing California **to achieve carbon neutrality**, meaning it would remove as much carbon dioxide from the atmosphere as it emits, also by 2045. *Global Geothermal News.....*

California Geothermal Energy Bill Came Close to Passing, but.....

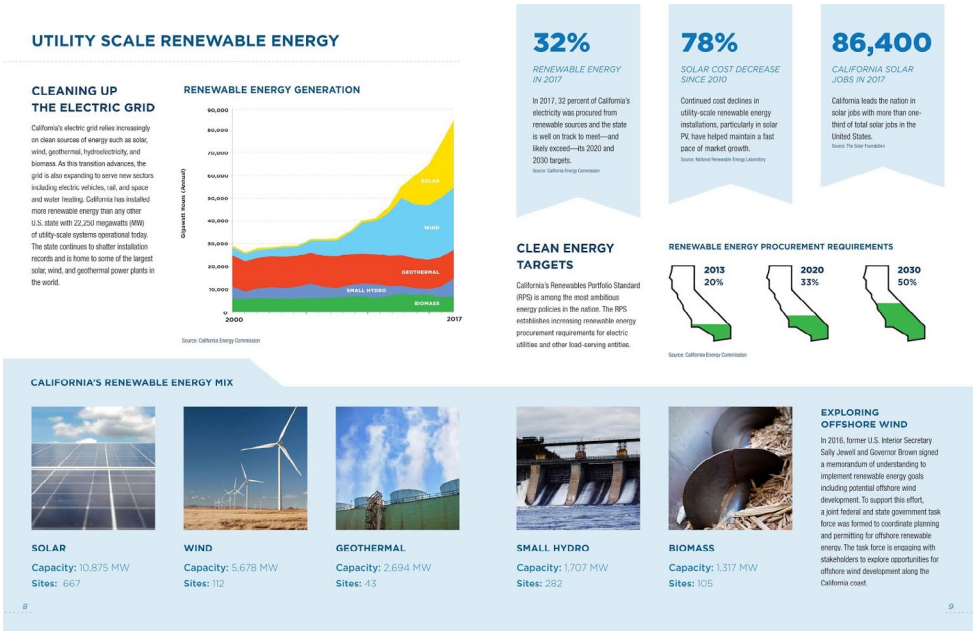
If the signing-into law of SB 100 could be a boon for renewable energy in California an opportunity to direct development to the geothermal energy sector fell by the wayside.

California lawmakers failed to pass a bill (**AB 893**) that would have promoted geothermal energy development in the Golden State. The geothermal bill might have passed, if not for last-minute opposition from a state Republican senator. *Global Geothermal News.....*

2.7 GW Geothermal Energy Helps California Achieve Clean Energy Goals

A new report by the **California Energy Commission** discusses how the Golden State continues to lead in increasing renewable energy and reducing greenhouse gas emissions (GHG). *Download the report.....*

Toward A Clean Energy Future details California's progress in setting innovative energy policy, promoting a clean energy economy, ensuring energy resiliency, and supporting disadvantaged and low-income communities. *Global Geothermal News.....*



GRC Executive Director Attends Renewable Energy Awards Ceremony

The **Center For Energy Efficiency and Renewable Technologies (CEERT)** 16th **Annual Clean Power Champion Awards** were held recently in Sacramento, California. The geothermal energy community was represented by the new Executive Director of the GRC, **Will Pettitt**, gratefully sponsored by **Berkshire Hathaway Energy**.

At the event four champions and pioneers of energy conservation and green, renewable energy were honored including good friends of the geothermal energy community, **Assemblymember Eduardo Garcia**, California State Assemblymember,

Assemblymember **Eduardo Garcia** *speaks to the audience at the awards ceremony. Courtesy* **Will Pettitt**.

District 56 and **James H. Caldwell, Jr.**, Technical Director, CEERT. *Global Geothermal News.....*

Fallon EGS Site Could Still be Developed

NAS FALLON
FORGE
Geothermal Research Observatory

Despite losing out on the decision to award the **Frontier Observatory for Research in Geothermal Energy (FORGE)** to Utah, the **Fallon FORGE** team still has hopes to develop the site.

As reported by the *Sparks Tribune*, GRC Member **James Faulds**, the **Nevada state geologist** and director of the **Nevada Bureau of Mines and Geology**, said that he thought the Fallon team, which he was involved with, put forward a strong proposal. He said the Fallon site would have explored three rock types whereas the Utah site would only target one rock type.

"We really thought we had the best project and best team," he said.

For everyone involved, the question has turned to what happens to years of research, development and initial exploration at the proposed lab site in Fallon.

"The dust is still settling a bit from the decision," Faulds said. "There is interest out there to do work on that site independent of the official FORGE [project]."

He said that it's possible a private company could develop a geothermal power plant on the site. He added that there has already been some industry interest in using the team's research to turn the site into a commercial project.

"We know that the site is very suitable for [an enhanced geothermal project]," he said.

Nathan Strong, who directs the **Churchill Economic Development Authority**, said that in addition to developing the Fallon site for a commercial project, there is still talk of conducting research there. **Western Nevada College**, he said, is interested in continuing work on the project.

"There's the potential to acquire money out there and kind of do our own thing," Strong said. *Global Geothermal News.....*

Ormat Plans to Add Additional 16 MW to Steamboat Hills Geothermal Power Plant

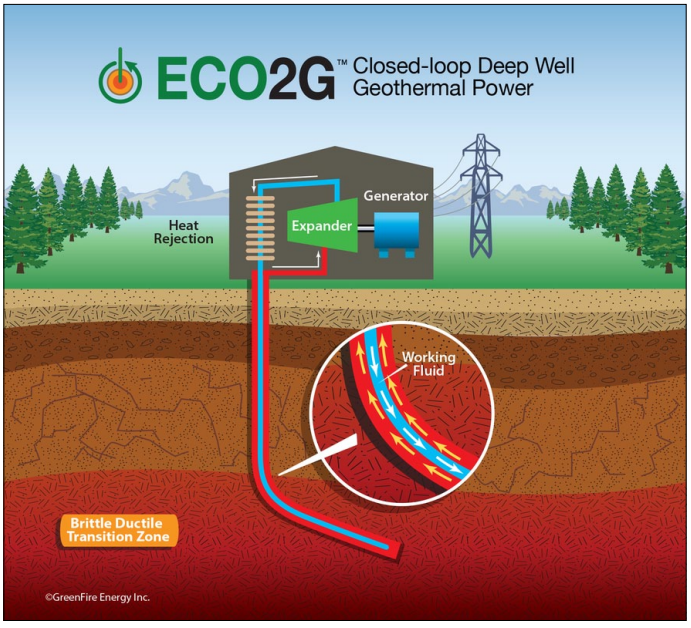
In an earnings call to discuss Ormat Technologies, Inc. Q2 2018 results **CEO Isaac Angel** announced the company's plans for the immediate future.

".... **we removed Puna enhancement from our plans** as the project is currently on hold and we added an enhancement project for **Steamboat Hills** power plant where **we expect to add additional 16 MW to the existing power plant** before the end of 2020. Steamboat Hills and its additional capacity will sell its power under the **Southern California Public Power Authority (SCPPA)** portfolio Power Purchase Agreement (PPA)." *Global Geothermal News.....*

Ormat will be exhibiting at the GRC Annual Meeting & Expo from 14-17 October in Reno, Nevada, USA. In addition there will be a fieldtrip to the Steamboat Hills geothermal field from the meeting.

New Interest in ECO2G™ Closed-Loop Geothermal Technology Project at Coso

California company **GreenFire Energy Inc.** has announced that **Electric Power Development Company, Ltd. (J-Power Company),** a utility company from Japan, and the **Electric Power Research Institute (EPRI)** of Palo Alto, California, will participate in GreenFire's demonstration of a



closed-loop geothermal power generation system. J-Power Company will have project observation and information rights. *Global Geothermal News.....*

Spring 2019 Opening for Utah FORGE

Under a *Work for Others* agreement, an **Idaho National Laboratory (INL)** team led by **Dr. Robert Podgorney** (a GRC Member and GRC Annual Meeting Technical Session chair) participated in the **Utah FORGE** work by building an earth model (a computer representation of the subsurface structure) and the reservoir model (a computational analysis of fluid flow through the structure), using commercial and INL codes.

The next phase of the Utah FORGE project will focus on building out the infrastructure in preparation for a spring 2019 opening. Podgorney said INL will contribute in the following areas:

- Assist in the implementation of updated geologic and geomechanics models.
- Supervise and coordinate development of the earth model.
- Coordinate and conduct Dynamic Reservoir Modeling activities that will inform drilling and stimulation of the production and injection wells.

Global Geothermal News.....

Dr. Robert Podgorney will present a number of papers on FORGE Research – Enabling EGS at the GRC Annual Meeting & Expo, from October 14-17 at the Peppermill Resort Spa and Casino in Reno, Nevada, USA.

New Mexico Institute of Mining and Technology to Research Geothermal Membrane Distillation for Large-Scale Use

The U.S. **Bureau of Reclamation** has announced **USD 3.5 million** funding for laboratory and pilot-scale research projects as part of the **Desalination and Water Purification Research Program** to develop more innovative, cost-effective and technologically efficient ways to desalinate water.

Included in the seven pilot-scale projects is **USD 200,000** for the **New Mexico Institute of Mining and Technology** to research **Geothermal membrane distillation for large-scale use**. *Global Geothermal News.....*

Nominate Lands In Alaska with Geothermal Resources for Potential Future Disposal

The Alaska **Department of Natural Resources (DNR)**, Division of Oil and Gas is soliciting **Nominations of Lands** with **geothermal resources** for potential future disposal.

The Division administers the geothermal exploration and development program in Alaska. Beginning this year, and biannually thereafter, the Division will solicit an informal Nomination of Lands period to identify areas for designations **as proposed geothermal disposal areas (PGDA)** for potential future geothermal lease sales or prospecting permits. Nominated lands are not automatically designated as PGDAs or offered for lease or prospecting permit.

To nominate geothermal lands, please provide the Division with a letter of interest identifying state lands to be considered for future disposal. **Nominations must be provided to the Division by November 14, 2018**. Letters of nomination can be mailed to the DNR offices at 550 W. 7th Ave, Suite 1100, Anchorage, Alaska 99501 or emailed to dog.geothermal@alaska.gov. *Global Geothermal News.....*

Drilling Rig Destroyed by Lava in Hawaii is Covered by Insurance

Ormat Technologies Inc. reported that it is suffered an initial **USD 3 million** revenue loss from the shutdown of the **Puna Geothermal Venture (PGV)** but expects further losses will be covered by insurance.

Ormat also said it has already received **USD 7.2 million** in insurance proceeds for **a drilling rig destroyed by lava.**

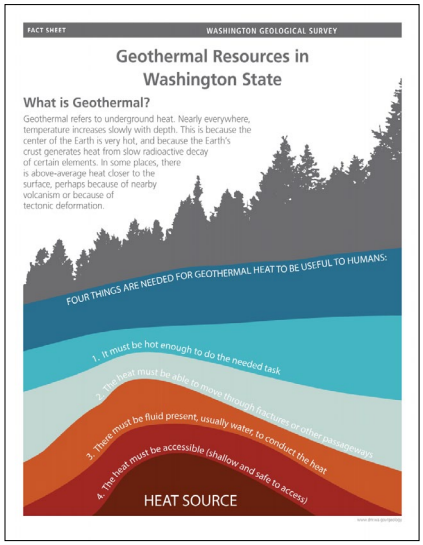
Insurance held by Ormat covers lost profit and property damage up to USD 100 million but excludes the first 30 days of lost revenue, the company said.

Doron Blachar, Ormat's chief financial officer, said on a conference call that it would take **at least 18 months** of work to **restore PGV** to operating condition. *Global Geothermal News.....*

It has also been disclosed that a British company **Air Charter Service (ACS)** was called on to source an aircraft capable of flying 68 tons of fire retardant ore and barite, to guard against the encroaching lava at PGV.

Richard Thompson, President of **ACS Americas** said "We were contacted by a specialist freight forwarder to source an aircraft that could fly in a large amount of barite, which acts as a fire retardant, as soon as possible. **Barite is a claylike substance that hardens when heated** and the plan was to use it to cap the geothermal wells and protect them from the lava flow". *Global Geothermal News.....*

Geothermal Exploratory Drilling in Washington State Begins



(Courtesy Washington Geological Survey)

At the time of publication the **Washington state Department of Natural Resources** had plans to start drilling for geothermal resources near Mount Baker north of Baker Lake.

Alex Steely, geothermal project manager for the agency's **Washington Geological Survey**, said a two-inch-wide, 1,600-foot-deep well will take about two weeks to drill. If the holes records brine temperatures above 100°C, additional drilling, temperature testing, rock analysis and mapping would be needed to determine the size and shape of the geothermal resource before a power plant could be built in the area. *Global Geothermal News.....*

Inter-American Development Bank Plans to Finance up to 300 MW Geothermal Energy in Mexico

The **Inter-American Development Bank (IDB)** has approved a modification of a loan totaling **USD 108.6 million** that aims to increase private investment in electricity generation projects from geothermal sources, putting at the developers' disposal a number of financial mechanisms tailored to meet the specific needs of each project at every step of their development.

This includes the following phases: exploration, drilling, field preparation, construction and operation of private geothermal projects, as well as reducing the value at risk for developers, which is the main barrier to investment.

The program's goal is to **finance up to 300 MW of geothermal capacity over a 10-year period**. It also hopes to **leverage other public and private funds** to contribute to Mexico's geothermal sector with estimated investment levels to the tune of **USD 4.2 billion** for proven geothermal reserves.

There are currently two processes underway: first an **International Public Tender** to pick the companies that will be in charge of performing the drilling work during the exploration phase; and second, a **Call for the Selection** of the Eligible Developers who will participate in this program. *Global Geothermal News.....*

Possible Geothermal Energy Resource Discovered off Baja California

According to scientists at the **National Autonomous University of Mexico (UNAM)** the deep waters off the coast of Los Cabos have high geothermal energy potential capable of meeting the electricity needs of the twin resort cities of **Cabo San Lucas** and **San José del Cabo**.

Location of Cabo San Lucas at the tip of the Baja California peninsula.

After searching for more than 10 years, a research team from the **Department of Natural Resources** at UNAM's **Institute of Geophysics** has located a deep-sea deposit containing hydrothermal vents or "sea chimneys" off the southern coast of the Baja California peninsula. *Global Geothermal News.....*

Tests Indicate High Permeability at Nevis Geothermal Power Project

Thermal Energy Partners (TEP) has provided details on their successful drilling efforts on the island of Nevis. **GeothermEx** has confirmed that the resource drilled by TEP **is economically viable** and has the potential to supply market competitive power to island residents and industries.

Injection testing of TEP's first exploration well demonstrated that the resource is **highly permeable**. TEP has not disclosed test results, but they reportedly indicate **high injectivity**, meaning very little pressure will be needed to inject water into the well. The high injectivity and productivity encountered by this exploration well means that TEP can expect to flow and inject large amounts of geothermal brine from each well it drills, reducing the size and expense of the wellfield.

At a **reservoir temperature of 492°F (255°C)**, TEP will be able to build a steam turbine and capitalize on higher conversion efficiency. *Global Geothermal News.....*

CENTRAL & SOUTH AMERICA

Flow Tests Expected to Demonstrate an Economic Geothermal Resource at Guatemala Project

Bluestone Resources Inc. of Vancouver, **British Columbia, Canada** has provided an update on its gold and geothermal energy project in Guatemala.

Flow testing data is expected to demonstrate an **economic geothermal resource**, as well as an estimated power generation capacity for a potential first phase project. Further drilling and follow up on the projected deeper reservoir beneath the **Mita** geothermal concession, could have the potential to increase the projected power generation capabilities in the future.

Flow testing of geothermal wells at the Mita Geothermal project. Courtesy Bluestone Resources.

Bluestone envisions a staged approach, with **Phase 1** being a smaller operation that could power the gold mine or be sold to the privatized national grid. A larger development could then be examined in a future **Phase 2**. *Global Geothermal News.....*

San Jacinto-Tizate Geothermal Power Plant Generating Average of 63.7 MW

Polaris Infrastructure Inc. based in **Toronto, Ontario, Canada**, reports record-level power generation capacity at the **San Jacinto-Tizate Power Plant** in **Nicaragua** of **139 GWh** (net) - an average of **63.7 MW** (net).

The company's wholly-owned operating subsidiary, **Polaris Energy Nicaragua S.A.**, which owns and operates the San Jacinto project, successfully connected both recently drilled wells, **SJ 12-4** and **SJ 12-5**. Initial steam production combined with other production wells has brought the San Jacinto plant close to its **77 MW** (gross) **nameplate capacity**. *Global Geothermal News.....*

Ecuador Geothermal Project Reports 200°C Source at 2,000 Meters

Drilling at the **Chachimbiro Geothermal Project,** located in the province of **Imbabura**, in northern **Ecuador**, has reached **2,000 meters depth**. The first results are encouraging: the **downhole temperature is higher than 200°C** and is located in a highly permeable area. The **generation capacity** of this project is projected to be **50 MW**. The results allows the project to move on to the second stage of development. *Global Geothermal News.....*

Cerro Pabellón Geothermal Power Project Set to be Expanded by 33 MW

Guido Cappetti, general manager of **Geotermica del Norte S.A. (GDN)** has stated that the two-unit **Cerro Pabellón** project is set to be expanded.

"After this first phase of development, the high geothermal characteristics of this reservoir in terms of temperature and permeability will allow an additional development with costs considerably lower than the previous one. Thus, it has been approved to **build a third unit of 33 MW**."

After that project is completed, GDN may explore e**xpanding the project to a massive 100 MW**, "which is the capacity of the transmission line," he said. "In the next few years, we will be working to develop the potential of the region," and that will mean a continued flurry of activity at Cerro Pabellón. *Global Geothermal News.....*

Report on Workshop on Geothermal Energy, Intermittency and the Need of Base Load Energy in Markets without Subsidies

by *Gonzalo Torres Macchiavello, Country Head Chile, Energy Development Corporation.*

The Mexican **Secretaria de Energia (SENER)** and the **Geothermal Council of Chile** held a workshop on "**Geothermal Energy, Intermittency and the Need of Base Load Energy in Markets without Subsidies**" in August.

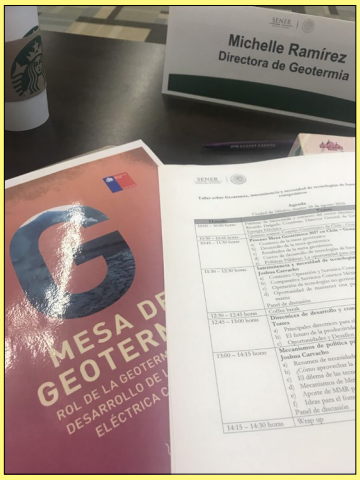
Gonzalo Torres Macchiavello, chairman of the **Geothermal Council of Chile** reported on the results of the "*Geothermal Roundtable of Chile*". The final report of this roundtable, released in July, proposes concrete public policies to promote geothermal power generation development in a free market economy with technological neutrality.

The *Geothermal Roundtable of Chile* report concludes that there has been enough exploration in Chile to calculate the **technically exploitable potential** of the explored areas, **ranging from 1,300 MW to 3,800 MW**, and with a range of investments between USD 9,000 and USD 25,000 million.

72% of the geothermal potential is concentrated in the mountain ranges of **Arica** and **Parinacota, Tarapacá and Antofagasta** regions.

The other 28% is distributed in the existing mountain range between the **Metropolitan** and **Los Lagos regions**. The report also notes that Chile is home to more than 25% of the active volcanoes in the world.

Courtesy Gonzalo Torres Macchiavello.



Courtesy Gonzalo Torres Macchiavello.

The workshop was attended by the Mexican Government main electricity system actors like **SENER, CENACE, CRE**, multilateral agencies (**CAF, IDB, KfW**) and IPP's (**Grupo Dragon, Mitsui, Energy Development Corporation**) and the Geothermal Council of Chile. **Mr. Nelson Delgado, Mr. Luis Munozcano, Mrs. Michelle Ramirez** and **Mr. Jesus Avila** among others represented the Mexican authorities' entities.

In addition, the Minister of Energy of Chile **Mrs. Susana Jimenez** announced her Government´s commitment to develop geothermal energy saying that she will push to update and improve the current geothermal law to expedite the development of the technology in Chile.

- *Mesa De Geotermia Rol De La Geotermia En El Desarrollo De La Matriz Eléctrica Chilena* - Geothermal Roundtable of Chile (PDF)

Canadian Geothermal Developer Forms JV Partnership with Chile Company

Innergex Renewable Energy Inc. of **Québec, Canada**, has announced that it has completed its previously announced joint venture partnership with **Energia Llaima** for a 50% ownership in the company.

Energia Llaima is an innovative and growing renewable energy player located in **Santiago, Chile**.

Innergex had previously acquired the assets of **Alterra Power Corp.** earlier this year. In addition to the new assets in Chile, Innergex has a stake in the 54 MW (Net Installed Capacity) **Reykjanes (1&2) geothermal power plant** and a 54% stake in the 49 MW (Net Installed Capacity) **Svartsengi geothermal power plant** in Iceland which includes a stake in the **Blue Lagoon Geothermal Spa and Resort.** *Global Geothermal News.....*

AUSTRALASIA

Te Ahi O Maui Geothermal Power Station On Track for Commissioning Before Year End

Eastland Group's Te Ahi O Maui geothermal power station, near Kawerau, on the North Island is largely complete and will boost the company's earnings by NZD 10 million a year, says chief executive **Matt Todd**.

The next stage is the commissioning of the power station, for which Eastland Group capitalized directly-attributable costs of NZD 121 million in March 2018.

"The original business case had **commissioning towards the end of the 2018 calendar year** and we are on schedule to achieve that."

Production from the plant, assuming a **capacity of 25 MW**, should be about **210 GWh a year**. *Global Geothermal News.....*

Commercial Extraction of Silica from Geothermal Brine Begins

Geo40 in co-operation with **Contact Energy** and the **Ngati Tahu Tribal Lands Trust**, were set to start commercially **extracting silica** from geothermal fluid in August.

The operation will see Geo40 use its technology to extract silica from geothermal fluid used at Contact's **Ohaaki geothermal power station**. The silica will be sold to manufacturers for use in everyday consumer goods, such as paint, providing an environmentally-sound source of silica that would otherwise require amounts of carbon-intensive energy to make.

The potential volume of high grade silica that will be sourced from Ohaaki is up to 10,500 tonnes a year, most of which will be exported overseas.

"Geothermal energy is a proven source of renewable energy and this partnership builds on geothermal's already impressive environmental credentials," said **James Kilty**, chief generation officer at Contact Energy.

For Contact, the operational benefits are significant. Silica builds up in the geothermal pipes over time, and **removing the silica significantly reduces equipment maintenance costs and increases the overall life-span of the plant.** Removing silica also allows the plant to extract more heat from the geothermal fluid, making it more efficient to run.

The deal provides financial and social benefits to **Ngati Tahu Tribal Lands Trust.** The partnership will provide an ongoing revenue stream to the trust, and the processed fluid will restore clarity to the Ohaki Ngawha, a sacred natural hot spring. *Global Geothermal News.....*

ASIA

New Tariff Makes it Profitable to Build Smaller Geothermal Power Plants in Japan

The **International Renewable Energy Agency (IRENA)** reports that in the wake of the Fukushima nuclear disaster the Japanese government introduced new policies to accelerate geothermal power plant deployment. These include streamlined procedures for the approval of projects in national parks and, crucially, a new higher **feed-in tariff (FIT)** for **small geothermal plants** to more than one-and-a-half times of that of larger facilities. **This made it profitable to build plants with an output below 7.5** MW, which do not require environmental impact assessments and can be built in around half the time of larger plants. *Global Geothermal News.....*

Japanese Government Targets Geothermal Energy to provide More Than 1% of Power Mix by 2030

Japan has approved an updated basic energy policy, leaving its **ideal mix of power sources for 2030** in line with targets set three years ago, despite criticism it places too much emphasis on unpopular nuclear power. Japan's power mix ratio targets for 2030 include **1.0-1.1% of the power mix being from geothermal energy**, part of a target of 22-24% for renewable energy, up from 15% in 2016. *Global Geothermal News.....*

More Climeon Geothermal Heat Power Modules Ordered for Japan

Swedish company **Climeon** has received a new order for its geothermal heat power modules in **Japan**. Subsidiary **Baseload Capital Sweden** is purchasing the units on the behalf of a new heat power start-up, to be delivered in 2019. *Global Geothermal News.....*

New Production Wells to be Drilled at MakBan and Tiwi Geothermal Power Plants

AP Renewables Inc. has signed a geothermal resources supply and services agreement with **Philippine Geothermal Production Co. Inc.** to drill **12 new production wells** at the **458 MW MakBan** and **289 MW Tiwi** geothermal power plants **over a six-year period** to **increase steam availability by about 20 percent.** *Global Geothermal News.....*

The Kalinga Geothermal Prospect Designated "Energy Project of National Significance"

Location of Kalinga in Luzon, Philippines.

The Philippines Department of Energy has declared the **Kalinga geothermal prospect** of **Aragorn Power** and **Energy Corp.** as an energy project of national significance.

Aragorn Power said the status ensures action on its application within 30 working days. The area, in Luzon, is estimated to have a **power generation potential of between 120 and 200 MW.** *Global Geothermal News.....*

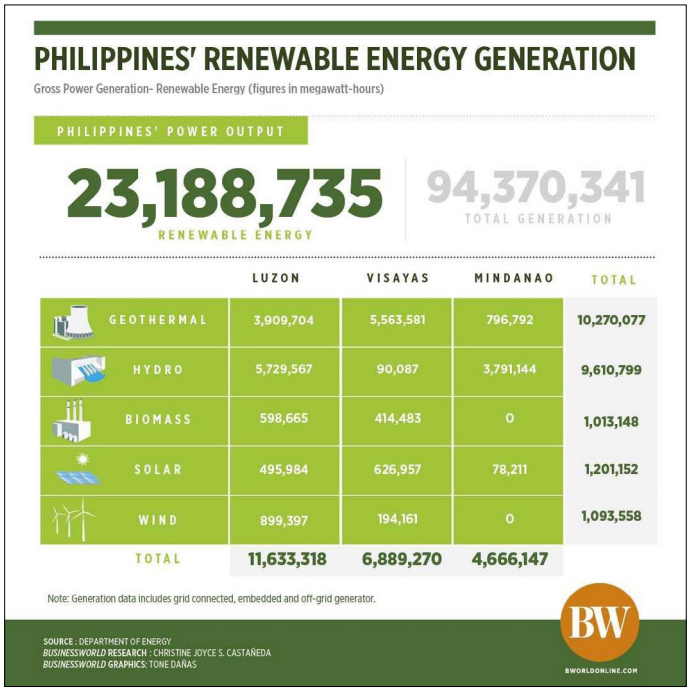
Energy Development Corp. to Acquire Remaining Publicly-Held Common Shares

Energy Development Corp. (EDC) has announced that its board of directors has approved the voluntary delisting of the company's common shares from the main board of the **Philippine Stock Exchange** and will conduct a tender offer for up to 2,040,006,713 common shares at P7.25 each that are held collectively by the public.

"The intention to eventually delist EDC was shared with the market last year and the tender offer that our board has approved today presents a meaningful opportunity for our minority shareholders to realize their investment prior to the delisting of the company, at a significant premium to the current share price," stated EDC President and Chief Operating Officer **Richard B. Tantoco**. *Global Geothermal News.....*

Geothermal Energy is Top Renewable in Philippines

Renewable energy resources in the Philippines accounted for **25% of the country's power generation mix** in 2017 generating 23.19 million MWh, up by 5.5% from 2016. **Geothermal** generated **10.27 million MWh** in 2017, topping the list of renewables. *Global Geothermal News.....*



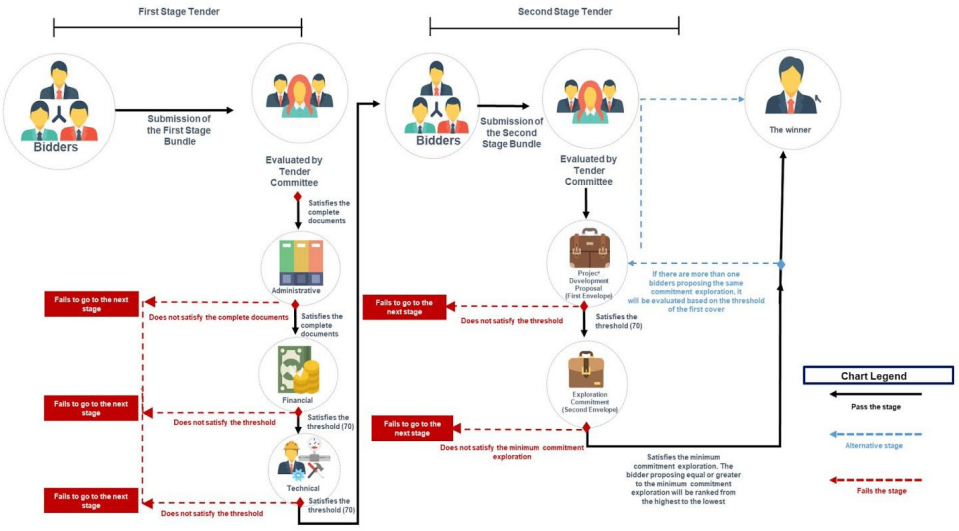
Inside Geothermal

Good Overview of New Geothermal Working Area Tender Procedures in Indonesia

UMBRA – an independent law firm in **Jakarta, Indonesia** has published a guide to the new geothermal working area tender rules for developers in the country.

UMBRA
STRATEGIC LEGAL SOLUTIONS

Geothermal Working Area Tender Flowchart



The **Minister of Energy and Mineral Resources (MEMR)** issued **MEMR Regulation No. 37 Year 2018** on *Offering of Geothermal Working Areas, Issuance of Geothermal License and Geothermal Business Assignment* (**MEMR 37/2018**) which provides detailed provisions on, among other things, geothermal working areas tender procedures.

Through MEMR 37/2018, the MEMR clarifies, among other things: (a) steps and procedures for geothermal working area tender; (b) criteria of bidding participants, (c) criteria for determining the winners of successful tenders, and (d) detailed procedures for issuance of Geothermal Licenses (Izin Panas Bumi/IPB). *Global Geothermal News.....*

Energy Development Corp Raises Funds for Geothermal-Drilling Activities

Energy Development Corp. (EDC) will raise **P11.5 billion** via bilateral term loans to refinance loans and fund its capital expenditure (capex), the bulk of which has been **earmarked for geothermal-drilling activities.**

EDC is the largest geothermal producer in the Philippines with a total installed **geothermal capacity of 1,457 MW.** *Global Geothermal News.....*

Drilling Starts at 86 MW Rantau Dedap Geothermal Project

Drilling has started at the **Rantau Dedap** geothermal power project in Muara Enim and Kota Pagar Alam, **South Sumatera, Indonesia.**

The drilling of the **RD-I3 well** is the first of **14 production wells** and **two injection wells** with estimated capacity of **7.8 MW per well.**

In addition, the first phase construction of the **86 MW Rantau Dedap geothermal power plant** by the consortium of **Rekayasa Industri** and **Fuji Electric Co.** has begun.

The geothermal power plant will developed over two phases, with **overall capacity of 220 MW**. The **first phase of development of 86 MW** is estimated to obtain commercial on date (COD) in mid 2020, with the **second phase of 134 MW** targeted COD by 2025. *Global Geothermal News.....*

Successful Test of 18.9 MW Geothermal Production Well at Ulubelu

PT Pertamina Geothermal Energy (PGE) Ulubelu Area has successfully conducted a well production test measured at a capacity of **18.9 MW**. The well, which was started on 4 November 2017 and completed on January 8, 2018, has a final **depth of 2,212 meters.**

According to the PGE website the Ulubelu area is located at in the **Gunung Way Panas** geothermal working area, **Lampung Province**. The Ulubelu

area has 4 geothermal power plants operating commercially since 2012. Total installed capacity at present is **220 MW.** *Global Geothermal News.....*

PLN Awarded Permits to Develop Three Geothermal Working Areas

The Indonesian **Ministry of Energy and Mineral Resources (ESDM)** has assigned the management of three geothermal working areas (WKP) to state-owned electricity company **Perusahaan Listrik Negara (PLN).**

- **WKP Gunung Sirung** with an [anticipated] installed capacity of 5 MW,
- **Ranau Lake** (55 MW), and
- **Oka Ile Ange** (10 MW).

Global Geothermal News.....

Geothermal Energy Could Power Tunnel in Jammu & Kashmir

The **National Highways and Infrastructure Development Corporation Ltd (NHIDCL)** of **India** is considering using geothermal energy for the heat and power needs of the **Zojila tunnel** project in **Jammu & Kashmir.** *Global Geothermal News.....*

Location of Zojila in Jammu and Kashmir state in northern India

AFRICA

Plan to Install Sensors in Geothermal Power Generation Facilities to Improve Efficiency

The **United Nations Industrial Development Organization (UNIDO)** is partnering with the **Government of Japan** to improve the efficiency of geothermal electricity production in East Africa.

The plan is to **install sensors** in geothermal power generation facilities, which will **detect temperature and vibrations**. The data will be analyzed by computers in order to **increase the plants' efficiency**. The technology allows companies to remotely monitor and manage the production and distribution of energy in real time. *Global Geothermal News.....*

USTDA to Support Development of Ethiopia Geothermal Project

The **U.S. Trade and Development Agency (USTDA)** has signed off on a grant to **Tulu Moye Geothermal Operations Private Limited Company (TMGO)**, to support development of the **first 50 MW** of the planned 520 MW **Tulu Moye Geothermal project** in Ethiopia. *Global Geothermal News.....*

Lac Assal Geothermal Power Project Goes Ahead

Djibouti has started work on the **Lac Assal geothermal** project after securing **USD 50 million** in funding from the **World Bank** and other financiers.

The nation now has an installed capacity of about 120 MW of geothermal energy and **the new plant aims to add 50-100 MW when completed.** *Global Geothermal News.....*

Marubeni Gets EPC Contract for 70 MW Unit 6 at Olkaria I Geothermal Power Plant

Japanese company **Marubeni Corporation** has been awarded a full turnkey *Engineering, Procurement and Construction* (EPC) contract from **Kenya Electricity Generating Company Limited** to construct the **70 MW Unit 6 at Olkaria I geothermal power plant** in Nakuru County, Kenya.

This will be Marubeni's first geothermal power plant project in Africa. **The project is expected to be completed in 2021.**

The steam turbines and generators, will be provided by **Fuji Electric Co., Ltd.** of Japan.

The project will be financed by an **Official Development Assistance (ODA)** loan from **Japan International Cooperation Agency (JICA)** and also by loans from the **European Investment Bank.** *Global Geothermal News.....*

Fuji Electric will be exhibiting at the GRC Annual Meeting & Expo from 14-17 October in Reno, Nevada, USA.

35 MW Quantum Power Menengai Geothermal Project Construction About to Start

At the time of writing the **35 MW Menengai geothermal project** in **Nakuru County**, Kenya was to have started construction. Geothermal Development Company **(GDC)** and developer

Quantum Power have finalized *Condition Precedents* which essentially allows the Independent Power Producer (IPP) to reach a financial close and commence construction. *Global Geothermal News.....*

Chinese Company Gets EPS Contract for Sosian Menengai Geothermal Power Project

China Machinery Engineering Co (CMEC), a subsidiary of **Sinomach**, has signed an *Engineering, Procurement and Construction* (EPC) contract for the **35 MW Menengai geothermal power project with Sosian Menengai Geothermal Power Ltd.**. *Global Geothermal News.....*

Drilling at Baringo Geothermal Power Project Begins

Also slated to start by the time of writing, **GDC** was to start drilling wells at the **Baringo-Silali geothermal project** in **Baringo County, Kenya.**

The company's general manager in-charge of drilling and infrastructure, **George Kinyanjui**, said the **first phase** of the project will be seeking to produce steam that can generate **300 MW**. *Global Geothermal News.....*

EUROPE

Funding Available for "Proven" Clean Energy Technologies Including Geothermal

European asset management company **Capital Dynamics** with a HQ in **Zug, Switzerland**, has closed its most recent clean energy funding round at a total of **USD 1.39bn** (EUR 1.2bn).

The **Clean Energy Infrastructure (CEI) Fund** focuses on 'proven' clean energy technologies including solar, wind, biomass/landfill gas, **geothermal**, gas-fired and hydro.

Capital Dynamics says it wants funds to focus on clean energy for a number of reasons: rising electricity prices; increased cost competitiveness of proven technologies; increasing economic, political and social demand; increased retirement of ageing power infrastructure in developed markets; and a range of legally binding regulatory and market-based investment incentives.

The CEI fund program, according to the company, "invests directly in commercial and utility-scale, clean and low-carbon power generation assets or related infrastructure employing proven technologies, **primarily in North America and Europe**". *Global Geothermal News.....*

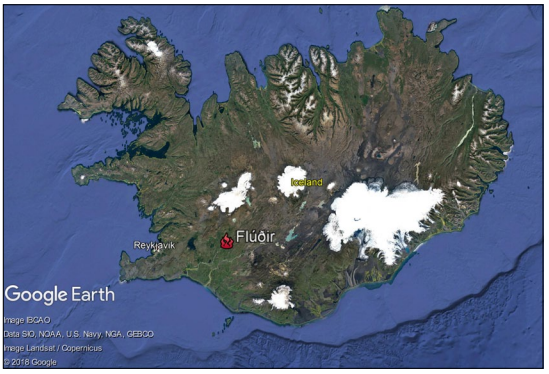
Icelandic Modular Geothermal Wellhead Power Plant Manufacturer taken Over by Canadian Company

Energy Co-Invest Global Corp. (ECC Global) of Toronto, Canada has acquired all critical assets of **Green Energy Geothermal (GEG)**, a provider of turnkey modular geothermal wellhead power plants. GEG is consolidating its operations and headquarters in Reykjavik Iceland, where it has maintained its core engineering and support teams since its founding in 2008. *Global Geothermal News.....*

GEG
GREEN ENERGY GEOTHERMAL

Flúðir Geothermal Power Plant to Start Producing Electricity Soon

A micro-scale geothermal power plant is due to begin operations shortly. The geothermal well in **Flúðir** produces hot water at a temperature of 116°C flowing at 45 liters per second. With a **Climeon Heat Power module** the community hopes to produce enough power for all homes and businesses. *Global Geothermal News.....*



Location of Flúðir in south-west Iceland.

Geothermal Powered Hydrogen Production at Hellisheiði to Begin Soon

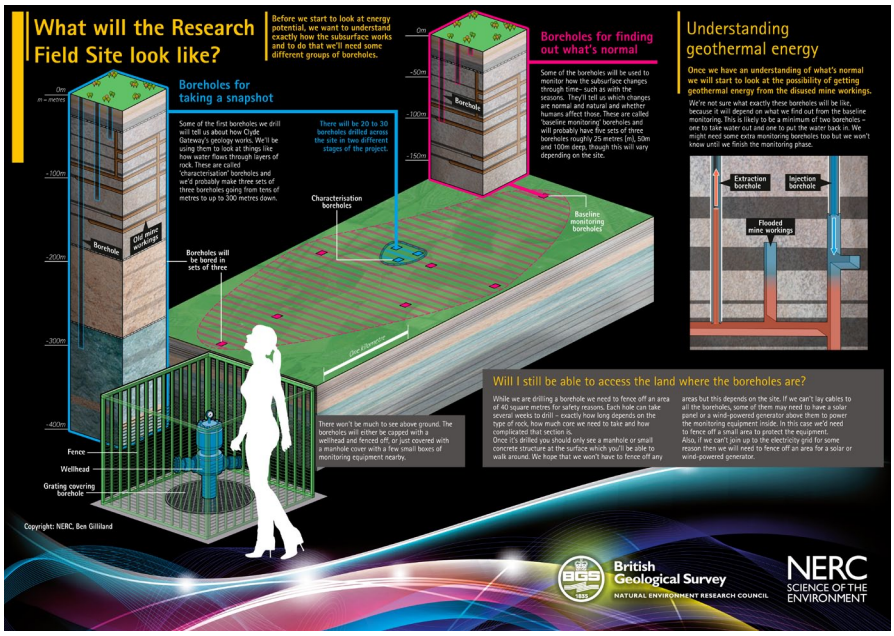
The Icelandic power company **ON Power (Orka náttúrunnar)** was scheduled to begin the **production of hydrogen** powered by electricity from a geothermal power plant at the end of August.

Hellisheiði geothermal power plant. Courtesy **Lydur Skulason** *of Deilir Technical Services, Kópavogur, Iceland.*

A production plant built around an electrolyzer has been installed next to **Hellisheiði geothermal power plant**. Sale of hydrogen for vehicles could begin as early as October. *Global Geothermal News.....*

United Kingdom Geothermal Energy Research Field Site Approved

Glasgow City Council and **South Lanarkshire Council** in central Scotland have approved plans to develop a world class geothermal research observatory in the east end of the city. Work will begin on site this autumn.



The research at the observatory aims to contribute to an understanding of the potential for warm water in disused coal mines to be used for renewable heat. The **Glasgow Geothermal Energy Research Field Site** will enable the UK science community to study the geothermal environment just below the Earth's surface. *Global Geothermal News.....*

Third Well Reaches 4,235 Meters at Balmatt Geothermal Project

The **Smet-Daldrup** company has successfully completed the third well at the **Balmatt** geothermal district heating project in **Mol-Donk** in the province of **Antwerp, Belgium**. The well has a **length of 4,905 meters** and is drilled to **a vertical depth of 4,235 meters**. A large part was drilled at an angle of 45°, so that **the end of the bore is located under the nearby hamlet of Mol-Sluis.** *Global Geothermal News.....*

Tender Issued for Exploration for Geothermal Heat and Power Project in South Poland

The town of **Szaflary** in the far south of **Poland** has announced a tender for **seismic and magnetotelluric research** to determine the location of, what would be, the **deepest geothermal well in Poland.**

The well will be drilled to a **depth of 5,200 meters** and possibility to 7,000 meters. Experts predict that the well temperature will be **above 120°C** and produce heat for homes and electricity for mining operations. *Global Geothermal News.....*

First Well at Munich Geothermal District Heating Project Completed

Exactly 3 months after commencement, the drilling and testing of the first geothermal well **(Schäftlarnstraße Th1)**, at the **southern power station** (HKW-Süd) in the **Sendling district in Munich**, has been completed.

The well was drilled to a final **depth of 3,860 meters.** The pump tests have confirmed the expected productivity of the well with a flow rate and temperature which lie in the upper bounds of the predictions. **Temperature readings are above 100°C.**

A second well, of a total of six, was planned to be drilled in August. *Global Geothermal News.....*

Inside Geothermal

Feed-in Tariff for Swiss Geothermal Energy Increased

	hydrothermally		petro thermal	
Power (MW)	Remuneration today (Rp / kWh)	**Remuneration planned (Rp / kWh)**	Remuneration today (Rp / kWh)	**Remuneration planned (Rp / kWh)**
≤ 5	40.0	**46.5**	47.5	**54.0**
≤ 10	36.0	**42.5**	43.5	**50.0**
≤ 20	28.0	**34.5**	35.5	**42.0**
> 20	22.7	**29.2**	30.2	**36.7**

The feed-in tariff for geothermal energy in Switzerland is to be **increased by 6.5 cents per kilowatt hour.** For **petrothermal geothermal** energy, **the maximum allowance increases to 54 centimes**, for **hydrothermal geothermal** energy **46.5 centimes**. The corresponding regulation on energy promotion is in consultation. *Global Geothermal News.....*

Enel Reports Geothermal Energy Capacity of Over 800 MW

Italian utility **Enel SpA** produced 50,170 GWh power from renewable energy sources in the first half of 2018, **up 25.4% year-on-year**, according to its Quarterly Bulletin.

In mid-2018, Enel had **804 MW of geothermal capacity** consisting of 762 MW in Italy and 41 MW in South America (Chile), up **2.8% on the year**. Net production of geothermal energy as of 2018 was 2,932 GWh, up 1.1% on last year. *Global Geothermal News.....*

Directional Controlled Vertical Geothermal Well in Austria to be Drilled to 2,750 Meters

A joint venture of **Züblin Ground Engineering** and **Huisman** has been awarded a contract for the delivery of the TH3.1 geothermal well in **Mehrnbach, Ried im Innkreis,** in **Upper Austria.**

The directional controlled vertical well is planned to be drilled up **to a depth of 2,750 meters** to tap the **Upper Malm reservoir.** The abandonment of the old well TH3 and the conductor installation for the new well have already been performed by Züblin earlier this year. *Global Geothermal News.....*

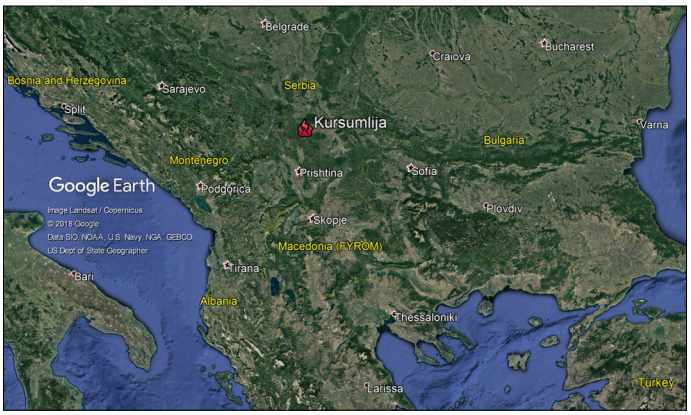
Tender Opened for Operation of Four Geothermal Resources in Croatia

Croatia's **Hydrocarbon Agency (CHA)** has issued a tender for the operation of four geothermal energy resources. The agency aims to select the best bidder for the **Slatina 1-4** geothermal sites in the municipalities of **Sopje, Cadjavica, Crnac** and **Nova Bukovica in Virovitica-Podravina** County, north Croatia, the ministry added. *Global Geothermal News.....*

Good Potential for Geothermal District Heating in Serbia

Two recent reports highlight the potential for **geothermal district heating** in **Serbia**.

The municipality of **Kursumlija** in southern Serbia has good potential for geothermal resources, according to the paper **A GIS-based method for analysis of a better utilization of thermal-mineral springs in the municipality of Kursumlija (Serbia)**, recently published in the journal *Renewable and Sustainable Energy Reviews.* There are three official and ten unofficial spas in the area with indoor temperatures ranging between 20°C and 68°C. The geothermal resources are currently being used for space heating, balneology, greenhouse heating, etc.



Location of Kursumlija and Bogatić in Serbia

The total energy in the whole territory is **620TJ/year**, or **19.6MWt**, which could be enough to **heat 500 households** or more than 100,000 sq. meters. *Global Geothermal News.....*

Meanwhile, what will be the **first geothermal district heating system** in Serbia is being built in the municipality of **Bogatić** in western Serbia. It will initially be used to heat public buildings, and then also homes and businesses.

The contract for construction was signed at the end of 2017 and will be completed **within the year**. *Global Geothermal News.....*

Mitsubishi Hitachi to Provide Maintenance for Germencik Geothermal Power Plant

Mitsubishi Hitachi Power Systems, Ltd. (MHPS) has received an order from **Gurmat Electric Generation Co. Inc.**, for long-term parts management and services at the **Germencik geothermal power plant** near the city of **Aydin** in western Turkey.

The agreement concerns maintenance of two MHPS **47.5 MW steam turbines** at **Galip Hoca (Unit 1)** and **Efe-1 (Unit 2)**, which went into commercial operation in 2009 and 2015, respectively. *Global Geothermal News.....*

Mitsubishi Hitachi Power Systems will be exhibiting at the GRC Annual Meeting & Expo from 14-17 October at the Peppermill Resort Spa and Casino, Reno, Nevada, USA.

SCIENCE & TECHNOLOGY

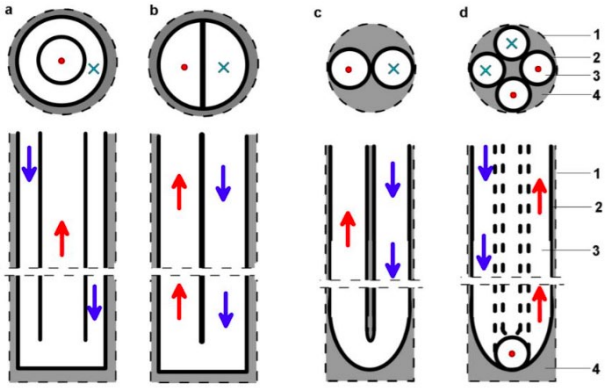
Granite Stored in the Earth's Crust is Partially Molten at 500 Degrees Celsius

Evidence from rocks in **Yosemite National Park** in **California, USA**, suggests that granite stored in the Earth's crust is p**artially molten at 500°C**, nearly 200 degrees lower than had previously been believed.

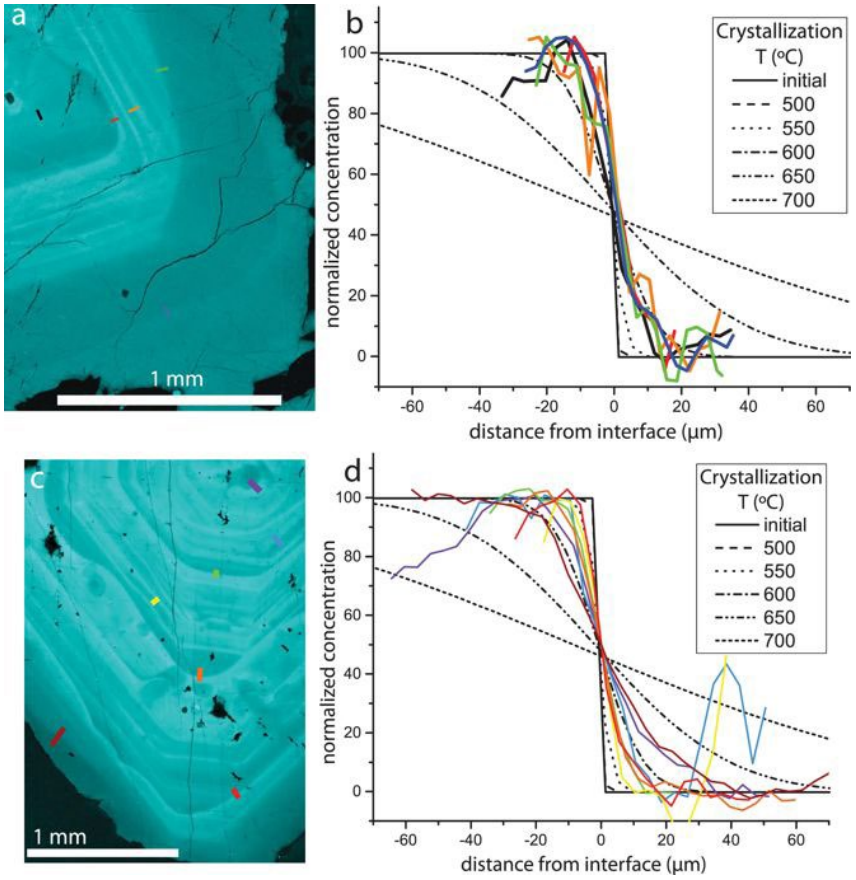
The finding, published in *Nature,* challenges long-held assumptions that underlie our views about the state of magma in volcanically active regions, the location of economically important ore deposits, and **Earth's geothermal gradient**. *Global Geothermal News.....*

Low-temperature crystallization of granites and the implications for crustal magmatism. Michael R. Ackerson, B. O. Mysen, N. D. Tailby & E. B. Watson Nature (2018).

Extracting Geothermal Heat Through Deep Borehole Heat Exchangers



Potential construction designs of BHE and DBHE systems (a – coaxial heat exchanger, b – demi-type heat exchanger, c – heat exchanger with single U-pipe, d – heat exchanger with double U-pipe, 1–wall of the borehole, 2–heat exchanger pipe, 3–heat carrier, 4–sealant) (Courtesy authors)



Core–rim Ti concentration profiles in quartz compared with a constant-cooling rate diffusion model. (Courtesy authors)

A recent paper describes a new method to extract geothermal heat from the Earth's crust through **vacuum insulated tubing** in **Deep Borehole Heat Exchangers (DBHE)**. These can be either drilled especially for a heat extraction or, more cost-effectively, reconstructed from already-existing, negative, or abandoned oil or natural gas wells.

Borehole heat exchangers allow an exchange of geothermal heat between rock formation and heat carriers, circulating in the closed-loop system between the surface and an underground reservoir. The heat can be supplied directly, for instance from deeper wells with higher geothermal gradient, or indirectly using heat pump systems. *Global Geothermal News.....*

Potential application of vacuum insulated tubing for deep borehole heat exchangers, by Tomasz Śliwaa; Michał Kruszewskiab; Alireza Zarec; Mohsen Assadic; Aneta Sapińska-Śliwaa. *Geothermics*, Volume

75, September 2018, Pages 58-67. https://doi.org/10.1016/j.geothermics.2018.04.001

Geyser Eggs Solidify Layer by Layer from Silica in Geothermal Brine

An article in *National Geographic* magazine describes the strange phenomena of "geyser eggs" at **Old Faithful** in **Yellowstone National Park**, which may hold clues about the iconic geyser's past and future.

A "nest" of geyser eggs. Photograph By Michael Nichols, National Geographic Creative.

Geyser eggs don't spawn a swarm of baby steam-sputtering structures; they are, after all, rocks. But they're far from ordinary: These pebbles are like geologic gobstoppers. **They solidify layer by layer as silica from the steamy waters of geothermal pools precipitate out of solution, making each layer a snapshot of pool conditions at the time it was formed.**

A trove of these geologic oddities lay scattered in the colorful thermal pools surrounding Yellowstone's Old Faithful geyser, yet strong protections within the national park have long prevented scientists from getting their hands on the eggs. But recently, for the first time, a team of geologists were allowed to remove a single "Old Faithful" egg. Their analysis of the bean-shaped pebble, which is roughly the size of a silver dollar, provides new insights into the egg's delicate structures and could provide clues to how Old Faithful changes overtime.

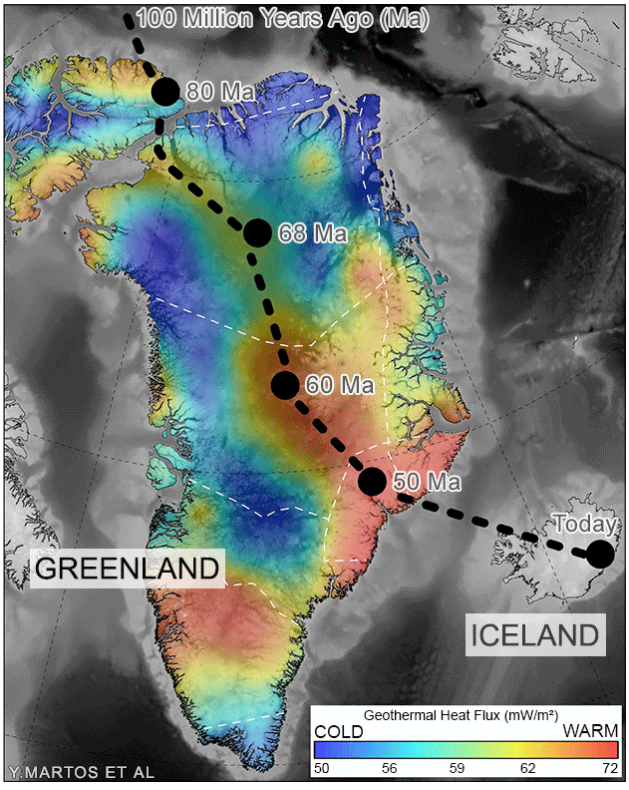
"It is amazing to think that these little rocks capture and preserve the history of the discharging fluid for as long as it is growing," says study author **Bridget Lynne** of the **University of Auckland** and the **Geothermal Institute**.

The study was conducted in conjunction with a National Geographic-funded project focused on teasing out near-surface geyser features led by GRC Member **Duncan Foley**. *Global Geothermal News.....*

Icelandic Geothermal Hotspot Used to be Under Greenland

From its northwest corner to its southeast coast, the world's biggest island has a band of relatively warm bedrock. Scientists say this confirms **Greenland ran over a hotspot of upwelling molten rock** tens of millions of years ago as it shifted towards the Arctic. It's like the underside of the island got a good roasting in the distant past and still has the big scar to prove it.

That hotspot, by the way, is the one which today is building Iceland in the middle of the North Atlantic. The plume of broiling rock rising from deep inside the Earth has broken through the thin ocean floor in Iceland and is now creating new land with regular eruptions of lava. *Global Geothermal News.....*

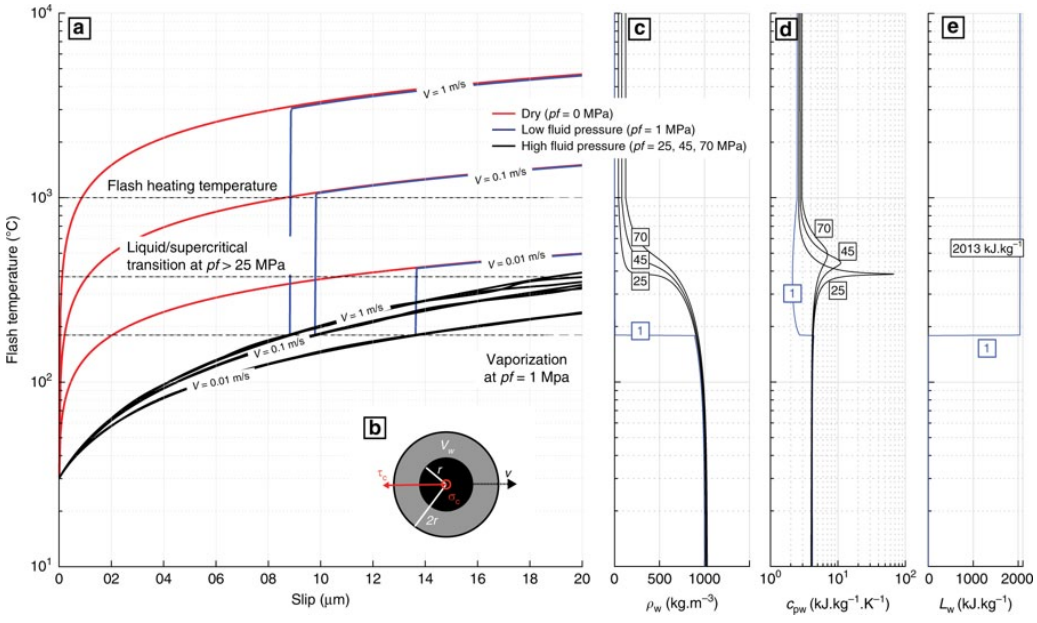


Geothermal heat flux map of Greenland showing the trail of the hotspot across the island to its current position underneath Iceland.

Geothermal heat flux reveals the Iceland hotspot track underneath Greenland, by Yasmina M. Martos; Tom A. Jordan; Manuel Catalan; Thomas M. Jordan; Jonathan L. Bamber; David G. Vaughan. *Geophysical Research Letters.* First published: 01 August 2018 https://doi.org/10.1029/2018GL078289

Discovery that Highly Pressurized Water in Vicinity of an Earthquake Tends to Limit its Intensity has Implications for Geothermal Energy

Researchers from **École Polytechnique Fédérale De Lausanne (EPFL)** and the **École Normale Supérieure** in Paris have found that the presence of pressurized fluid in surrounding rock can **reduce the intensity of earthquakes** triggered by underground human activities like **geothermal energy production.**



Flash temperature calculation. Red curves correspond to dry conditions, blue to low fluid pressure (1 MPa) and black to high fluid pressures (25, 45 and 70 MPa). Courtesy Authors.

The researchers just completed a study into the role of fluids in the propagation of induced earthquakes in an effort to decipher the underlying mechanisms. Their findings include the extremely counterintuitive discovery that highly pressurized water in the vicinity of an earthquake tends to limit – rather than increase – its intensity. *Global Geothermal News.....*

M. Acosta et al. *Dynamic weakening during earthquakes controlled by fluid thermodynamics*, *Nature Communications* (2018). DOI: 10.1038/s41467-018-05603-9

Crypto-currency Mining Industry Should Utilize Geothermal Energy

A recent article **Clean Energy Sources That The Crypto-currency Mining Industry Should Utilize** in *Bitcoin Exchange Guide* concludes that geothermal energy should be used in the power-hungry production of the money alternative.

"**Blockchain technology** and its most popular crypto-currency, **bitcoin**, have been called of equal importance to the internet, capable of transforming businesses, government, and social interaction: the entire fabric of modern society. The enthusiasm—and the hype—are both inescapable and infectious."

"However", according to the article authors, "there is a darker side to the technology and the industry. We must recognize and address this danger soon, or else we run the risk of undoing decades of social and environmental progress. This threat is **the immense energy consumption** and potential climate impact of the blockchain and its two leading currencies, bitcoin and ethereum."

"While some suggest that we should seek to slow the growth of the blockchain revolution, the industry is creating so many beneficial technologies, and therefore should be encouraged to grow, in sustainable ways. **New innovations in green energy should be taken advantage of**."

"**Geothermal energy** is generally considered environmentally friendly. The carbon footprint of a geothermal power plant is minimal. Their reservoirs come from natural resources and are naturally replenished, therefore it is a renewable energy source. It is excellent for the base load energy demand, as opposed to other renewables such as wind and solar."

"Places like Iceland, where volcanic activity pushes that heat closer to the surface, allow us to tap into this power at an affordable rate and with almost no environmental impact. **Of all the renewable energy technologies, geothermal power provides some of the most consistent power output** because it doesn't rely on unpredictable aspects of nature, like wind or sunlight." *Global Geothermal News.....*

Successful Trial of Microbiological Control Program at Geothermal Power Plant

The production rate of electricity that can be generated at a geothermal power plant is heavily dependent on the **control of microbiological slime in the plant condenser cooling system.**

Thailand-based company **ZI-Chem** has recently completed a successful plant trial of a **Microbiological Control Program** at a geothermal power plant in Indonesia involving the application of a unique **oxidizing biocide** and **biodispersant** combination to control microbiological growth in the cooling tower. The program also proved effective at reducing consumption of other chemicals needed to maintain pH levels in the cooling water. *Global Geothermal News.....*

U.S. Lab Develops Self-Healing Cement that Performs Strongly in Harsh Geothermal Conditions

Pacific Northwest National Laboratory (PNNL) researchers are developing a **self-healing cement for use in harsh environments** where cement can fail over time due to exposure to chemical and physical stresses. When cement in power plants, **geothermal wells**, oil and gas applications, or hydroelectric dams fails, it can lead to expensive excavation, repair and replacement costs, along with lost production time and revenue, and potential environmental concerns.

On the left, conventional cement shows the damage caused by harsh conditions found in power plants, geothermal wells, dams or in gas and oil applications. In contrast, PNNL's self-healing cement, on the right, could begin repairing itself within 24 hours of a crack appearing. Courtesy Andrea Starr, Pacific Northwest National Laboratory.

With funding from the U.S. **Department of Energy (DOE)'s Geothermal Technology Office,** PNNL scientists have been using their chemistry and materials science know-how to create self-healing cements **by adding polymers to traditional cement mixes**. The resulting cement has re-adhering properties that extend its lifetime and reduce the risk of failure. *Global Geothermal News.....* ■

Geothermal History in the Making

by Ian Crawford, Director of Communications

In 2021, the Geothermal Resources Council, the GRC, will be celebrating its 50-year anniversary. Our association was established in 1971 "to encourage development of geothermal resources worldwide." To mark our golden anniversary, we are running a series of articles looking back on the history of geothermal energy around the world over these past decades.

In this issue we document how an initiative by the GRC in the 1980's resulted in a more global-focused International Geothermal Association (IGA).

Today, the GRC continues to support the geothermal community worldwide and is actively pursuing collaboration with other associations globally to help promote and develop geothermal technologies and industries. This includes working with other country associations, the IGA, the Global Geothermal Alliance (GGA), the International Partnership for Geothermal Technology (IPGT), and other interested stakeholders in geothermal energy, renewable energies and international government agencies.

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The Creation of the International Geothermal Association

In the August 1987 *Bulletin* (Vol. 16 No. 8), Raffaele Cataldi reported on the ongoing discussions on the creation of a more global, less USA-focused geothermal association.

Raffaele noted that the idea had been discussed in previous decades but the first time a group of geothermalists had met informally to discuss the possibility was at the International Symposium on Geothermal Energy held in Pisa, Italy in September 1970. However, no action was made on the matter until the initiative was re-launched within the GRC in 1986.

In January 1986, three non-U.S. members were elected to the GRC Board of Directors and then another two were added in 1987. There was "favorable reception within the GRC of the proposal to create a new organization, to serve the geothermal community of the world...attributed to the awareness of the need for a joint effort on an international level, in order to strengthen the scientific, educational and information base required for the effective continuance of geothermal exploration and utilization in the world."

The GRC Board of Directors hence created an ad hoc international committee in 1986. The members recognized the need to promote the effort as a joint effort by the GRC and the five international geothermal schools in Iceland, Italy, Japan, Mexico and New Zealand. The committee discussed the new association's objectives and activities, a possible structure, organization and operational procedures, a draft charter, and estimated budget.

In the April 1988 *Bulletin* (Vol. 17 No. 4) Patrick Muffler reported on developments. In October 1986 the GRC ad hoc committee transitioned to an Independent Organizational Group for the International Geothermal Association (OWG-IGA). At the time of writing in 1988 the members consisted of 26 individuals from 19 countries. The first meeting of the new group was held in Sparks, Nevada in October 1987, in conjunction with the GRC Annual Meeting. A second meeting was held in Auckland, New Zealand in February 1988. On 6 July, 1988, International Geothermal Association Inc. was registered in Auckland, New Zealand.

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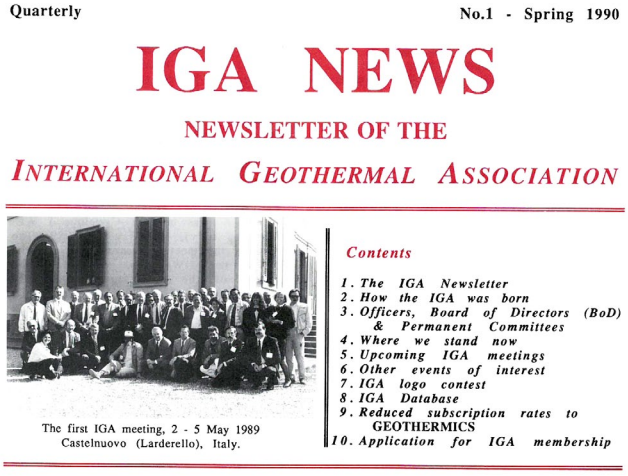
Today, the IGA has 4,500 members worldwide from 36 affiliated organizations - the Geothermal Resources Council remains one of the largest of its affiliate associations. The IGA helps to promote geothermal development worldwide. The IGA's "objectives are to encourage and facilitate scientific and technical education in geothermal matters worldwide through the publication of scientific and technical information among the geothermal specialists, business community, governmental representatives, UN organizations, civil society and the general public."



Quarterly No.1 - Spring 1990

IGA NEWS

NEWSLETTER OF THE

INTERNATIONAL GEOTHERMAL ASSOCIATION

The first IGA meeting, 2 - 5 May 1989 Castelnuovo (Larderello), Italy.

Contents

1. The IGA Newsletter
2. How the IGA was born
3. Officers, Board of Directors (BoD) & Permanent Committees
4. Where we stand now
5. Upcoming IGA meetings
6. Other events of interest
7. IGA logo contest
8. IGA Database
9. Reduced subscription rates to GEOTHERMICS
10. Application for IGA membership

The new International Geothermal Association (IGA) published the first issue of it's Newsletter in the spring of 1990. This and subsequent issues were included in the GRC Bulletin for many years.

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Through the GRC's affiliation with the IGA , GRC Members are automatically members of the IGA, which offers access to its international paper database, access to international affiliations with international organizations such as the World Bank, IRENA and others, a special discount rate for the international publication, *Geothermics*, and a discount registration to its World Geothermal Congress events (every 3 years).

The GRC looks forward to a long and fruitful relationship with the IGA and other global partners to help speak with one voice for our community and industry. ■
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Searching for Blind Geothermal Systems Utilizing Play Fairway Analysis, Western Nevada

James E. Faulds[1], Jason W. Craig[1], Mark F. Coolbaugh[1], Nicholas H. Hinz[1], Jonathan M. Glen[2], and Stephen Deoreo[1]

[1]Nevada Bureau of Mines and Geology, University of Nevada, Reno, NV 89557

[1]U.S. Geological Survey, Menlo Park, CA 94025

Background

Geothermal *play fairway analysis* is a concept adopted from the oil industry aimed at improving the efficiency and success rate of geothermal exploration and drilling. It involves integration of multiple geologic and geophysical parameters indicative of geothermal activity as a means of identifying the most promising areas for new geothermal development[1]. This includes the evaluation of the relative favorability of known, undeveloped geothermal systems, as well as assessing the probability of a particular area for hosting a relatively robust blind system (>~130°C). Blind systems lack surface hot springs and steam vents and are thought to comprise the majority of geothermal systems in the Great Basin region[2].

Compared to the oil industry, play fairway methodologies for geothermal systems are in their relative infancy and have generally not been fully tested. Also, geothermal play fairway methodologies can vary widely between regions depending on the tectonic setting, structural and stratigraphic framework, quality of exposure, and effectiveness of various geophysical techniques under local geologic conditions.

We have applied the play fairway methodology across a broad swath (96,000 km^2) of the Great Basin region of Nevada, a well-exposed extensional to transtensional (from east to west, respectively), active tectonic setting within the Basin and Range province of western North America (Figure 1). The Great Basin region of Nevada and adjacent parts of

neighboring states currently host ~25 geothermal power plants with over ~700 MW of capacity. However, studies indicate a vast untapped potential for conventional geothermal energy in this region[3].

Here, we describe a successful application of the play fairway analysis that resulted in the discovery of a heretofore unrecognized, blind geothermal system in southeastern Gabbs Valley in western Nevada. No previous geothermal exploration had occurred in this area. Initial regional-scale play fairway analysis indicated a high prospectivity. This prompted more detailed geologic and geophysical studies[4, 5], which coupled with finer-scale play fairway analyses, yielded favorable targets for geothermal drilling. The project culminated with successful temperature-gradient drilling in June 2018, whereby temperatures of 122°C were attained at depths of 152 m[6].

This play fairway analysis also identified other sites where preliminary exploration work suggests that undiscovered blind geothermal systems are present1. It is expected that when these sites are fully vetted, additional geothermal discoveries will be made.

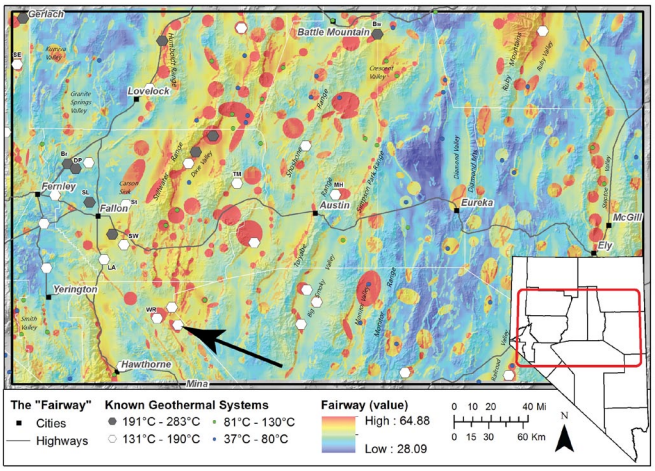

Figure 1: Geothermal play fairway map of west-central to eastern Nevada. Warmer colors indicate areas of higher potential; cool colors show areas of relatively low potential. Fairway values are not normalized and are based on parameters and relative weighting shown in Figure 2. Black arrow points to the southeastern Gabbs Valley area. Abbreviations for known geothermal systems in the region: Br, Bradys; Bw, Beowawe; DP, Desert Peak; LA, Lee-Allen; MH, McGinness Hills; SE, San Emidio; SL, Soda Lake; St, Stillwater; SW, Salt Wells; TM, Tungsten Mountain; WR, Wild Rose-Don Campbell.

Play Fairway Methodology – Nevada Style

In Phase I of this project, we developed a comprehensive, statistically based geothermal potential map for 96,000 km^2 across the Great Basin of Nevada (Figure 1). This project focused on fault-controlled geothermal play fairways due to the affiliation of most geothermal systems in the region with Quaternary faults. Nine parameters were incorporated into the regional geothermal potential maps, including: 1) structural settings, 2) age of recent faulting, 3) slip rates on recent faults, 4) regional-scale geodetic strain rates, 5) slip and dilation tendency on Quaternary faults, 6) earthquake density, 7) gravity gradients, 8) temperature at 3 km depth, and 9) geochemistry from springs and wells.

These parameters were grouped into key subsets to define regional permeability, intermediate-scale permeability, local permeability, and regional heat, which were combined to define the fairway (Figures 1 and 2). A major challenge was determining the appropriate weighting of individual data types to best predict permeability and overall geothermal potential. Rigorous statistical methods, utilizing 34 benchmarks of known relatively high-temperature (>130°C) geothermal systems within the region, were employed to constrain the hierarchal weights of each parameter[7]. Analyses of these parameters were also coupled with a thorough review of the degree of previous exploration, thus permitting identification of under-explored regions that are potentially ripe for development. To facilitate economic assessments for exploration and development, the final favorability map also included layers showing land use status and critical infrastructure, such as electrical transmission and transportation corridors.

Owing to the active extensional to transtensional tectonism and high heat flow, many sites in the broad study area (96,000 km^2) yielded relatively high play fairway values. In Phase II of the project, we chose 24 of the most promising sites for reconnaissance on the basis of the play fairway values, land status, and proximity to an established electrical transmission corridor. We then down-selected five sites for detailed studies through a semi-quantitative analysis involving consideration of a) available geological, geochemical, and geophysical data, b) new shallow temperature and geochemical data collected in this study, c) land

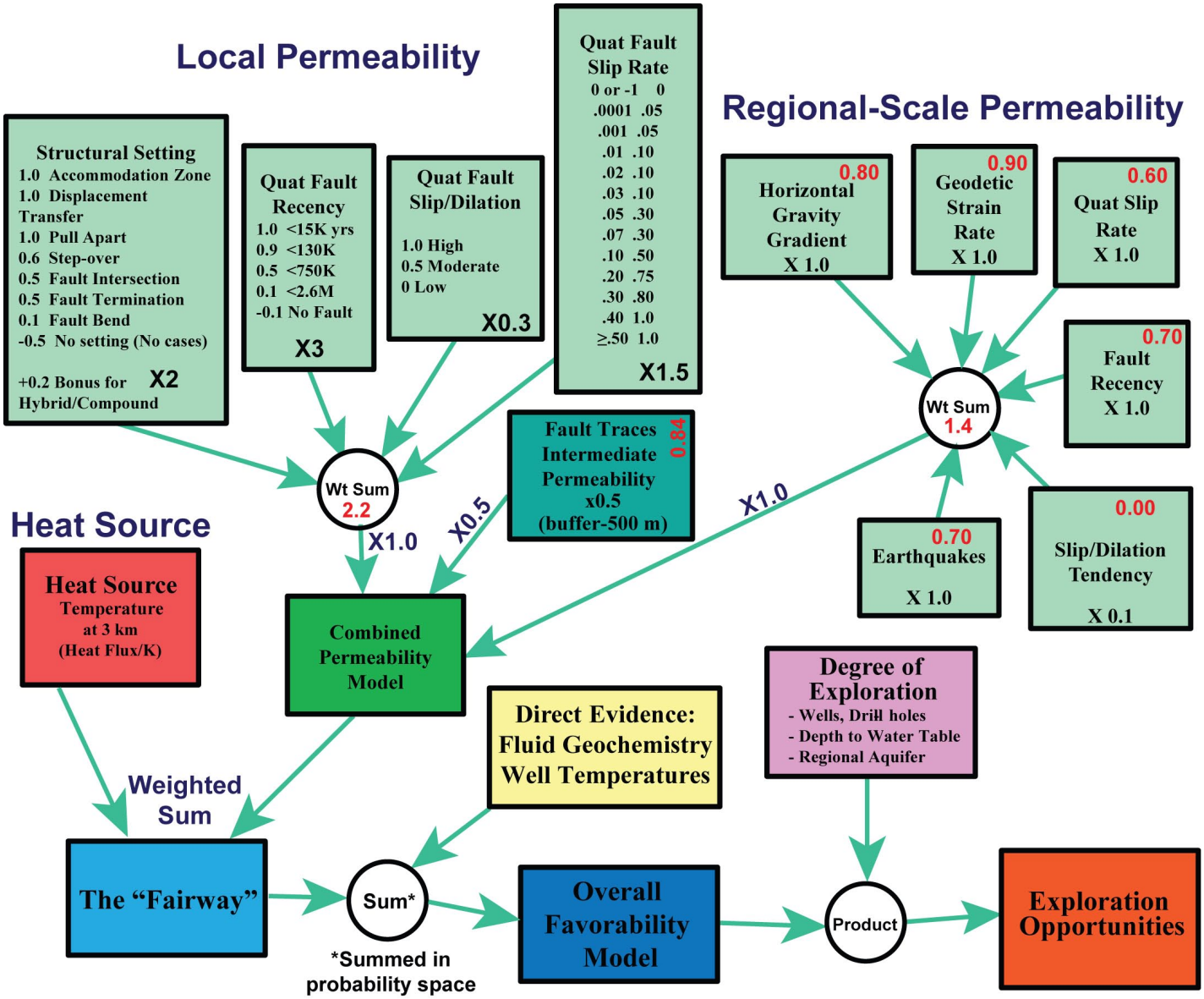

Figure 2: Nevada play fairway modeling workflow. Red numbers indicate relative weights determined from weights of evidence. Black numbers indicate expert driven weights used in the analysis. In all cases, the expert driven weights took into account the statistical analyses. We have generally focused on the fairway model (light blue box in lower left).

status, d) distance from an electrical transmission corridor, and e) degree of previous exploration (Figure 3).

Southeastern Gabbs Valley – Evidence Leads to Hot Water

Southeastern Gabbs Valley in west-central Nevada was one of the areas chosen for detailed study. It is a complex, tectonically active structural basin at the transition between the Walker Lane and Basin and Range province (Figures 1, 4 and 5). The Walker Lane is a belt of primarily right-lateral strike-slip faults that collectively accommodate ~20% of the dextral motion between the Pacific and North American plates. As individual dextral faults in the Walker Lane terminate, they commonly splay into arrays of normal faults in what we refer to as *displacement transfer zones*, generating an area of focused extension favorable for geothermal activity. Southern Gabbs Valley contains a displacement transfer zone near the end of the recently active (<15 ka) Petrified Springs dextral fault (slip rate=1.4 mm/yr), which splays into numerous north- to north-northeast-striking normal faults within the basin, effectively transferring dextral shear from the Walker Lane to WNW-directed extension in the Basin and Range. This favorable structural setting combined with relatively high regional strain

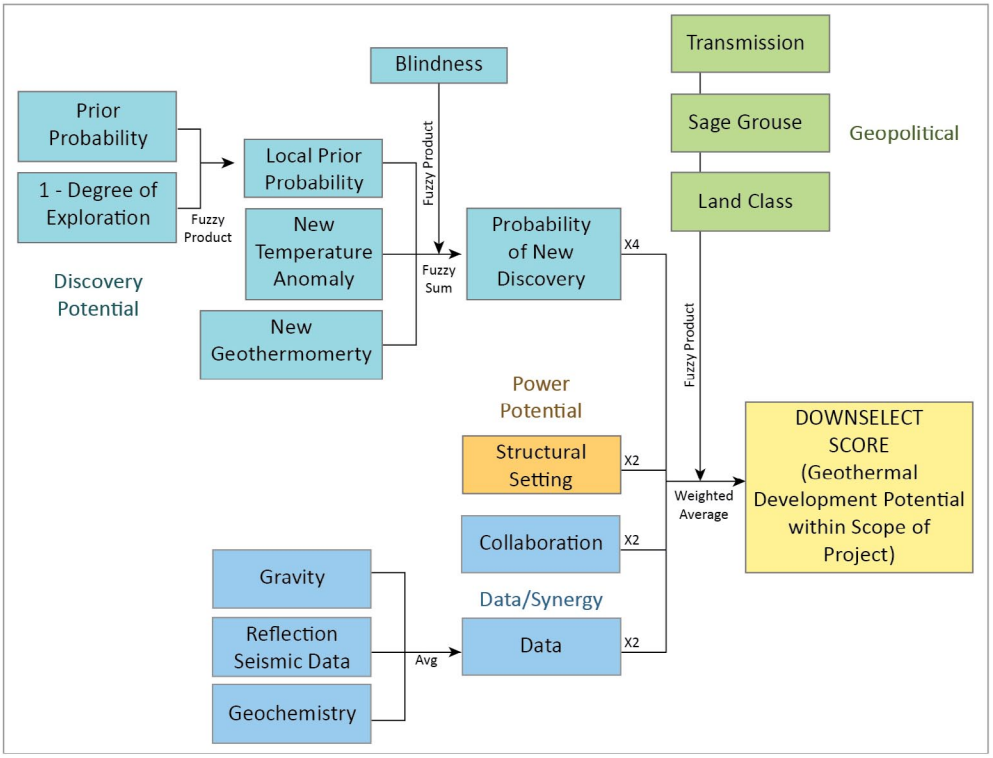

Figure 3: Flow chart showing down-selection process for selecting Phase II detailed study areas from prospective areas identified in Phase I."Collaboration" refers to potential for industry collaboration.

rates and Quaternary faults with relatively high slip rates resulted in a high play fairway score for southeastern Gabbs Valley in the regional analysis completed in Phase 1 (Figure 1). Although some geothermal exploration has occurred ~15 km north of the study area, no previous exploration had taken place in southeastern Gabbs Valley.

Our initial reconnaissance of southeastern Gabbs Valley found no surface evidence (e.g. sinter or travertine) of a geothermal system, but anomalously warm wells (32°C) were identified in the area (Figures 4, 5, and 6), which prompted more detailed reconnaissance, including a shallow (2-m depth) temperature survey (Figure 4 and 7). This survey showed a shallow temperature anomaly (up to 5°C above background) up hydrologic gradient from the warm wells. Based on these favorable attributes, southeastern Gabbs Valley was down-selected as one of the five areas for detailed analyses in Phase II.

Detailed analyses in Phase II included geologic mapping (180 km^2), Quaternary fault analysis, a gravity survey (274 stations), 2-m temperature survey (124 stations), geochemical analyses of water samples, and slip and dilation tendency analysis of Quaternary faults. This work defined a 7 km^2 shallow temperature anomaly in southeastern Gabbs Valley near the intersection of gravity gradients indicating a major subsurface fault intersection within the broader displacement transfer zone. Further, geothermometry on water samples suggested subsurface temperatures of 130-140°C.

All of these favorable factors prompted more detailed geophysical analyses in Phase III to facilitate selection of sites for temperature-gradient holes (TGH). The more detailed geophysical analyses included additional gravity (480 stations) and new magnetic (300 line km) and magnetotelluric (MT, 24 stations) surveys. The additional gravity work better defined the probable location of intersections between subsurface faults. This showed that the shallow temperature anomaly was not only collocated with sharp intersecting gravity gradients but was also collocated with a conspicuous magnetic low and a resistivity low, suggesting hydrothermally altered rocks at depth.

TGH targets were therefore selected to span and straddle the collocated 2-m temperature anomaly, intersecting gravity gradients, magnetic low, and resistivity low. We commenced drilling of TGHs in late May 2018 and completed six holes in a month (Figure 8). Bottom-hole temperatures from two wells in the central part of the collocated anomalies were 112°C and 122.5°C at 152 m (500 ft) depth (Figures 4D and 9). Bottom-hole temperatures fall off rapidly to the north and more gradually to the south. At ~150 m depth, the thermal anomaly is at least ~2 km long in a north-south extent and probably at least 1 km wide from east to west. Potential host rocks for a geothermal reservoir include highly fractured Mesozoic basement rocks (granitoids and metasediments) and

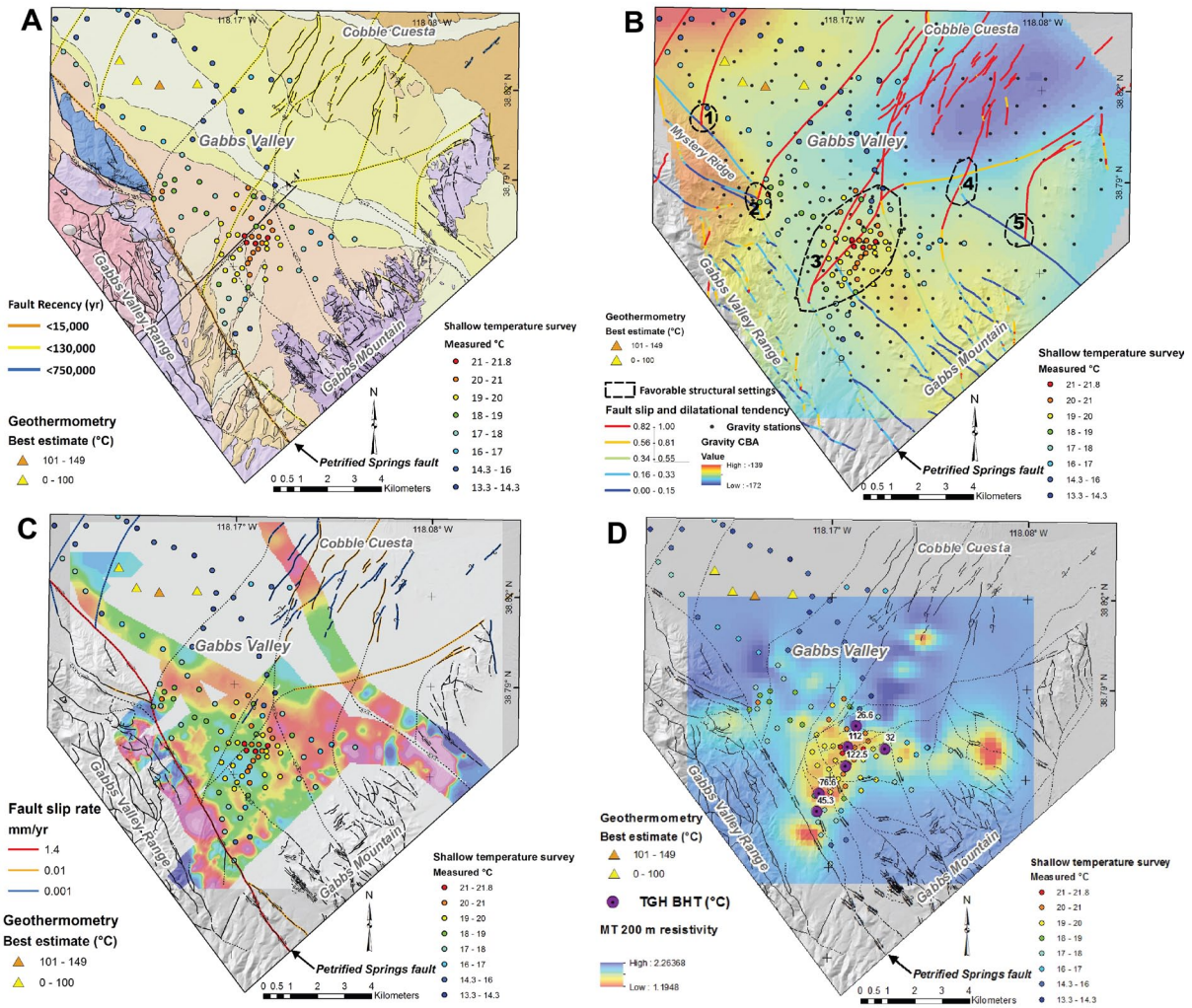

Figure 4: Southeastern Gabbs Valley. A. Geologic map showing Quaternary faults, geothermometry, and 2-m temperature data. Quaternary sediments are in yellow, white, and light orange; Tertiary volcanic units in lavender and pink; Mesozoic metasedimentary rocks are blue. Cross section A-A' is in Figure 5. B. Slip and dilation tendency, complete Bouguer gravity, and favorable structural settings with geothermometry and 2-m temperature data. C. Ground magnetic data and fault slip data with geothermometry and 2-m temperatures. Note collocated magnetic low and shallow temperature anomaly. D. MT data (200 m depth), TG holes, and bottom-hole temperatures (as of June 2018) of TGHs (~152 m depth). Note collocation of resistivity low with hot TGHs and shallow temperature anomaly.

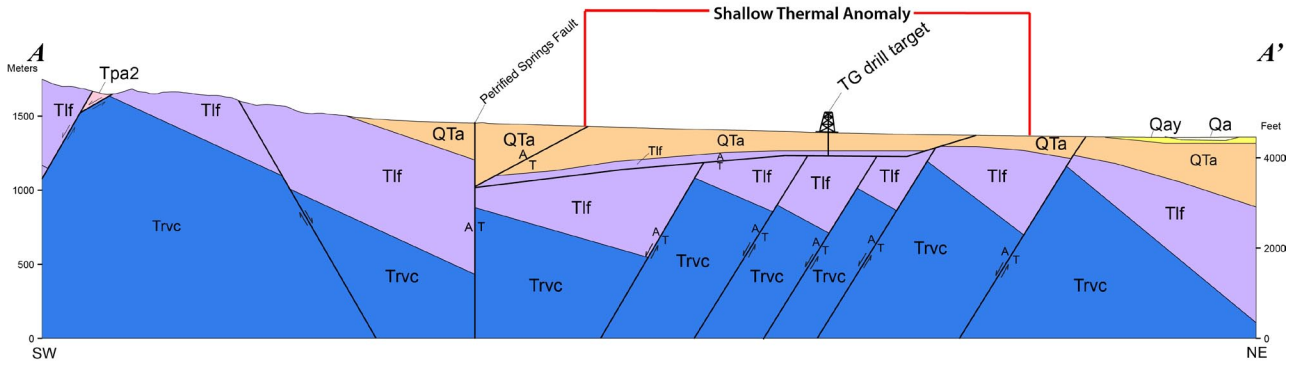

Figure 5: Cross section A-A' in southern Gabbs Valley (location in Figure 3A), showing complex fault intersection collocated with 2-m temperature anomaly and approximate location of hot TG wells marked by drilling derrick. Qay, Qs, QTA – late Miocene-Quaternary sediments; Tlf – Miocene volcanic rocks; Trvc – Triassic metasedimentary rocks.

Miocene ash-flow tuffs along and proximal to faults. NNE-striking normal faults have the highest slip and dilation tendency (Figure 4B). Thus, many faults are well oriented for potential geothermal fluid flow.

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Figure 6. Measuring temperatures of water wells in southeastern Gabbs Valley.

Figure 7. Shallow (2 m depth) temperature survey in southeastern Gabbs Valley.

Figure 8. Temperature-gradient drilling in southeastern Gabbs Valley.

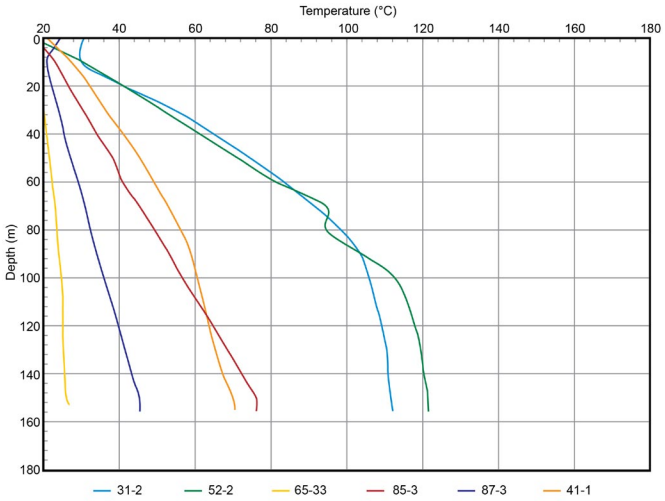

Figure 9: Data from TG holes in southern Gabbs Valley. The two hot wells are collocated with the shallow temperature anomaly, intersecting and terminating gravity gradients, magnetic low, and low-resistivity anomaly.

Discussion – Multi-Scale Adaptability of Play Fairway Analysis

It is important to note that the regional analysis of Phase I recognized relatively broad favorable settings (Figure 1), which were later refined with additional data input in Phase II. As is typical in any regional exploration program for natural resources, it is difficult in the early stages to parse out the detailed characteristics of a particular area to select the most favorable targets for drilling. Upon more detailed analysis in Phase II, it became apparent that southeastern Gabbs Valley contained multiple favorable structural settings (Figures 4B). This presented the immediate challenge of applying our play fairway methodology at a finer scale to effectively model the geothermal potential of each of the favorable settings within a particular study area. The detailed geological, geochemical, and geophysical investigations afforded such an analysis. Ultimately, we utilized play fairway scores to compare individual favorable settings in each of the study areas to one another and rank such areas to select the most promising sites for drilling. Thus, we found that our play fairway methodology was very adaptable to the natural evolution of an exploration program, as it progresses from a regional analysis and subsequently vectors into the most promising prospects that present the lowest risk for development.

We further note that the additional geophysical data from southeastern Gabbs Valley was especially important due to its location in a large, late Cenozoic basin. New geophysical data from the basin afforded discovery of previously unrecognized intrabasinal, favorable structural settings and identifying the most promising area based on the collocation of multiple features. These findings epitomize the importance of the detailed studies in refining exploration targets in such areas. Considering that about half of the Great Basin region is covered by basins, this also demonstrates the broad applicability of such detailed studies as well as the large untapped potential for commercial-grade geothermal systems in many of these basins.

Conclusions

Multiple features, including hot TGHs, geothermometry from nearby water wells, intersecting gravity gradients, magnetic low, and low-resistivity, indicate that the south-central part of southeastern Gabbs Valley contains a relatively high temperature (>130°C) blind geothermal system. Additional work is needed, however, to fully characterize the temperature and geometry of this resource and provide a platform for evaluating commercial viability. These tasks include: 1) collecting and analyzing fluid samples directly associated with the resource to better define the reservoir temperature and provide direct context for the TGH results; 2) integrating the detailed potential field geophysical (gravity and magnetics) and geologic data to build a detailed 3D geologic model; and 3) integrating all data to develop conceptual models of the geothermal resource and constrain its size.

Nonetheless, the discovery in southeastern Gabbs Valley is significant, as no previous geothermal exploration had been conducted in this area. These results provide preliminary validation of our methodology and suggest that broader applications of play fairway analysis will likely yield positive results. Not only are there many additional promising sites within the original 96,000 km^2 study area, but other parts of the Great Basin region abound in favorable geologic settings and could greatly benefit from play fairway analysis, especially considering that blind systems probably represent the bulk of the geothermal resources. Play fairway analysis provides a platform from which to conduct geothermal exploration at multiple scales and ultimately minimize the inherent risks in drilling and development. Although the details of play fairway analysis will differ between regions, depending on tectonic setting, available data, and other factors, the general methodology utilized in this project provides a roadmap for unleashing the vast untapped potential of conventional geothermal systems in the Great Basin and other regions.

Acknowledgments

This project was funded by a Department of Energy grant (grant number DE-EE0006731). Collaborations with the geothermal industry, including Ormat Nevada, Inc. and U.S. Geothermal, have been beneficial to this study. We also thank Dick Benoit and Ian Warren for fruitful discussions.

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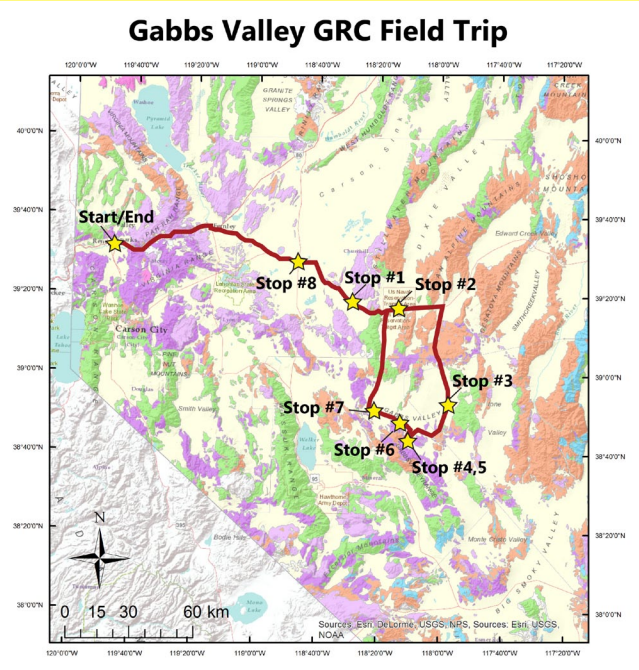
Gabbs Valley Field Trip, October 18 2018

Searching for Blind Geothermal Systems Utilizing Play Fairway Analysis, Western Nevada

A field trip to the discovery area in Gabbs Valley will be conducted immediately following the 2018 GRC Annual Meeting. Field-trip stops are designed to 1) provide an overview of the regional geologic and geothermal setting, 2) describe the play fairway methodology, and 3) review the evidence for the previously unknown geothermal system in southeastern Gabbs Valley. Specific planned stops (Figure 1) include the following:

1. Overview of regional geologic and geothermal setting along Highway 50 near the Salt Wells geothermal field.
2. Overview of geothermal activity of Dixie Valley, including 1954 fault scarps, if time allows.
3. Overview of southeastern Gabbs Valley.
4. Geologic and geophysical setting of southeastern Gabbs Valley.
5. TGH sites in southeastern Gabbs Valley.
6. Mesozoic basement exposure.
7. Don A. Campbell geothermal power plant – geologic overview and plant tour.
8. Dinner in Fallon, Nevada.

It's not too late to join the trip! Sign-up with GRC Annual Meeting & Expo registration..... ■



Planned stops on GRC field trip overlain on generalized geologic map of the region.

Corporate Focus

The GRC would like to highlight our partners in the industry with a regular series of articles featuring our company colleagues. We thank our friends in the corporate sector for their ongoing support.

Headquartered in Santa Maria, California with offices in Bakersfield, California and Norman, Oklahoma, Kenai Drilling Limited is California's largest independent drilling contractor. It has been meeting the geothermal industry rig needs since 1988. Built on a commitment to safety, operational excellence and hard work, Kenai Drilling Limited has been able to grow from a 4 rig operation to its current 23 rig operation with 16 rigs serving the West Coast and 7 rigs meeting the needs of the Mid-Continent market. Behind this growth is a management team with a combined total of 201 years' experience in the Geothermal and Oil and Gas industries. Over the years Kenai has had the privilege of partnering with many of the leading Geothermal Operators in the US including, CalEnergy, Coso Operators, CalPine, University of Utah, Hudson Ranch, EnergySource, Terra-Gen, Gradient Resources, BottleRock Power and Ormat Geothermal. It is this experience that has led Kenai Drilling Limited to their strong reputation as the preferred Drilling Rig contractor for the Geothermal and O&G markets.

Throughout the years Kenai has not only been able to provide exceptional equipment, their team has also partnered with operators to provide over 1.22 million man-hours under labor only contracts running operator owned rigs. Kenai Drilling has also partnered with operators to build fit for purpose rigs to meet their needs. Most recently Kenai completed the build of Kenai Rig 19; a 1,500 horsepower rig capable of drilling to 21,500' with 5" drill pipe. This build was completed by the Kenai team in their Bakersfield yard in Q4 of 2017. In September of 2018 Kenai added 2 additional rigs to the fleet, Kenai 20 & 21. These 1,500 horsepower AC rigs are currently in the Bakersfield yard undergoing extensive upgrades and both are contracted to begin operation in early 2019.

This technical expertise and willingness to work not only as a drilling rig service provider, but also as a dedicated business partner, has Kenai Drilling Limited poised for continued growth. For additional information about Kenai Drilling Limited please visit their website at www.kenaidrilling.com or contact David Arias at DArias@KenaiDrilling.com. ■

Kenai Drilling Rig 7 Drilling Range: 25,000' with 5" Drill Pipe.

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Kenai Drilling is very kindly sponsoring the Event App for the GRC Annual Meeting & Expo.
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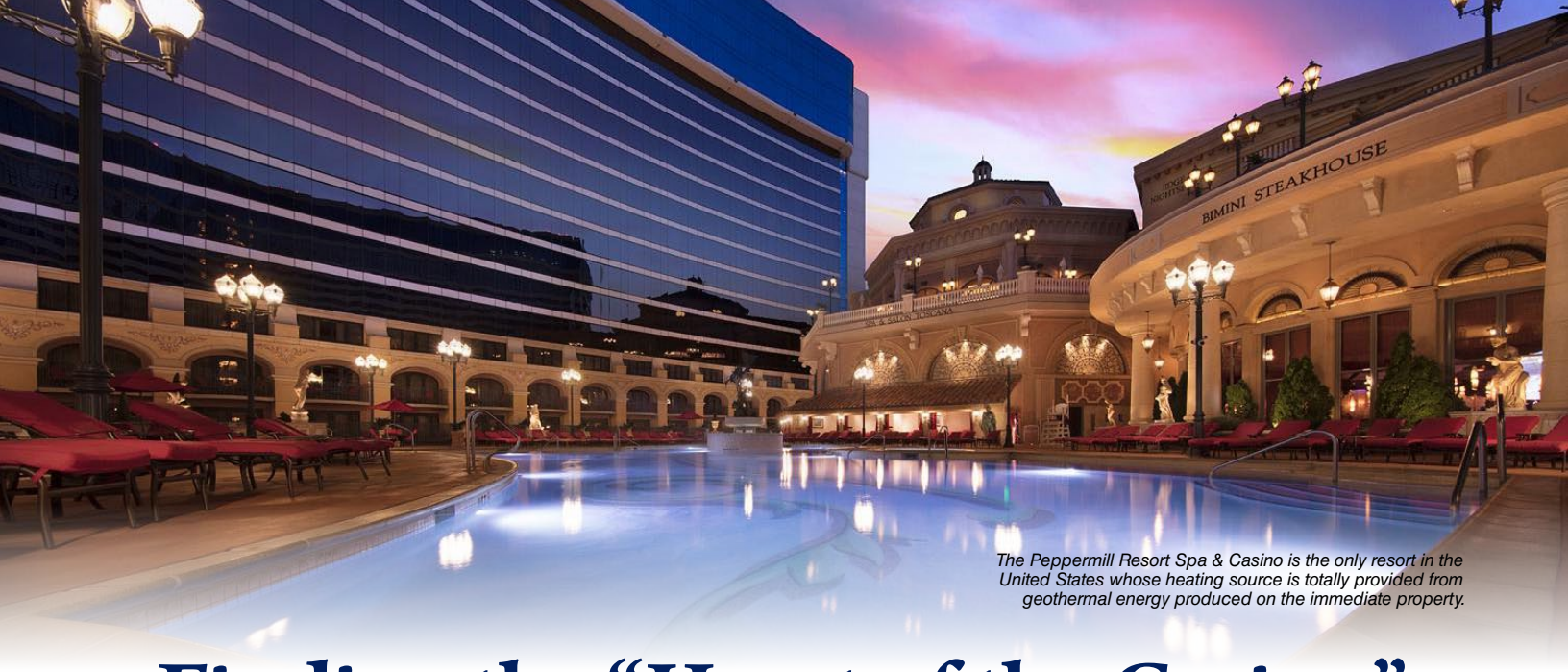


The Peppermill Resort Spa & Casino is the only resort in the United States whose heating source is totally provided from geothermal energy produced on the immediate property.

Finding the "Heart of the Casino" Peppermill Commits to Geothermal

There have been many environmental ventures throughout the Peppermill Resort Spa Casino's history. From recycling projects and ongoing water conservation programs to using artificial grass turf and LED and fluorescent retrofit lighting, going green has been a priority at the 45-acre resort located in Reno, Nevada.

However, nothing boasts the resort's commitment to being eco-conscious more than the investment and use of geothermal.

Just like the name of the game in the industry, the Peppermill took a big gamble in the hopes of drilling deep into the earth to find the perfect water pressure and temperature. Only if the prime conditions were met would the casino be able to harness and convert the energy through a closed-loop system.

All the cards were laid on the table, and the house won.

Peppermill Central Plant Manager John Kassai said the casino is the only major facility in the city of Reno, and to his knowledge, still the only U.S. casino to harvest the earth's energy to heat 100 percent of the resort's domestic water and mechanical heat 24/7.

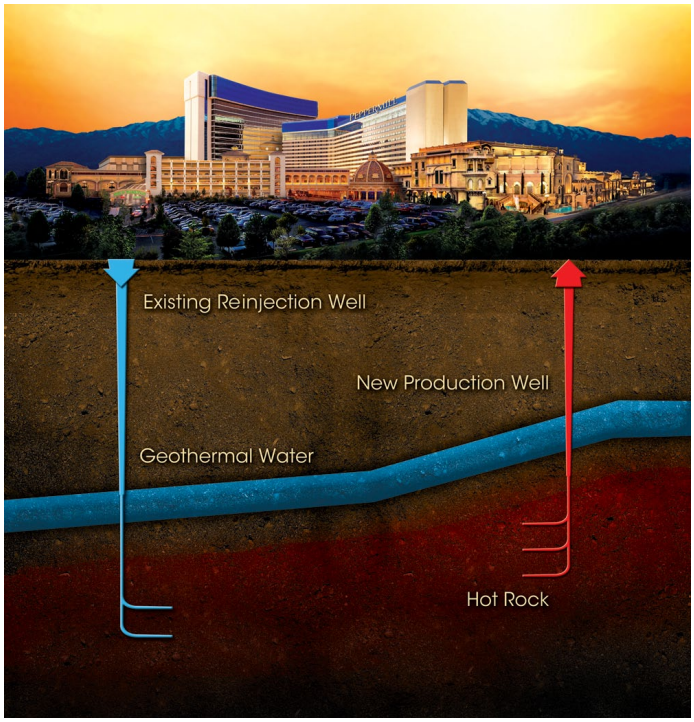
"We're one of the top energy users in Reno," he said. "It just made sense to be the first energy user to have the largest single-use geothermal facility."

Why go with geothermal?

Underneath the Peppermill – 4,421 feet to be exact – lies the prime conditions to harvest geothermal energy for the resort. The aquifer was first tapped in the 1980s, but is no longer in use. It wasn't until a major expansion project that the full potential of the earth's energy would be used.

From 2005 to 2008, the Peppermill's property doubled in size with the addition of the Tuscany Tower. What was once a large casino and resort to begin with, then grew to a whopping 2.1 million square feet of facility, 1,635 hotel rooms and three swimming pools. With the increase of property also came a drastic increase in utilities; the resort's water, gas and electricity use doubled. At the time, the facility was spending an estimated $2.2 million in utility bills, Kassai said.

As a means to stay afloat financially during the recession and help conserve resources, feasibilities were conducted on wind, solar and geothermal. Peppermill Owner Bill Paganetti worked with geothermal expert Dr. Jim Combs of Geo Hills



The Peppermill is located on approximately 50 acres, right on the edge of the Moana Geothermal Resource, and has several geothermal wells on location. All are direct-use wells, drawing from the tertiary volcanic's of the Kate Peak formation.

Associates LLC of Reno to consult on the existing historical data and information from earlier projects. Because of the existing reinjection well, Dr. Combs recommended a new geothermal well be drilled on the property.

The feasibility for geothermal came back with a projected return on investment of 3.5 years and natural gas savings to be approximately $2 million per year, Kassai said. The estimated cost to build would be approximately $6.5 million and take about 12 months to complete; however, the overall benefits for the property and environment outweighed the initial cost. With the active reservoir conveniently located thousands of feet under the casino, the pre-existing reinjection well on the property and the added bonus of a wallet-friendly option, the decision was made to take the gamble on geothermal.

Injection to reinjection

From the conception of the idea to fruition, it took five years, hard work and a lot of luck to have the Peppermill fully switched over to using geothermal for domestic and mechanical heat by 2013.

In 2008, $1 million was invested to overhaul the existing system with stainless steel piping,

The caldarium in the Peppermill spa.

heat exchangers, new well pumps and a variable frequency drive system. The shallow well went online in May 2009 and was designed to heat 600 rooms, two outside swimming pools and two Jacuzzi pools. After five months, the natural gas boiler production decreased by 30 percent and saved the property up to $468,000 per year.

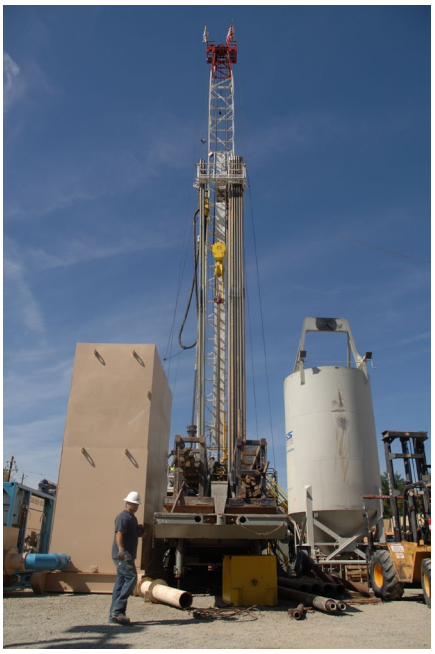
The production well was drilled to a vertical depth of 4,421 feet, the injection well to 3,900 feet deep.

Then, it came time to drill.

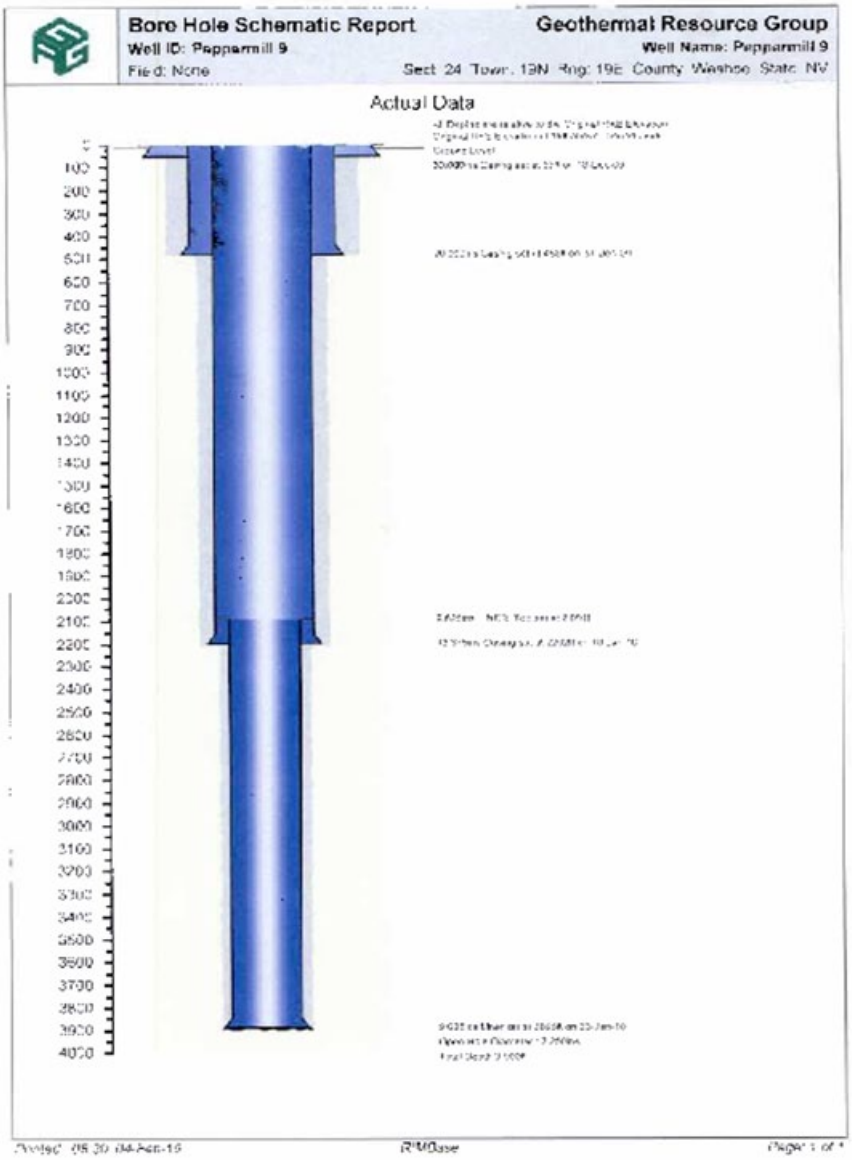
Ensign Drilling Company was contracted by the Peppermill to create what is now known as Production Well #8.

"It took 28 days to drill and it was a hefty 24/7 operation all on a risk that we might find the right conditions," Kassai said.

Operations had continued for weeks with the promise of tapping some of the earth's resources looking slim. However, the team persisted.



Drilling of production well #8.



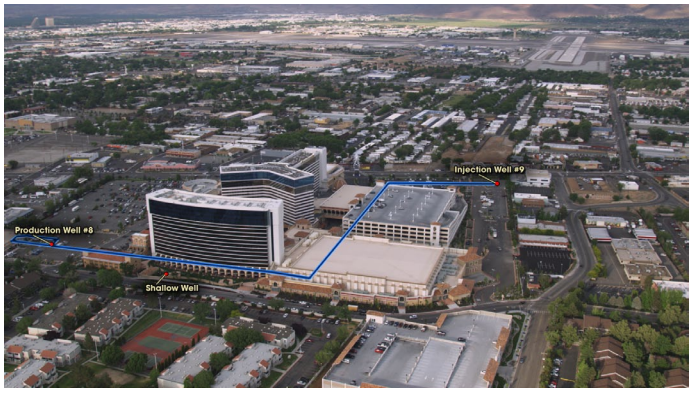
Borehole schematic report for injection well #9 prepared by Geothermal Resources Group.

At a vertical depth of 4,421 feet, water that pumped 1,200 gallons per minute at 150 psi and temperatures of at least 170 degrees Fahrenheit, the needed conditions were found. After drilling and construction, the geothermal system was ready to go online. As Kassai said: "We found the heart of the Peppermill."

Water at 174 degrees Fahrenheit is pumped from Production Well #8 at a rate of up to 1,200 gallons per minute. The artesian water heated by volcanic energy then travels to the heat exchanger in the boiler room and heats copper tubes filled with water provided by the municipal water authority. The municipal water is then diverted throughout the hotel or stored in the twelve 1,000-gallon holding tanks designed to heat the Tuscany Tower. The facility's HVAC system is also connected to the geothermal operations, allowing hot and cold air to be supplied indirectly by the geothermal water. While the municipal water is diverted, the geothermal water – still untouched by the municipal water to avoid contamination – is pumped back into the aquifer, ready to be naturally reheated and reused.

The reinjection well – now known as Reinjection Well #9 – was drilled in January 2010 on the southwest end of the property at 3,900 feet deep and can handle a rate of 1,500 gallons per minute. The "used" artesian water is returned to the aquifer and is naturally heated by the earth. Kassai said the water is returned from the facility at about 153 degrees Fahrenheit in the summer and about 140 degrees Fahrenheit in the winter.

Drilling of injection well #9.



Location of the production and injection wells, looking east across the Peppermill Resort Spa & Casino towards Reno Airport in the top-right.

The geothermal system is monitored on a daily basis. The geothermal front-end automating system provides all information in real time and can be accessed throughout the facility. One of the key metrics measured daily is the temperature. Over the past two years, Kassai noted that the temperature of the artesian water has decreased about 1.5 to 2 degrees Fahrenheit, making the average temperature pumped out of the earth about 172 degrees Fahrenheit. Kassai said there isn't a reason to be concerned yet because it's unknown if the temperature will drop any further or if the degrees will ever drop to an amount where it will be unusable.

In case of a geothermal system failure, the Peppermill still has the boilers that were used before the sustainable system went online.

Inside the Central Plant, there are four boilers that operate at 25 million BTUs each and are driven by natural gas. Before the geothermal system, on average, the boilers cost $2.2 million in natural gas per year. Kassai said hot water is still run through the boilers to keep them ready in case of an emergency.

"If something ever breaks, we will always have the capacity to keep going," he said.

In the five years since the rollover to the geothermal system, Kassai said there has never been a major issue or cause to use the boilers.

Future of geothermal

The cost of the drilling, site preparation, fencing, piping and system totaled approximately $6.5 million while the whole project – from drilling both wells, piping, man power, flow testing and everything in-between – was an estimated $9.7 million investment. Financially, the geothermal project paid off, but the use of environmentally friendly options paid off even higher.

The Peppermill – in only a few years – decreased its yearly carbon footprint by 12,000 metric tons, saw a major reduction in its utility bills, improved bottom line return on investment, developed into a more competitive site and became a more attractive location for eco-conscious consumers.

While the Peppermill has achieved great strides in being environmentally friendly, its commitment to being a steward for the planet isn't stopping here.

Looking ahead, Kassai said, there are plans to try to drill again, this time for enough heat energy to produce electricity for part or all of the property. The Peppermill would need to dig again in the exact right spot to find enough energy at about 215 degrees Fahrenheit to power the property, but if the house was lucky once, it might just be able to do it again.

All photos Courtesy John Conelea, Peppermill Casinos, Inc.

MONDAY – WEDNESDAY, OCTOBER 15-17

Geothermal Direct Use Tours of the Peppermill Resort

Compliments of the Peppermill Resort & GRC

The tour will highlight the geothermal wells and engineering facilities. Our knowledgeable guides will provide an interpretive commentary during the trip, and you won't even need to leave the hotel.

Schedule:

- Monday: 12:30pm-1pm, 3:10pm-3:40pm
- Tuesday: 9:40am-10:10am, 12:30pm-1pm, 3:10pm-3:40pm
- Wednesday: 9:40am-10:10am, 12:30pm-1pm

Tours will depart from and return to the Tuscany Ballroom foyer. (Limited to 30 participants per tour). Sign-ups for the tour will be available at the GRC registration desk.

Peppermill Green Initiatives

REDUCE

A hydronic system to heat or cool the facility by using a closed-loop system. The cold water is cooled by a pre-chill system utilizing outdoor temperatures instead of chillers; the hot water is heated by geothermal. In the wintertime, the Peppermill uses cooling towers to cool the return hydronic chill water and then send it through a plate and frame exchanger that acts like big Trane chillers. The pre-cooling process keeps the Trane chillers shut off, which saves the Peppermill approximately $5,000 per 24-hour period. On the boiler side, the geothermal will heat the entire facility – keeping the Cleaver Brook boilers shut off, which will save the company about $2.2 million per year.

A building management system to control and regulate heating room and water temperatures as opposed to constantly heating the water throughout the day. It is difficult to estimate the savings by having the Peppermill facility controlled by "Building Control System" (Computer) but the BCS, in conjunction with DDC (Direct Digital Control) stats and VFD (Variable Frequency Drive) units, makes the entire control systems 1,000 percent more efficient than running manually.

An ongoing property-wide water conservation program through room placards encouraging reuse of towels and water conservation and changing guest bed linens and towels per stay on a request-only basis.

Installed more than 30,000 square feet of artificial grass turf, saving the Peppermill approximately 5,184,000 gallons of water per season and more than $18,000 in annual cost, including reducing chemical and pesticide use.

LED and fluorescent retrofit lighting throughout the resort.

Creation of a virtually paperless HR department through the implementation of new software systems and transferring all forms and documents into digital applications.

REUSE

Working with Clean the World, a nonprofit that collects, sorts and processes discarded soaps and shampoos from hospitality partners and redistributes domestically and worldwide to children and families whose lives are threatened by poor hygiene. The Peppermill diverts more than 1,000 pounds of soap and shampoo per month from local landfills and to communities in need. Annually, soap recycled from the Peppermill will serve more than 1,200 children a year.

Reusable serving utensils, eating utensils, napkins and tablecloths in all restaurants.

RECYCLE

Installation of 30 plasma air generators within the mechanical systems throughout the casino resulting in a cleaner, healthier casino environment. Plasma air purification units produce an all-natural bipolar ionization that significantly improves the casino air quality by neutralizing odors, cigarette smoke, allergens, bacteria and other airborne irritants and inhibiting volatile organic compounds found in carpet, furniture and cleaning agents. The concept is similar to how sunlight helps improve the atmosphere.

Installation of a water recycling system for all laundry services, conserving millions of gallons of water each year. Installed an aqua recycling system that captures, filters and reuses commercial wash machine grey laundry water. This system saves the Peppermill approximately $246,000 per year in domestic water consumption and detergents.

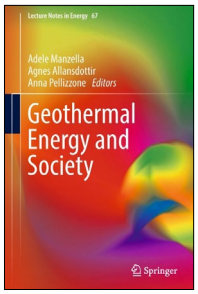
Shredding and recycling paper receptacles in all administrative offices, including onsite print shop and advertising departments.

The Peppermill participates in an organics and composting program where food scraps from the general waste produced in the casino's kitchens are collected by Waste Management and are then transported to a local composting facility that turns the material into compost. The production of compost is a natural process, where plant and animal materials are decomposed by microbes. The final product is used for gardening to improve soil. The Peppermill diverts 60 yards of organic waste from the local landfill monthly, and as time goes on, that amount will increase. ■

Publications, Websites, Videos & Maps

by Ian Crawford

Geothermal Energy and Society (Springer)

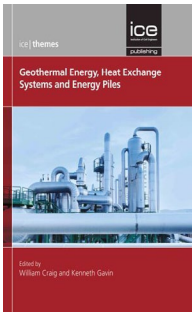


Editors: Adele Manzella, Agnes Allansdottir and Anna Pellizzone

This book addresses the societal aspects of harnessing geothermal resources for different uses, such as power production, heating and cooling. It introduces a theoretical framework for a social scientific approach to the field, and presents a preliminary collection of empirical case studies on geothermal energy and society from across the world. By providing a conceptual and methodological framework to the study of geothermal energy and societies, it brings together information and analyses in the field that to date have been sparse and fragmented.

This should be of interest to researchers from a range of disciplines who wish to explore the issues surrounding energy and society, it is also a valuable resource for geothermal experts and postgraduate students wish to study the field in greater detail. Order eBook or hardcover book from Springer.....

Geothermal Energy, Heat Exchange Systems and Energy Piles (ICE Themes)



Edited by Kenneth Gavin and William Craig

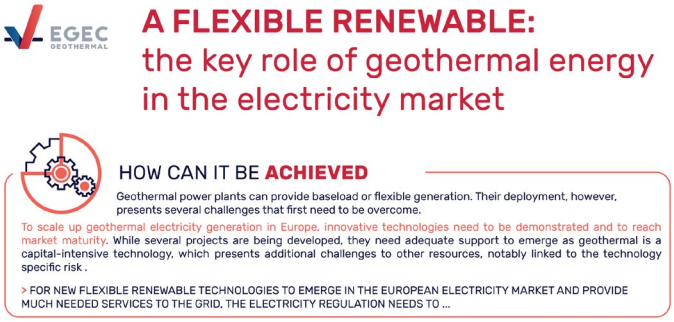
This book focuses on topics from high temperature geothermal energy extraction, to lower temperature situations at ground surface and shallow depths. Providing broad international coverage, the chapters encompass field observations on sites in several countries as well as computational and laboratory studies. Ground conditions vary from hard rock to chalk, loess to London Clay.

Key features of this book include:

- international case histories on geothermal energy extraction
- coverage of geothermal resource exploration, characterisation and evaluation
- design and assessment of energy piles.

This book, which has been edited by two leading experts in the field, is an ideal resource for engineers and researchers seeking an overview of the latest research in this exciting area. Order hardcover book from ICE Themes.....

Geothermal as a Key Flexible Player in The European Energy Market (EGEC)



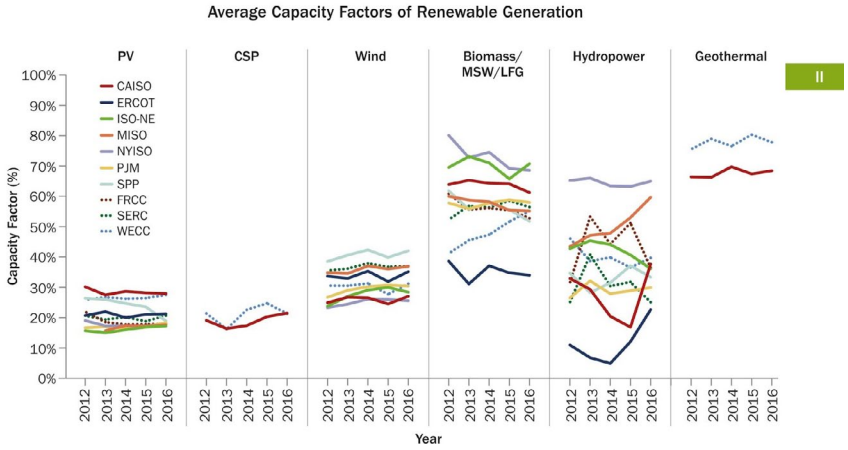
The **Electricity Market Regulation** considers renewable power production only as a source of instability, due to the variable or intermittent production of PV and wind technologies. It introduces **Capacity Remuneration Mechanisms** for dispatchable or flexible generation able to provide grid services to stabilize an electricity market with high renewable penetration. Yet, the debate ignores the potential of flexible renewable production, i.e. geothermal, to provide such grid services. Download the Factsheet.....

Renewable Energy Statistics 2018 (IRENA)

The **International Renewable Energy Agency (IRENA)** has set out to produce comprehensive, reliable data sets on renewable energy capacity and use worldwide. The *Renewable Energy Statistics 2018* yearbook shows data sets on renewable power-generation capacity for 2008-2017, renewable power generation for 2008-2016 and renewable energy balances for about 120

countries and areas for 2015 and 2016. Further, it features statistics on investments in renewable energy compiled from the OECD-DAC database and 20 major multi-lateral, bilateral and national development financial institutions, presented for the period 2009-2016. More Information.....

2016 Renewable Energy Grid Integration Data Book (EERE)



Geothermal energy has the highest average capacity factor of renewable generation and is NOT variable.

Variable renewable energy (VRE) sources—i.e., those that are fluctuating in nature, like wind and solar—are the fastest growing sources of electrical capacity in the United States. As wind and solar photovoltaic costs continue to fall dramatically, more operators are deploying these energy sources, but **their ever-changing nature creates many challenges for system planning and grid operations.**

The **Office of Energy Efficiency and Renewable Energy (EERE)** has released the *2016 Renewable Energy Grid Integration Data Book,* which sheds some light on questions about how power system operators handle the uncertainty that comes with VRE sources of power. The data book tracks how much VRE power is going onto the grid and highlights the experiences to date. Download the Data Book.....

Report - Hot Commodity: Geothermal electricity in Alberta (Canada West Foundation)

Innovative technologies promise to provide goods and services better, cheaper and in ways never envisioned before. But often these technologies are ahead of the regulatory curve and stumble because the regulatory environment is designed in ways that exclude them.

With an increasing need for low-emission, reliable electricity, geothermal energy provides a big opportunity. With the right technology, investment and regulatory climate, these resources can be developed in Canada.

One example is geothermal energy for distributed electricity production. Geothermal energy is renewable, controllable and clean. Distributed generation – small-scale electricity production at or near where the electricity will be consumed – is reshaping how the world thinks about electricity grids. Both are relative novelties in Alberta. More information.....

Advice Notes on Geothermal Economics for the NPA Region (GREBE)

GREBE (Generating Renewable Energy Business Enterprise) is a EUR 1.77m, 3-year (2015-2018) transnational project to support the renewable energy sector. It is co-funded by the **European Union** (EU)'s **Northern Periphery & Arctic (NPA) Programme**. It focuses on the challenges of peripheral and arctic regions as places for doing business, and helps develop renewable energy business opportunities in areas with extreme conditions.

The focus of the *Advice Notes* is to provide regional partner information on some of the main economic characteristics, sited as imperative, when making an informed choice, regarding which renewable energy technology may be the optimal choice for the business. Download the Advice Notes.....

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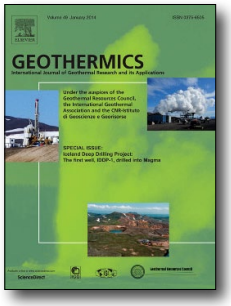
Geothermics



Through affiliation with the **International Geothermal Association (IGA)** the GRC offers a discount to the professional journal *Geothermics*, which publishes articles on the theory, exploration techniques and all aspects of utilizing geothermal resources.

Current, past as well as upcoming articles in *Geothermics* can be found by going to: http://www.elsevier.com/locate/geothermics

Members can contact the publisher Elsevier at JournalsCustomerServiceEMEA@elsevier.com in order to subscribe to the journal. Upon request Elsevier will send a *proforma* invoice to the member e-mail ID.

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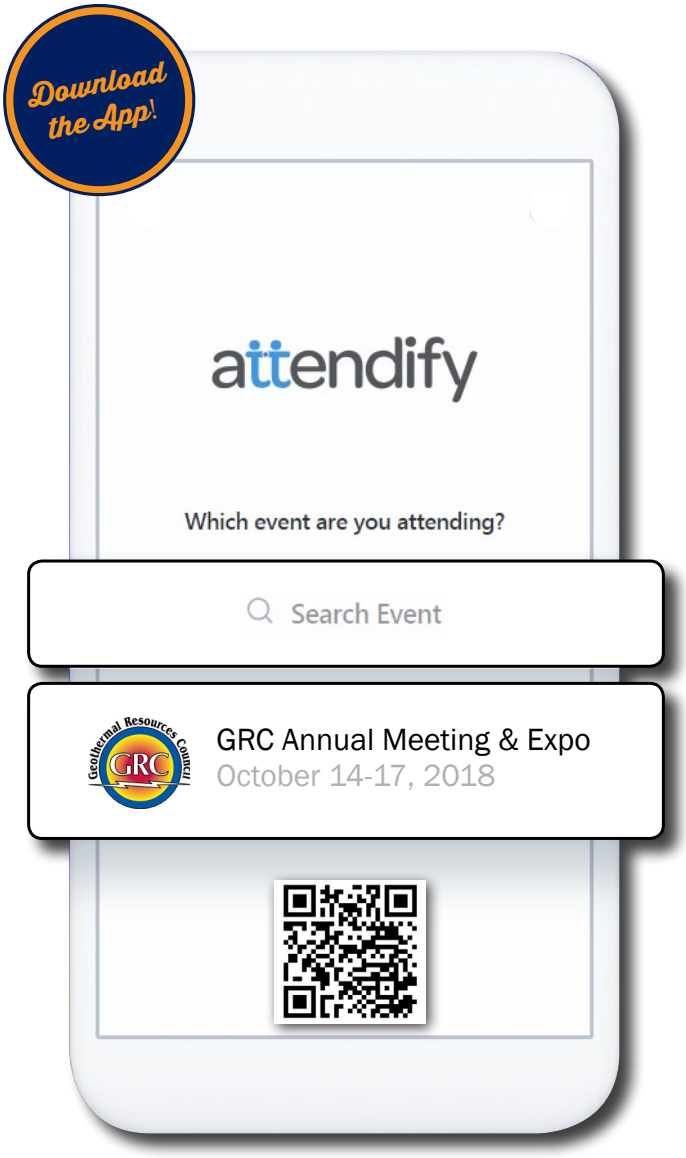

GEOTHERMAL LIBRARY

The GRC Library can be accessed at:
www.geothermal-library.org
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In Memoriam

Marcelo J. Lippmann
1939 - 2018

Marcelo J. Lippmann

Marcelo J. Lippmann, a long-time member and board member of GRC, passed away at his home in Berkeley, California, on September 10, 2018, after a long bout with cancer.

Marcelo was born in Buenos Aires, Argentina in 1939, and received his BS in geology from the University of Buenos Aires in 1966. He and his wife Martha then moved to California, where Marcelo continued with his studies, receiving his MS in 1969 and his PhD in 1974 in Civil Engineering from UC Berkeley as part of Prof. Paul Witherspoon's group.

After a short stint working at UC Berkeley, where he conducted research on numerical modeling of heat and mass transfer in geothermal systems, Marcelo moved up the hill to join Lawrence Berkeley National Laboratory in 1976, where he worked the remainder of his career. Marcelo's expertise was in the modeling of geothermal systems, with a focus on determining their energy capacity and commercial longevity and designing sustainable exploitation strategies. Some of the systems he studied included Cerro Prieto, Mexico; Heber and The Geysers, USA; Miravalles, Costa Rica; Ahuachapán and Berlín, El Salvador.

Together with Paul Witherspoon, he helped lead the Mexican-American cooperative program at the Cerro Prieto geothermal field from 1977 to 1982 and was a key member of many other international geothermal research projects. Marcelo was in charge of LBNL's geothermal program from 1985-2000, helping establish Berkeley Lab as a world leader in geothermal research.

He authored or co-authored more than 100 scientific papers and reports. While Marcelo officially "retired" from LBNL in 2005, he continued on as a rehired retiree until 2015, and remained active as a lab affiliate up until the time of his passing.

In addition to his contributions as a scientist, he selflessly devoted much of his energy to the international geothermal community, serving as an advisor and mentor. He was Associate Editor of the journal *Geothermics* from 1992-1995 and 2009-2010, and was Editor-In-Chief from 2004 to 2008; he continued to review articles to the very end. As an editor of *Geothermics*, he devoted countless hours helping authors to polish their manuscripts.

He was tireless in his support of the Geothermal Resources Council, having served as a board member from 1999-2000 and 2004-2009, and was a member of the Education, Honors and Awards, and International committees. The GRC recognized his extensive scientific achievements and contributions to the geothermal community in 2010 with the Joseph W. Aidlin award, the highest award bestowed by the Council.

Marcelo was also given a special award by the Asociación Geotérmica Mexicana in 2015 for his many contributions to geothermal energy research in Mexico. Marcelo also served as a board member for the International Geothermal Association from 1993-1998.

Marcelo is well known and admired throughout the global geothermal community for his generosity and willingness to help and his fostering of international collaboration. Those of us who knew him well will miss him dearly. He is survived by his wife Martha, his son Julian, his daughter-in-law Jessica Owley, and two granddaughters. *Thanks to Patrick Dobson, Sabodh Garg, Ron DiPippo, and Iraj Javandel for their contribution.*

Carel Otte
1922-2018


Dr. Carel Otte

Geothermal pioneer and innovator Dr. Carel Otte passed away peacefully at home, in La Canada, California on Saturday July 21st. Dr. Otte was born in Amsterdam, the Netherlands, on June 29th, 1922. He did his undergraduate work at the University of Amsterdam in geology and chemistry. At the start of World War II, he was too young for the Dutch military and was sent to work in a German work camp. He escaped and helped with the Dutch underground posing as a Dutch geologist working in Austria. Recognized for his language and survival skills, he served as a Captain in a Dutch contingent of the RAF after the war helping repatriate returning prisoners of war. Returning to Amsterdam, he was accepted for graduate work first at Johns Hopkins and then at Caltech in Pasadena. He completed his Masters Degree in 1950 and his PhD, in geology in 1954.

Dr. Otte's first job after Caltech was with the Pure Oil Company at their research department in Illinois. He worked for a time with Shell Oil Company and, resisting a move to Calgary, returned to Pure Oil. His involvement in the geothermal industry began with a casual acquaintance with a group of people who owned land north of Santa Rosa, California known as "The Geysers." Inspired by the idea of utilizing this great resource, he convinced Pure management to form a subsidiary called Earth Energy. When Pure merged with Union Oil Company where he became the head of the Geothermal Division.

Dr. Otte was a strong advocate for geothermal energy and was instrumental in the large-scale development of The Geysers striving to put 100 MW/year online every year through the 1980's. He expanded Union's geothermal operations to the Imperial Valley, pioneered geothermal development in the Philippines and Indonesia and drove geothermal resource exploration into every promising prospect around the world.

Carel Otte leaves a deep legacy with the GRC and within the geothermal industry. Many in academia and industry benefited from his knowledge, determination and expertise. The GRC awarded him the Geothermal Pioneer Award in 1986 and he was recognized as a distinguished alumnus of Caltech in 1984 and was awarded the highest engineering honor with his election to the National Academy of Engineering in 1988. For all who knew him, he is fondly remembered and will be sorely missed.

His wife Mary, four children and nine grandchildren survive him. A memorial service and a celebration of his life were held at the Caltech Athenaeum on Tuesday, August 21st from 3 to 5 pm. *Thanks to Gene Suemnicht for the contribution.*

Jeff Nichols
1964-2018


Jeff Nichols

It is with heavy hearts that we share the sad news of the sudden passing of Jeff Nichols on Saturday, August 18, 2018, after a short and courageous battle against cancer. Jeff has been a vital part of the Quantec family since 2011, and his unexpected and untimely death is deeply felt by all of us at Quantec.

Those of us who had the privilege of knowing Jeff – not just as a co-worker, but also as a friend – will remember him as a passionate and caring person.

Jeff's love of the outdoors led him to a career in geophysics. After working on survey crews around the world for Zonge Engineering and then Geosystems, a division of Schlumberger, Jeff joined Quantec in a sales capacity. Jeff was very keen about the Geothermal sector and developed new business for the company there. Jeff was an excellent liaison between clients and Quantec operations due to his hands-on knowledge of field geophysics, and this resulted in him being Quantec's top salesperson for 5 years running.

We will miss Jeff's wry sense of humor, his love of geophysics, and his passion for life. *Thanks to Rob Gordon FGC., Marketing & Sales Manager, Quantec Geoscience Ltd.* ■

Calendar of Events

GRC Annual Meeting & Expo
14-17 October, Reno, Nevada, USA
www.geothermal.org/meet-new.html

6th National Geothermal Congress - Polish Geothermal Association
23-25 October, Zakopane, Poland
www.energia-geotermalna.org.pl/vi-ogolnopolski-kongres-geotermalny/

Seventh African Rift Geothermal Conference (ARGeo-C7)
29 October–4 November, Kigali, Rwanda
www.theargeo.org

U.S. Hot Springs Conference
7–9 November, Glenwood Springs, Colorado, USA
www.hotspringsconnection.com/

The 12th Asian Geothermal Symposium (AGS12)
9-12 November, Daejeon, Republic of Korea
www.aist.go.jp/fukushima/en/AGS12/index.html

GEORG Geothermal Workshop
14-15 November, Reykjavík, Iceland
https://geothermalworkshop.com/

NZ Geothermal Workshop
14-16 November, Taupo, New Zealand
http://www.geothermalworkshop.co.nz/

German Geothermal Congress - Der Geothermiekongress (DGK) 2018
27-29 November, Essen, Germany
www.geothermie.de/aktuelles/der-geothermiekongress-2018.html

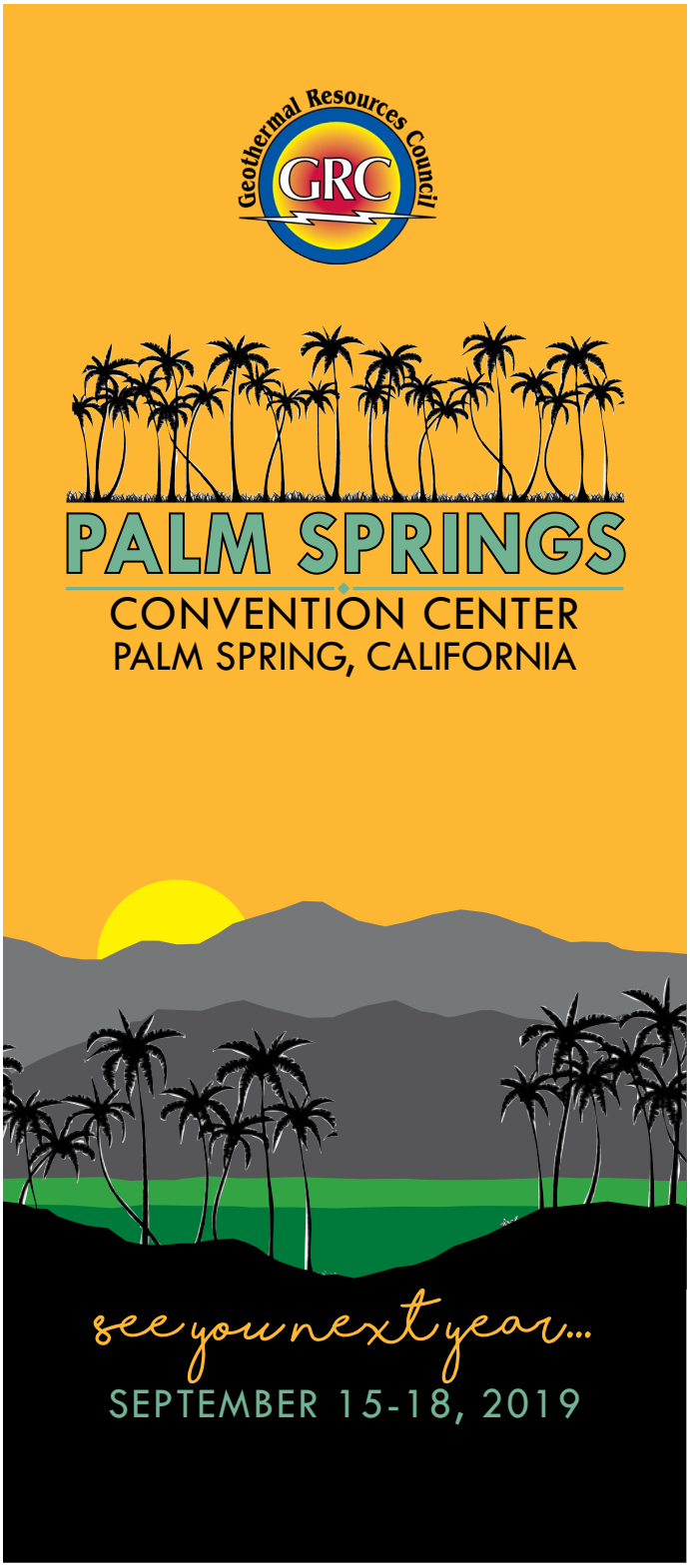
3rd Colombian National Geothermal Meeting - Reunión Nacional de Geotermia (RENAG 18)
13-15 December, 2018, Bogotá, Colombia
www.ageocol.org/

GeoTHERM - Expo & Congress
14-15 February 2019, Offenburg, Germany
www.geotherm-germany.com/

EAGE Annual Conference & Exhibition 2019
3-6 June 2019, London, UK
https://events.eage.org/2019/eage-annual-2019

European Geothermal Congress 2019 (EGEC)
11-14 June 2019, The Hague, Netherlands
http://europeangeothermalcongress.eu/

GRC Annual Meeting & Expo
15-18 September 2019, Palm Springs, California, USA
www.geothermal.org/meet-new.html ■



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GRC ANNUAL MEETING & EXPO

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