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GEOTHERMAL RISING CONFERENCE

Evaluation of Physics-Based Limiter Redesign Drilling and Alternative Bit Design at The Geysers

1. Sandia National Labs
2. Geysers Power Company
3. Texas A&M University
4. University of Utah EGI

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ABSTRACT

As part of a U.S. DOE Geothermal Technologies Office funding opportunity, Geysers Power Company, LLC, an indirect subsidiary of Calpine Corporation, partnered with Sandia National Labs, EGI at the University of Utah, and Texas A&M University to demonstrate increased drilling performance at The Geysers Geothermal Field. The performance target in the drilling demonstrations is at least a 25% improvement in rates of penetration with increased time on bottom for each bit. The planned drilling demonstrations are being conducted as part of an existing drilling campaign intended to enhance reservoir utilization. A major goal of the project is to assess the effectiveness of implementing mechanical specific energy (MSE) and drilling dysfunction diagnosis and remediation in these challenging environments, as well as alternate bit technologies. The first demonstration well has been completed, with a total of 15 PDC bit runs in the 17.5”, 12.25” and 8.5” sections. Initial analysis shows ROP gains in all three hole sections, especially in the 17.5” and 12.25” sections, compared with conventional roller cone bit runs in the demonstration well and offset wells. However in the 8.5” hole, wear and damage to the PDC bits resulted in relatively short bit runs. Analysis is underway to take advantage of the positive results and remediate the challenges.

BACKGROUND

Combining physics-based practices along with the resources and technology available to the drilling industry at large, significant performance gains have been made in a variety of oil and gas industry efforts. The same concept translates to geothermal development in high strength, hot rock. Drilling at Utah FORGE has demonstrated the performance gains possible when implementing physics-based, limiter redesign workflows. At Utah FORGE, in a relative homogeneous granitoid, within the span of four (4) wells, instantaneous drilling rates were improved by nearly 500% while bit life was improved by nearly 200% (Figure 1).

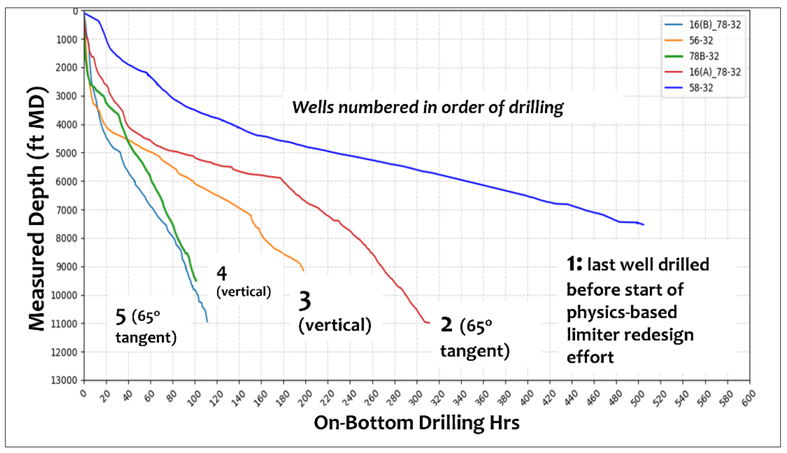


Figure 1. Reduction in on-bottom time in sequential wells at FORGE during physics-based limiter redesign drilling effort. At the same time ROP was increased, bit life in the hard granite was more than doubled (courtesy Fred Dupriest and Sam Noynaert).

THE GEYSERS PDC DEPLOYMENT PLAN

Prior to spud, the drilling team, rig crews and service personnel, along with the research team participated in a multi-day training session on physics-based drilling practices. The training covered physics-based limiter redesign, with emphasis on physics-based understanding of expected Geysers drilling dysfunctions and how to identify them using electronic drilling records (EDR) data.

Baseline performance of historic drilling protocols was established by analyzing neighboring wells drilled during the late summer of 2022. Data from these wells were used to define the nominal drilling rates and formation conditions in various parts of the play. Instantaneous rates of penetration along with other indicators of drilling performance were documented and evaluated by the team.

The Phase 1 drilling campaign focused on implementing off-the-shelf PDC bits in intervals traditionally drilled by roller cones.

A typical campaign well (Figure 2) completion starts with a 30” conductor in a 36” hole drilled to 30’. A 26” diameter hole is then drilled to nominally 500’ and 20” casing is cemented to surface. A 17 ½” diameter well is drilled with mud to approximately 2500’ with directional work starting in this section. A 13 3/8” casing is cemented to surface in the 17 ½” hole. A 12 ¼” diameter hole is drilled on mud to approximately 5,000’ MD where the top of the steam reservoir is encountered. Then, 9 5/8” casing is cemented to surface. The last section of the well is drilled using 8 ½” bits on air to a total depth of approximately 9,000’ and completed with a slotted liner and tieback.

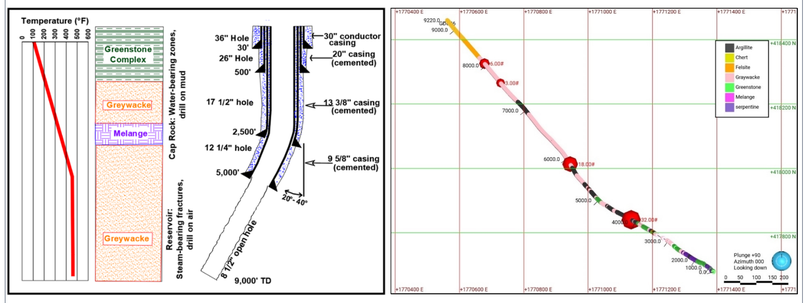
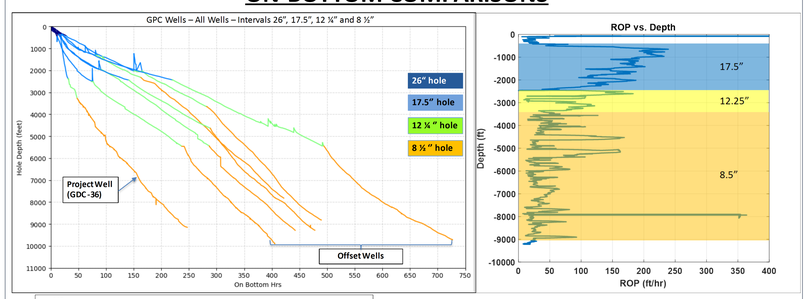
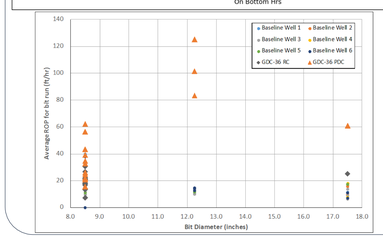


Figure 4. Schematic of a representative Geysers well for the drilling campaign.

ON-BOTTOM COMPARISONS





- ~50 on-bottom hours ahead of the next fastest well at the last intermediate hole TD (12.25”).
- At minimum 125 hours ahead of the group average at TD

17.5” SECTION

Interval was drilled using a bent-sub mud motor and directional BHA with stabilizers on the nose and at the top of the 1.5 deg bend motor. The interval was drilled from 428 ft MD to 528 ft MD, using an insert bit as a baseline for comparison with the subsequent PDC test runs. A commercial off-the-shelf (COTS) PDC was used to drill the remaining interval to 2,452 ft MD. Gross overall ROP (including connection times and other off-bottom time) over that interval was approximately 60 ft/hr, with instantaneous ROP generally in the range of 100 to 200 ft/hr in this interval (Figure 3).

17.5” Bit (before)

17.5” Bit (after)

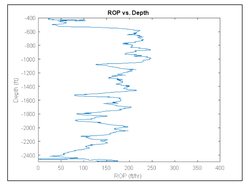


Figure 3. Instantaneous ROP vs. Depth in the 17.5" interval.

12.25” SECTION

The interval contained lost circulation zones that were remediated with cement plugs. The plugs had mixed results in preventing lost circulation in the zone. In the end, the team decided to drill through the losses and was able to reach the end of the interval with a combination of insert bits and PDCs. The instantaneous ROP vs. depth is shown in Figure 4. Again, during normal drilling, instantaneous ROPs mostly were in the range of 100 – 200 ft/hr for PDC bits. Slower intervals shown in the chart were either due to use of insert bits or control drilling during the lost circulation events and while drilling out cement plugs.

12.25” Bit (before)

12.25” Bit (after)

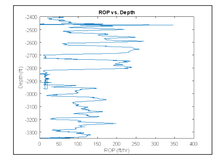
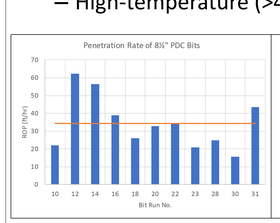
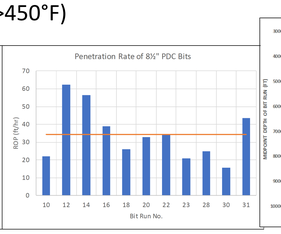


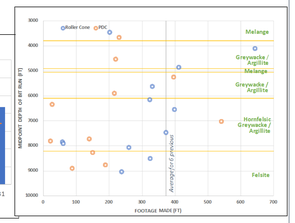
Figure 12. Instantaneous ROP vs. depth (12.25” interval).

8.5” SECTION

- Interval challenges
  - Air-drilled
  - Fractured
  - Moisture-sensitive formation
  - No motor
  - High-temperature (>450°F)
- Several PDC bit runs were terminated because of acute damage occurring over very short intervals (several feet).







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