

Geothermal Drilling and Completions: Petroleum Practices Technology Transfer (SURGE)

Project Officer: Eric Hass
Total Project Funding:
\$248,000 (FY15) \$200,000 (FY14)
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HYDROTHERMAL

- Geothermal and petroleum industries share similar drilling and completion challenges.
 - Petroleum has a large advantage (1000X) in investment, people, and wells.
- The project will:
 - Identify petroleum drilling and completion practices transferable to geothermal.
 - Provide geothermal industry with more effective, lower cost and lower risk methods.
 - Identify pathways for technology transfer.
 - Advise GTO on opportunities to accelerate technology transfer and testing of petroleum best practices for geothermal.
 - Identify reciprocal opportunities for technology transfer from geothermal to petroleum.
- Primary goals: reduce the cost of geothermal drilling and completion, improve the economics of geothermal energy, and increase the developable geothermal resource.



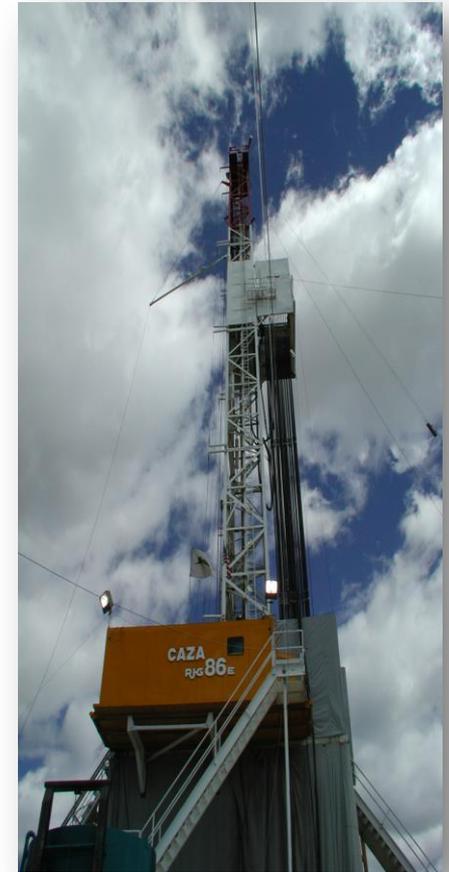
- Research supports the attainment of GTO hydrothermal goals:
 - Accelerate near term hydrothermal growth
 - Lower risks and costs of development and exploration
 - Lower levelized cost of electricity (LCOE) to 6 cents/kWh by 2020
 - Accelerate development of 30 GWe of undiscovered hydrothermal resources
- Project aims to define at least two opportunities for the transfer of technologies and/or practices from petroleum to geothermal drilling with the combined potential to reduce geothermal drilling rig days by 10%.





- Interview geothermal drilling experts to prioritize top well construction challenges.
- Interview petroleum drilling experts to identify approaches to cost reduction which are applicable to geothermal wells.

- Analyze geothermal and petroleum well data to define the physical limits to drilling and completion performance.
 - Perfect Well Analysis compares what a "perfect well" should look like and where real wells fall short. Magnitude of the variation tells us the priority of the improvement opportunities.
 - Perfect Well Analysis has never been applied to geothermal drilling, to our knowledge.





- Identify key factors contributing to high geothermal drilling and completion costs. Set priorities and conduct targeted research of opportunities to transfer oil and gas technology to geothermal.
 - Review geothermal drilling operations in detail to determine issues related to rig operations, equipment limits, and data access.
- Document findings and recommendations for technology transfer, technology development, and demonstration in geothermal wells.
- Develop drilling data acquisition protocols for future GTO sponsored wells.

- Analyzed 21 geothermal wells and 21 petroleum wells.
 - Profound drilling performance differences, greater than expected from the physical differences in rock types and temperature.
- Defined key non-productive time (NPT) factors in geothermal.
 - Lost circulation, rig/equipment selection, rate of penetration (ROP), efficient and consistent drilling program, effective time management, cementing.
- Investigating petroleum practices that may reduce geothermal NPT.
- Investigating drilling data acquisition methods and protocols to improve geothermal drilling data acquisition and enable learning and cost improvement.
 - Geothermal drilling data is scarce and not optimal to enable learning.
- Research team is working with industry to gather robust drilling data.
- Developing protocol for higher quality data capture in future GTO sponsored wells.

Original Planned Milestone/ Technical Accomplishment	Actual Milestone/Technical Accomplishment	Date Completed
Define primary areas of investigation for FY15 drilling technology transfer work, including drilling data sensor suite minimums and ideal requirements	12/31/2014	12/31/2014
Review findings of technology transfer research and down-selection of opportunities for comprehensive study in FY15 (this will necessarily be ongoing).	3/31/2015	3/31/2015

- Research has documented dramatic reductions in petroleum drilling cost and time, compared geothermal drilling performance with petroleum, and identified key areas for geothermal drilling performance improvement.
- Project is investigating several specific opportunities for technology transfer from petroleum drilling to geothermal.
- Project is defining protocol for geothermal drilling data collection to enable optimization of geothermal drilling practices.
- Team is working with an ongoing industry geothermal development drilling program with rich opportunities for data capture, learning, tech transfer, and optimization.

Milestone or Go/No-Go	Status & Expected Completion Date
Review the probable outcomes of technology transfer research for FY15 and areas for additional work (if warranted) in FY16. Determine data protocols and analysis procedures.	6/30/2015 On schedule
Final report to GTO with recommendations of drilling and completion technology transfer opportunities from petroleum to geothermal. Summary of demonstrations and outcomes that have resulted from technology transfer from petroleum to geothermal. Recommended next steps in research, technology transfer, and demonstration. Testing of data protocols and analysis tolls.	9/30/15 On schedule
SMART Milestone: Define in the final report at least two opportunities for the transfer of technologies and/or practices from petroleum to geothermal drilling with the combined potential to reduce geothermal drilling rig days by 10%.	9/30/2015 On schedule

GEOHERMAL DRILLING

- Heat
- Small community of GT drillers
- One-off nature of many GT wells
- Severe chemical, physical conditions
- Lost circulation
- Cementing
- Directional drilling challenges
- High wear
- Geologic challenges
- Casing design
- Drilling departures from perfection
- “Drilling on the Cheap”

PETROLEUM DRILLING

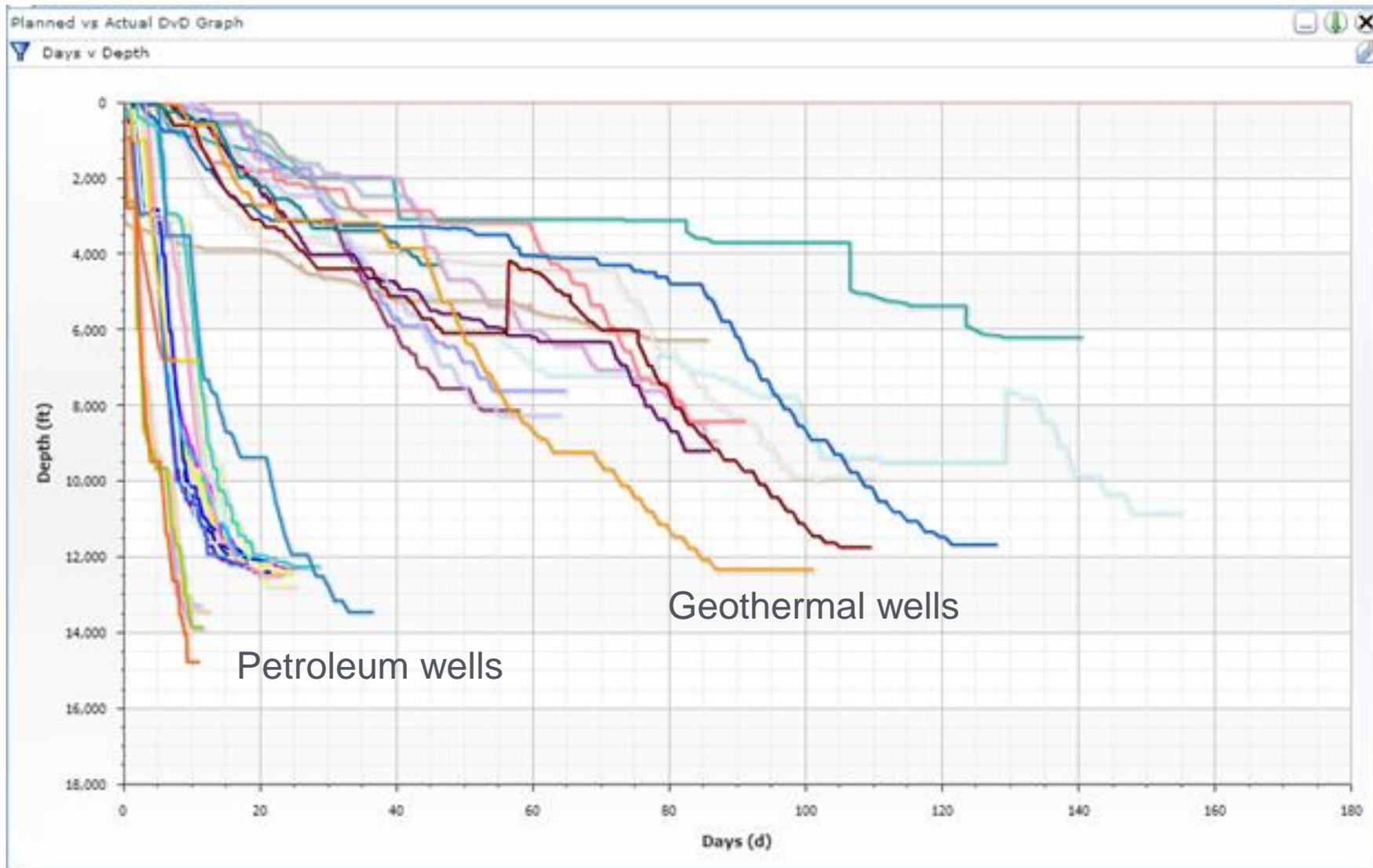
- Economies of scale not as great as expected
- Rig technology (built-for design)
- Hardware improvements
- Automation is not a time saver; however, improves safety
- Drilling team cohesion
 - Feedback critical to continuous improvements
 - Many small things contribute to more effective, lower cost drilling

- Identify and quantify the opportunities for transfer of practices and technology transfer and develop an economic base for employment in geothermal operations.
- Analysis Tool: IDS DrillNet:
 - Sophisticated web-based solution for capturing, tracking, analyzing, and reporting on all drilling and completions activities.

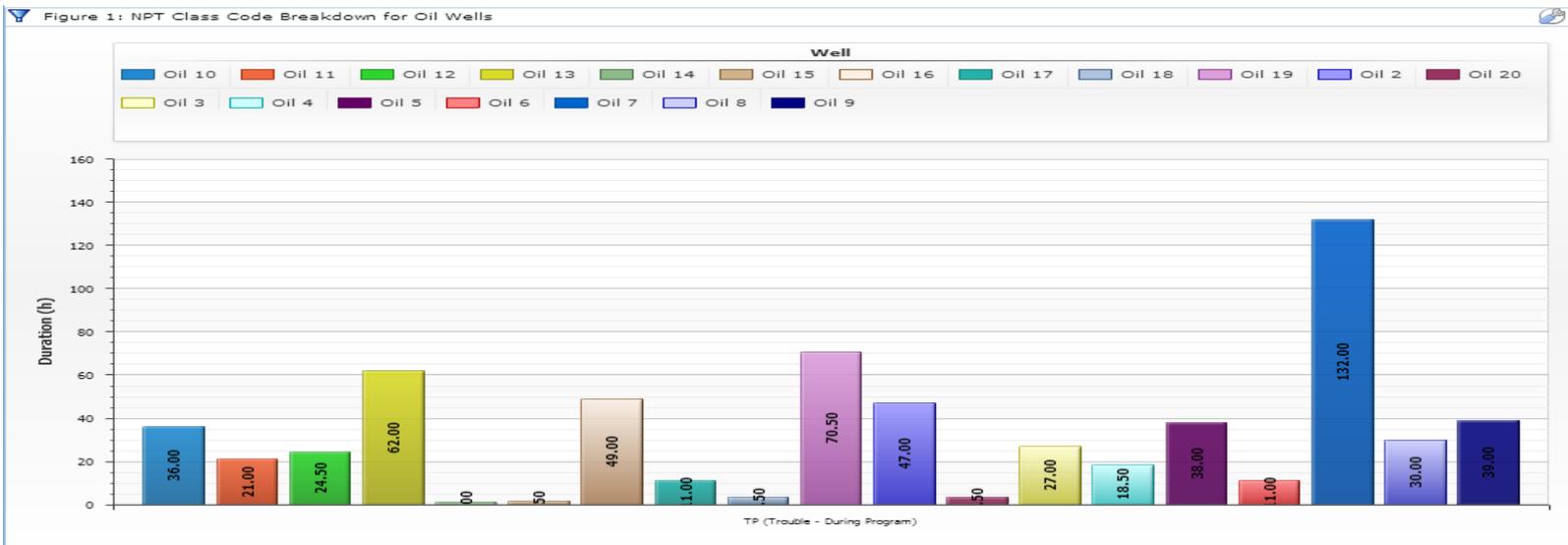
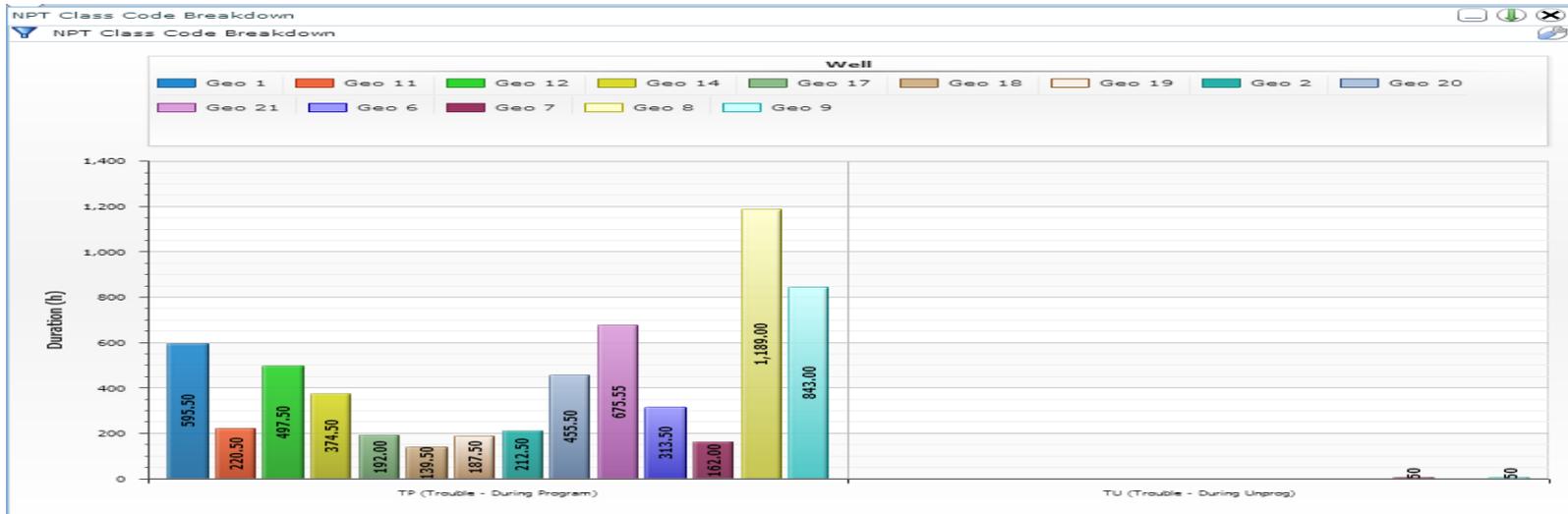


- The Perfect Well is the absolute fastest time that a well could possibly be constructed— the theoretical physical limit of what can be done.
- The Perfect Well concept provides an objective measure of well construction effectiveness. Wells that operate at double the perfect well are overall more efficiently constructed than wells constructed at five times the perfect well.
- Identify the aspects of geothermal well construction that depart most significantly from the Perfect Well and comparing these departures with Petroleum Best Practice.

Defining "The Issue"



Nonproductive Time: Geothermal vs. Petroleum Wells



- Lost circulation
 - In the 21 geothermal wells combined, 3474 total hours was lost to lost circulation mitigation, fluid influx/control, and pumping cement plugs. Using the average of \$50,000 a day, this accounts for a cost of \$7.24MM.
- Rig and equipment selection
 - Difficult to analyze the NPT due to lack of complete data for the rigs and other on-site equipment used in the operations analyzed
 - 24,231 hours were needed for the geothermal wells and only 9723 hours were needed for the petroleum wells. This, in part, is due to the less than ideal rigs utilized in the geothermal industry.
- Efficient and consistent drilling program
- Effective time management
- Rate-of-penetration (ROP)
- Cementing

- Rate of penetration issues
 - Techlog¹ input of geology and rig operations data
 - Mechanical specific energy models and derivation (SNL)
 - High temperature rock properties
- Drilling data acquisition – sensors, derived data
- Lost circulation techniques
 - Managed pressure drilling (offshore)
 - Underbalanced drilling techniques
- Agua Caliente Walker Ranch drilling dataset
- Integrate new team members
 - Graduating the initial cadre of research team members!

¹Schlumberger

- Data issues
 - Consistent nomenclature
 - Data access
 - Electronic data acquisition
 - Downhole data acquisition?
- Build repository
 - Create synergy of all geothermal operators

- Project has documented profound performance differences between geothermal and petroleum wells
 - Greater than anticipated even with differences in lithology and wellbore environment.
- Project has identified promising pathways to improve geothermal drilling practices through transfer from petroleum and vice versa.
- Detailed rig time analysis has identified major elements of geothermal nonproductive time and is yielding focused solutions to primary geothermal drilling and completion challenges.
- The geothermal well data was sparse and inconsistent.
 - Deficient information limits ability for continuous improvement of geothermal drilling and completion operations
 - Acquisition of digital data is likely to be cost effective in identifying opportunities for practice transfer and performance improvements.