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Exploration Case Studies on OpenEl

Katherine R. Young

INTRODUCTION

Detailed exploration case studies, such as Beaumont and Foster (1990, 1991, 1992), which were completed for oil and gas plays, will give operators an accessible portal for gathering clean, unbiased information with which to explore for geothermal drilling prospects. Providing a database of these case studies with each case study broken down into queriable properties makes this information even more powerful in planning future exploration efforts in new areas.

The goal of this effort is to develop a template for geothermal case studies in a crowd-sourced platform to allow for contributions from the entire geothermal community. Information collected for the case studies includes historical information regarding exploration and development in an area and current information about reservoir characteristics and facility production. The initial focus is on populating case studies for developing and operational geothermal areas throughout the world that can then be used as a basis for discovering new areas, and guiding efficient exploration and development of those areas.

STUDENT CONTRIBUTIONS

This project has drawn heavily on student involvement. Although NREL has been instrumental in the design and implementation of the OpenEI template, the content has been populated through different student vehicles.

- 2013 Three student interns developed case studies for ten geothermal areas.
- 2014 The student Case Study Challenge (<u>http://en.openei.org/wiki/CSC</u>) allowed students from across the country to compete. The top three student entries were featured in the GRC Poster Session, where students showcased their work and were presented with awards from DOE.
- 2015 NREL is working with technical communications departments at universities to

METHODS

In developing the methodology for completing case studies, the objective was to create a process that could be used in the future by students completing these case studies. We wanted to be able to develop consistently accurate, queriable case studies, with input from geothermal experts who knew the areas well, but with minimal impacts on the experts' schedules.

A case study template and user input form has been developed through iterative modifications based on input from student interns populating the case studies and expert review of these studies and templates. This template and form is continually updated as additional feedback is received from the user community. Though the pre-developed Open Energy Information (OpenEI) template for the case studies may seem restrictive at first, adhering to it allows for gathering of consistent information for each geothermal area, and for querying of information across areas. The template includes:

For the data to be easily accessible, it was important to create a template (and associated form) on the OpenEI website (<u>http://en.openei.org/</u>) to solicit crowd-sourced information sharing. Some of the advantages of cataloging this information on OpenEI include the ability to:

- 1. Crowd-source information
- 2. Easily search for the information needed

- incorporate contributions to geothermal case studies into their future curriculum.
- 2015 NREL is discussing the project with the GRC Student Committee the potential to continue to offer the Case Study Challenge in the future.
- 2014, 2015 NREL has worked with students from the Student Undergraduate Laboratory Internship (SULI) program to develop research projects that contribute data and analysis to these case studies. These internships have resulted in two published papers (one each year).

FUTURE WORK

Geothermal resources can be examined using any number of properties, such as temperature, structural control, geothermal region, or occurrence model. As an example, a property of "Brophy Occurrence Model" (Williams et al. 2001) has been assigned in OpenEI to over 75 operating systems worldwide. Analyses can be conducted for areas of the same model looking at exploration histories, data, and exploration plans to identify successful methods for exploring a similar resource.

The OpenEI template can be easily updated and modified as new information and classification schemes are developed. For example, a more formal catalog of play types is currently planned for development by the International Geothermal Association's (IGA) Resources and Reserves Ad Hoc Committee. This catalog could easily be incorporated into the current template, and data uploaded with a script to allow the information to be available for use in a query.

The goal of assembling these case studies is to be able to explore and analyze exploration data and information in a variety of areas to identify correlations between successful exploration programs for areas with similar geologic occurrence models and to guide efficient exploration of new systems.

- 3. Query information to compare various techniques
- 4. Link these data to other databases on OpenEI (e.g., the NEPA database, Exploration database).



To access the case studies from the OpenEI landing page (http://en.openei.org), click on the Geothermal Gateway, then Geothermal Areas for a map of areas in the database.

S7"N 36"N	Fault (Figure 5). A shallow (<2 km) and hot at 200– 328°C (393–622°F) resource is a result of crustal thinning, seen in the shallow seismic-aseismic boundary and rock and fluid chemistry. ^[2] The geothermal field at Coso is classified as a hot water resource compared to a steam dominated system with the system most likely liquid-limited and not heat- limited. The superheated groundwater flashes to steam at less than 2 km depth. The area also shows its youthful character in the abundance of surface thermal features. The hot springs, mud pots, mud volcanoes, and fumaroles of the area indicate an active near- surface resource over nearly 6,400 acres. The many surface features in the area show considerable variability both temporally and spatially. The Coso Geothermal Field is located in a zone of high seismicity that produced a magnitude 7.5 earthquake in 1872 and large seismic events continue through to the present. ^[23] The earthquakes in the area near Coso	Topographic IHorst and Graben Features: Brophy Brophy If Type E: Extensional Model: Tectonic, Fault- Controlled Resource Moeck- Beardsmore Domain Play Type: Ceologic Features Modern Geothermal IF Fumarole [21] Features: Alteration 22 Volcanic Age: IP Pleistocene [22] Host Rock Lithology: Image:	Features: Brophy Brophy Model: Controlled Resource Moeck- Beardsmore Domain Play Type: Ceologic Features Modern Geothermal Brumarole Features: Relict Geothermal Brydrothermal [22] Features: Alteration Volcanic Age: Bresch Lithelenen Beardsing	For example, the Coso Geothermal Area page (which can now be cited as Williams et al. 2008) has a property for Mean Reservoir Temperature = 285°C. result is that the Case Study templates on OpenEl no allow for the referencing of individual data points (e all data in tables now have unique references), as shown in Figure 1a. The impact of this new feature i increase the credibility of cited data in all of the
Garlock Fault. ^[2] Range region in the late Cenozoic. ^{[24][25][26][27]} Global p dextral shearing across the Coso region. ^[28] Recent micr injection of fluids and is diagnostic of fracture permeabi represent permeable pathways for circulation of hydroth	are predominantly dextral strike-slip events, consistent with the minimum of 150-170 km of extension that affected the southwestern Basin and positioning system data show approximately 6.5 mm/yr of ro-seismicity within the field is related to production and ility. Clusters of seismicity beneath the field correlate with the p nermal fluids.	Cap Rock Age: Cap Rock Lithology: rojection of surface faults and appear to		Exploration Techniques, Geothermal Resource Areas and Energy Generation Facilities pages.
Structure A silicic magma body is inferred to be present beneath C may still be partially molten since basaltic eruptions bas	Coso at a depth of approximately 8 km. ^[30] The magma body ve occurred as late as a few thousand years and. The trend of	Annandon nach gibb anthogaile ford neckanows Kanin In Solar Wate today sugards gardbarrag a' Anthogaile and a' Solaris solar		

 Depth to resour Surface manifes Permeability - [Type B: Andesitic Volcanic Resource Type C: Caldera Resource Type D: Sedimentary-hosted, Volcanic-related Resource Type E: Extensional Tectonic, Fault-Controlled Resource Type F: Oceanic-ridge, Basaltic Resource 				
Examples						[edit
Vant to add an exa	mple to this list? Select a Geotherm	al Resource Area to edit its "Brophy Model"	property using the '	'Edit with Form" buttor	7.	
Download CSV	3					
Geothermal Resource ¢ Area	Geothermal Region	Control Structure	Host Rock Age	Host Rock ÷ Lithology	Mean Capacity 🕈	Mean Reservoir \$ Temp
Amedee Geothermal Area	Walker-Lane Transition Zone	Displacement Transfer Zone	Mesozoic	granite; granodiorite		
Beowawe Hot Springs Geothermal Area	Central Nevada Seismic Zone	Pull-Apart in Strike-Slip Fault Zone	Ordovician	shale; quartzite		
Blue Mountain Geothermal Area	Northwest Basin and Range Geothermal Region	Intrusion Margins and Associated Fractures Fault Intersection	Triassic	Metasedimentary		
Brady Hot Springs Geothermal Area	Northwest Basin and Range Geothermal Region	Accommodation Zone	Mesozoic	metamorphic rocks		
Bruchsal Geothermal Area	Upper Rhine Valley	Major Normal Fault	Triassic	Sandstone		404.15 K
Coso Geothermal Area	Walker-Lane Transition Zone	Pull-Apart in Strike-Slip Fault Zone	Mesozoic	granitic		
Desert Peak Geothermal Area	Northwest Basin and Range Geothermal Region	Stepover or Relay Ramp in Normal Fault Zones	Mesozoic	greenstone		
Dixie Valley Geothermal Area	Central Nevada Seismic Zone	Stepover or Relay Ramp in Normal Fault Zones Major Normal Fault	Jurassic	Basalt		558.15 K

This work was supported by the U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy (EERE), Geothermal Technologies Office (GTO) under Contract No. DE-AC36-08-GO28308 with the National Renewable Energy Laboratory (NREL). NREL/PO-6A20-63988 **GTO Peer Review** May 2015