



Identifying Pathways for Enhanced Collaboration Between the Mining and Geothermal Industries

MINEXCHANGE 2021 SME Annual Conference
and Expo

Aaron Levine, Esq.
aaron.levine@nrel.gov

Greg Rhodes

The Geothermal Discovery Problem

The U.S. Geological Survey estimates approximately 30 GW of undiscovered geothermal resources exist in the western United States, which are difficult to discover because these are “blind” or hidden geothermal systems.

- Geothermal exploration is high risk/high cost
- Need solutions to de-risk early stage geothermal exploration

Potential Pathway to Geothermal Discovery: The Mining Industry

Synergies with the locatable mineral industry presents one pathway to geothermal resource discovery.

As such, we wanted to:

- Understand the value of mining data for discovering geothermal resources in the western United States.
- Understand the regulatory synergies or challenges between the mining and geothermal industries.
- Develop techno-economic assessment for geothermal resources discovered through mining data and compare with diesel fuel (commonly used at mine sites) to understand benefits to the mining industry.

Project Details

Research Summary

Our study analyzed:

- The type and quality of data collected by the locatable mineral industry to determine feasibility for geothermal resource exploration
- The regulatory pathways and potential barriers that could prevent development of geothermal resources discovered via a mining claim (and vice versa)
- The historical development of geothermal resources discovered via mineral exploration data
- The value propositions for both the locatable mineral and the geothermal industries to collaborate.

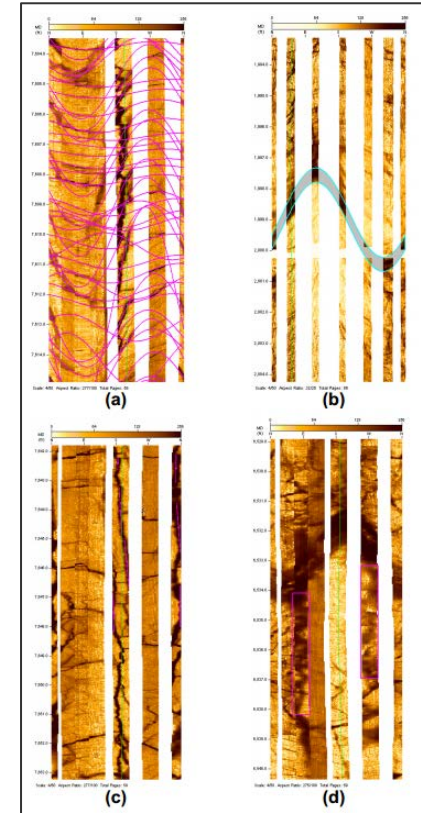
Project Details: Mining Data

Analyzed mining data from 11 databases

- E.g., Nevada Bureau of Mines and Geology databases, USGS :Core and Mineral Resources Databases, Anaconda Geologic Database at the University of Wyoming

Analyzed mining data related to:

- Temperature
- Geochemistry
- Geologic/Hydrologic
- Remote Sensing
- Stress



An example of images taken from a well at the [Coso Geothermal Area](#) for stress tests. (a) natural fractures, (b) A fracture with significant apparent aperture, (c) fractures caused by drilling, (d) borehole breakouts.

Project Details: Regulatory

Distinct leasing programs for geothermal resources and locatable mineral development.

- Locatable minerals stake a claim (30 U.S.C. §§ 22 et seq. (General Mining Law))
- Geothermal generally uses default competitive leasing (30 U.S.C. §§ 1001 et seq. (Geothermal Steam Act)
 - Non-competitive exceptions including an existing mine with a federally approved plan of operation
- Both industries require National Environmental Policy Act (42 U.S.C. §§ 4321 et seq.) on Federal Lands



Project Details: Case Studies

Several geothermal projects have been the result of mineral exploration that identified an undiscovered or “blind” geothermal system.

- McGinnis Hills Geothermal Power Plant
- Blue Mountain Geothermal Power Plant
- Don A. Campbell Geothermal Power Plant

Some geothermal projects have been co-located with mineral extraction projects

- Florida Canyon (small scale demonstration)
- Lihir gold mine in Papua New Guinea (56 MW geothermal power plant)



Blue Mountain Geothermal Plant, Nevada Geothermal Power (NGP), Humboldt County, Nevada. Waste water pond. (Photo by DENNIS SCHROEDER / NREL)

Project Details: Techno-Economic Analysis

Developed a series of techno-economic analysis scenarios using the Geothermal Electricity Technology Evaluation Model (GETEM) managed by NREL.

Ran three scenarios:

1. Business-as-Usual GETEM scenario for geothermal resource development
2. Geothermal resources discovered through mineral exploration + development on BLM-managed public lands
3. Geothermal resources discovered through mineral exploration + development on private land

Techno-Economic Analysis

Table: Summary of TEA Using GETEM

GETEM Input		Business-as-Usual	Discovery Through Mining: BLM Land	Discovery Through Mining: Private Land	Diesel Generation
RESOURCE EXPLORATION AND DEVELOPMENT INPUTS	Exploration Duration	4 yrs	0.75–1 yrs	0.75–1 yrs	N/A
	Exploration Costs with Early Drilling (\$/project)	\$19M	\$1.1–\$8.8M	\$1.1–\$7.6M	N/A
	Drilling Costs (\$/project)	\$12.6M	\$14.8M	\$14.8M	N/A
	Royalty	1.75%		0%	N/A
	Leasing Costs \$/acre	\$20	\$1	0	N/A
	Transmission Costs	\$750k–\$1M/mile	0	0	N/A
RESULTS	Period to Project On-Line	8.3 yrs	4.7–5.2 yrs	4.2–4.75 yrs	N/A
	CAPEX \$/kW	\$8.6k	\$5.4k–\$5.6k	\$5.3k–\$5.6k	N/A
	LCOE \$/MWh	\$87	\$65-67	\$62-65	\$109-185
	Total capital cost	\$116M	\$101–\$107M	\$99–\$106M	N/A

Project Details Impact Summary

Our study found that:

- Much of the data collected by the mining industry as part of locatable mineral exploration could also be useful for identifying and developing previously unknown geothermal hydrothermal resources.
- Leveraging locatable mineral data to develop geothermal resources and/or co-located minerals and geothermal resources could represent significant cost savings when compared to developing geothermal resources under a business-as-usual scenario as well as compared to current generating technologies employed at remote mining operations.
 - The LCOE for geothermal electricity under a business-as-usual scenario is approximately **\$87/megawatt-hour (MWh)**, while the LCOE for geothermal electricity discovered through a mineral exploration scenario is approximately **\$65–\$67/MWh**.
 - In addition, this compares favorably to the LCOE for diesel generation (used at many remote mining sites) of **\$109–\$185/MWh**.

References

Geothermal Data Repository (GDR) Locatable Mining Data Sources and Techno-Economic Analysis Summary:
<https://gdr.openet.org/submissions/1279>

Applicable databases include:

- [Nevada Bureau of Mines and Geology \(NBMG\) Great Basin Science Sample and Records Library](#)
- [NBMG Nevada Mining District Database](#)
- [NBMG Mineral Industry and Exploration Reports](#)
- [County Mineral Reports](#)
- [Anaconda Mining Database at University of Wyoming](#)
- [USGS Core Library and Data Center, Mercury, Nevada](#)
- [USGS Core Library, Denver, Colorado](#)
- [USGS Mineral Resources Data System](#)
- [University of Utah Energy & Geoscience Research Catalog](#)
- [Core Database Utah Geological Survey](#)
- [Hydrothermal alteration in the Basin and Range, western US](#)
- [National Mine Map Repository](#)
- National Uranium Resource Evaluation Program

Thank You!

Aaron Levine, Esq.

Aaron.Levine@nrel.gov

303-275-3855

www.nrel.gov

NREL/PR-6A20-80588

