

# Geothermal Resource Decision Workshop – Virtual Hands-on Introduction

E-course Presented by **PETROLERN LLC**  
24 – 27 May 2021, 9 am – 5 pm CDT



## Instructed by:

William Cumming  
Irene Wallis  
Nicholas Hinz  
Jonathon Clearwater  
Amanda Lonsdale  
Anna Colvin

Registration Fee: 1,800 USD

Un-employed Discounted Fee: 900 USD

Student Fee: 400 USD (limited availability)

To register, visit: [www.petrolern.com/training/](http://www.petrolern.com/training/)



# Geothermal Resource Decision Workshop: Virtual Hands-on Introduction

During geothermal exploration and development, a resource team predicts reservoir properties and estimates uncertainty to support high-value decisions. This workshop simulates the decision process from geothermal prospect identification to power plant commitment. During the workshop, participants get immediate feedback on decision outcomes in order to improve prediction reliability and decision effectiveness. Teams of 3 to 5 participants complete hands-on exercises with support from expert coaches, ensuring progress regardless of participants' backgrounds. Participants use real data to construct geothermal conceptual models, use these conceptual models to generate probabilistic outcomes for well targets and electrical power generation capacity, make decisions based on those predictions and economic constraints, and test those decisions against real outcomes. Interspersed among the exercises are lectures that introduce key concepts on geothermal geochemistry, geology, geophysics, the thermodynamics of water flow in rock, well temperature log and production test interpretation, decision risk assessment and economic criteria for decision making.

This virtual, interactive, and hands-on workshop has received outstanding reviews by geoscientists and reservoir engineers from both the geothermal and petroleum industries. It is based on the Geothermal Resource Decision Workshop curriculum that has been used worldwide since 2000 for training geothermal industry professionals and within academic courses. The workshop demonstrates the application of current resource analysis technology and offers participants the opportunity to interact with geothermal industry experts. Each day concludes with a virtual social hour where participants have the opportunity to mingle with presenters and coaches to clarify concepts, discuss specialized interests or make contacts.

## **WHAT YOU WILL LEARN**

Upon completion of the course, participants will:

- Understand elements of conceptual models for different geothermal resource types and how resource type affects exploration strategy;
- Rank exploration prospects based on key indicators;
- Integrate the most decisive types of surface geoscience data to build geothermal deep circulation conceptual models used to predict well targets, resource capacity and uncertainty;
- Make well design and targeting decisions based on resource predictions in the context of economic constraints;
- Update conceptual models using the immediate feedback on well target success, geothermal well logs and well performance tests;
- Appreciate realistic impacts of uncertainty and economic constraints on geothermal exploration programs, well design and resource capacity decisions.

## **WHO SHOULD ATTEND**

Geoscientists, engineers and managers who wish to better appreciate what geothermal resources are and how surface geoscience data, subsurface well data and production test data are integrated to support geothermal resource exploration decisions in the context of realistic conceptual models and economic constraints.

## **WHAT YOU WILL RECEIVE**

- A detailed course manual including all presentations and up-to-date reference materials
- Resource capacity assessment Excel tool
- References to books and publications relevant to the course materials

# Geothermal Resource Decision Workshop: Virtual Hands-on Introduction

## WHO WILL TEACH



William (Bill) Cumming is an independent consultant who provides resource exploration and development services in the geothermal industry. His 40+ years of geothermal experience include 20+ years with Unocal Corporation in positions from Geophysicist to Chief Geoscientist. Since 2000, he has provided consulting services to geothermal industry, academic and government clients at over 60 geothermal fields and 300 prospects in the Americas, SE Asia, Europe and Africa. In 2000, he began development of the Geothermal Resource Decision Workshop curriculum that has grown to a wide range of in-person and virtual hands-on workshops that use real data to train geothermal resource professionals and support university courses.



Irene Wallis is an independent consultant specializing in structural geology and geomechanics for high-temperature geothermal reservoirs, conceptual model development and well targeting, and the geoscience components of drilling and testing programs. Since transitioning from mining to geothermal, she has accumulated more than 10 years' experience in the exploration, development and operation of high enthalpy resources in New Zealand, Chile, and Indonesia. She has previously led and/or coached Workshops at conferences and for commercial clients in Indonesia, New Zealand, and the US, and has lectured graduate-level geothermal and epithermal courses at the University of Auckland.



Nicholas (Nick) Hinz conducts structural and geological mapping, wellsite geology, integrated geothermal conceptual model development, and well target and resource assessment services for geothermal field developers, research consortia and educational institutions. He has over 20 years of experience in both magmatically heated and deep-circulation heated systems hosted in volcanic and sedimentary settings in North America, Eastern and Southern Africa, Turkey, Indonesia, Central Asia and the Caribbean. Worldwide training services include extensive field instruction in structural geology mapping, wellsite geologist training and conceptual model workshops for industry and universities.



Dr Jonathon (JC) Clearwater is a geothermal reservoir engineer who, as co-director of Flow State Solutions Ltd, provides reservoir simulation services and software to the geothermal industry with a focus on creating models that enable better management of geothermal resources. During over 10 years' experience in the geothermal industry, he has worked on projects in New Zealand, Indonesia, the Philippines and Chile. In addition to reservoir simulation, JC has expertise in well testing, wellbore modelling, well stimulation, pressure transient analysis, financial modelling, and resource assessment. As co-developer of the Volsung Geothermal Simulation software system, JC has supported education in reservoir simulation and resource conceptual models, including providing simulations supporting the volcano-hosted and the deep circulation modules of the Geothermal Resource Decision Workshops.



# Geothermal Resource Decision Workshop: Virtual Hands-on Introduction

## WHO WILL TEACH



Amanda Lonsdale is an independent consultant providing financial structuring and project development services, with over 20 years' experience in renewable energy and 10 years in geothermal development. She helped lead geothermal business development and equity investments for GeoGlobal Energy in the USA, Chile, and Germany and served as the lead commercial advisor for DFID (EAGER) and USAID (PowerAfrica) geothermal programs in East Africa. For both private and public sector clients she has developed decision models that combine both technical and financial aspects of geothermal projects to determine feasibility and obtain equity and debt investment. She has provided mentoring and numerous international short courses sponsored by ADB, Adam Smith International, Deloitte, TetraTech, USAID, the World Wildlife Fund and Georgetown University.



Anna Colvin is a geothermal geoscientist with 11 years of international experience providing technical consulting services in support of geothermal exploration and development. She has worked on behalf of private developers assessing high-enthalpy geothermal fields worldwide, including in Indonesia, the Philippines, New Zealand, East Africa, Latin America, the Caribbean and the USA and has carried out country-level geothermal technical reviews and analyses throughout Guatemala, Peru and Chile.

In addition, this workshop will be supported by team coaches, all of whom are senior geothermal industry professionals and geothermal educators with experience in geothermal exploration and in building geothermal conceptual models to support risk assessment and high value decisions. These include Gabe Matson (Project Geophysicist, Geologica Geothermal), Steve Sewell (Senior Geothermal Geophysicist, Ormat Technologies), and Ryan Libbey (Principal Geologist, Ormat Technologies).



Gabe Matson



Steve Sewell



Ryan Libbey

# Course Outline

## Day 1 09:00-12:00, 13:00-16:00

### **Introduction:**

- Welcome, workshop concept and outline
- **Lecture:** Types of geothermal systems, how they are explored and what type this workshop covers.
- **Lecture:** Thermodynamics of fluid flow in rocks and the descriptive power of isotherms.
- **Exercise 1:** Understanding buoyant fluid flow and heat transfer processes in fractured rock

### **Geothermal Exploration Methods:**

- **Lecture:** Introduction to geothermal geology and structure.
- **Exercise 2:** Teams evaluate real and unreal geology and rank geothermal prospects based only on geology.
- **Lecture:** Introduction to geochemistry, geothermometry, and inferring the origins and properties of reservoir water.
- **Exercise 3:** Teams rank geothermal prospects based only on geochemistry and surface alteration.
- **Lecture:** Introduction to geophysics: Matching tools to targets, why types of MT resistivity dominate geothermal exploration, and survey design.
- **Lecture:** Introduction to geothermal well types (thermal gradient, slim, and production) and interpreting temperature logs.
- **Exercise 4:** Teams vector to the geothermal resource by generating isotherms from slim hole data that has been extrapolated with geophysics, and then interpreting the implications for fluid flow.

**Social hour:** 16:00-17:00 open discussion with instructors, coaches and participants.

## Day 2 09:00-12:00, 13:00-16:00

### **Geothermal Deep Circulation Exploration:**

- **Lecture:** Introduction to deep circulation geothermal systems and examples of real systems.
- **Lecture:** Overview of the geothermal exploration process, data priorities, and survey design.
- **Lecture:** Introduction to economics, exploration budgets and the exercise spreadsheet.
- **Exercise 5:** Teams explore the economics tool provided by proposing an exploration strategy for the base case project assumption, get bids and then check the strategy against the likely project economics and potential value of information.

### **Frankenflow Prospect Exercises:**

- **Lecture:** Introduction to Frankenflow Prospect
- **Exercise 6:** Teams decide on initial exploration surveys for Frankenflow Prospect that are within budget (as dictated by the project economics) and provide value of information.
- **Discussion:** Teams receive data for the exploration surveys they selected, and presenters will review interpretation issues special to current case, including model distortion by data location.
- **Exercise 7:** Teams evaluate the exploration survey data and use it to build conceptual model alternatives.
- **Discussion:** Presenters will review conceptual models that teams generate and highlight models that are inconsistent or incomplete relative to the available data and resource physics.
- **Lecture:** Introduction to probabilistic assessment of geothermal resource capacity and well targets.
- **Exercise 8:** Assess Frankenflow Prospect resource capacity using the conceptual model and resource capacity tool (provided).

**Social hour:** 16:00-17:00 open discussion with instructors, coaches and participants.

# Course Outline

## Day 3: 09:00-12:00, 13:00-16:00

### ***Geothermal Deep Circulation Well Targeting:***

- **Lecture:** Design, budget and strategy for thermal gradient, slim and production wells in geothermal exploration.
- **Exercise 9:** Using the resource capacity estimate to constrain the budget and conceptual model to constrain well targeting locations, teams recommend thermal gradient or slim wells and predicted results. Once targeted, well results are reported to each team with guidance on what to do next.
- **Discussion:** Presenters will review resource capacity estimates and approaches to well targeting.
- **Exercise 10:** Teams integrate well results into their conceptual model and then update their resource capacity estimate and their approach to well targeting. Teams recommend thermal gradient, slim or deep/shallow production wells with predicted results based on their conceptual models. Once targeted, well results are reported to each team with guidance on what to do next.
- **Discussion:** Presenters give a summary of the day and feedback to the teams on progress.

**Social hour:** 16:00-17:00 open discussion with instructors, coaches and participants.

## Day 4: 09:00-12:00, 13:00-16:00

### ***Geothermal Power Plant Decision:***

- **Lecture:** Introduction to the economics of production wells and best practice targeting strategies in geothermal exploration.
- **Exercise 11:** Teams integrate the well results into their conceptual model and update their assessment resource capacity and well targets. Teams target deep/shallow production wells with predicted results based on their conceptual models. Once targeted, well results are reported to each team with guidance on what to do next.
- **Lecture:** Introduction to the economics of power plant commitments and options in geothermal exploration.
- **Exercise 12:** Teams integrate the well results into their conceptual model and update their assessment resource capacity and well targets. Teams target a second round of deep/shallow production wells with predicted results based on their conceptual models. Once targeted, well results are reported to each team with guidance on what to do next.
- **Exercise 13:** Teams integrate well results into conceptual model interpretation and update assessment of resource capacity. Teams must decide if they will commit to a power plant development, further exploration drilling or to sell the project.
- **Lecture:** The actual resource conceptual model, 3D geological model, numerical reservoir simulation, and full distribution of well results are revealed.
- **Discussion:** Presenters review team results relative to actual conceptual model and capacity of the Frankenflow prospect.
- **Discussion:** Closing statements with reflections on geothermal exploration and development case histories.

**Social hour:** 16:00-17:00 open discussion with instructors, coaches and participants.

# Testimonials

## Rebecca Bolton, CGG

Very informative and well-designed sessions, with an innovative approach to training structure and style. A fully online workshop with the benefit of geothermal experts across the disciplines and across the globe. It was a well-executed workshop, focused on the exploration of a geothermal field. Great set up in terms of the team compositions and the approach with 1 expert to steer the group activities was a really great plus. Overall a well thought out, informative and enjoyable workshop. I really enjoyed working with the dataset and having access to different discipline experts.

## Vincejet Nino G. Ejera, Geothermal Geologist, Manila, Philippines

I highly recommend this workshop. I think the exercises were excellently organized and had much applicability to real-life exploration scenarios. Despite the virtual setup being quite challenging at first, it has the advantage of being more conducive for group exercises where each participant could easily contribute their input on a 'virtual whiteboard' all at the same time, which would otherwise be challenging on a physical setup since it would tend to crowd up a table. I learned a lot from the facilitators during our virtual table discussions.

## Chengwu Yuan, Senior Reservoir Engineer, Unconventional Reservoir Technology, Upstream Technology, BP

The multi-discipline approach in this short course is very practical and effective, which is very similar to my previous day-to-day work in the oil and gas asset team and my current technical team. It starts with an Excel economic data, a business case, and a business decision with cost/benefits. This business case is embedded throughout the course, reminding me how data or technology realistically supports business decisions. It fed more and more data in a realistic sequence, mimicking a practical case in 3 days, gave me strong first-hand feelings. I got connected with the best minds in geology, geophysics, and engineering in the geothermal world, and with some classical references as well. This workshop made my extensive oil and gas experience much more relevant to geothermal development and filled my gaps. I feel more confident to support potential future geothermal projects.

## Dr. Ellie MacInnes, Head of Geothermal Science, CGG

I recently made the shift from a leadership role in oil and gas to one in geothermal energy, as such, the course provided a good foundation in the principals of geothermal exploration and resource assessment. The small workshop group and individualized attention provided me with the support required to quickly grasp new concepts and techniques.



---

**PETROLERN Engineering and Geosciences Advisors**

Atlanta: +1 404 993 0416

Houston: +1 404 917 9780

E-mail: [info@petrolern.com](mailto:info@petrolern.com)

[www.petrolern.com](http://www.petrolern.com)

© 2021 Petrolern LLC, All rights reserved