

Case study: Utah, United States

Vulcanix PDC bit drills farther and faster than conventional bits in abrasive geothermal formation

Drilling geothermal wells typically requires robust drill bits that withstand high downhole temperatures while efficiently navigating through hard, abrasive igneous formations.

A geothermal operator in Utah facing such conditions needed a drill bit to maximize rates of penetration (ROPs) while drilling a 9 ½-in. section through a granite formation with an unconfined compressive strength (UCS) upwards of 40,000 psi.

A proven solution in hard rock

Baker Hughes proposed its Vulcanix™ polycrystalline diamond compact (PDC) drill bit as a solution.

Incorporating technologies and designs tested and refined in hard, abrasive formations around the world, the Vulcanix PDC bit offers proven capabilities to reach target depth in the most complex geothermal drilling environments.

A durable cutting structure. Vulcanix bits are designed to stay sharper for longer with ShockWave™ shaped cutters on the outer profile. The shaped cutters provide a longer profile and extended shoulder for enhanced durability and less wear—letting the bit drill farther than conventional PDC bits.

Staying cool with improved hydraulics.

The Vulcanix PDC bit stays cool and lasts longer while drilling hard, abrasive lithology in high-temperature formations. Design features like an open layout with maximized junkslot area and face volume help improve flow around the bit. Multiple nozzles maintain cooling on the outer portions of the bit.

Strategically placed cutters. Vulcanix bits include Prism™ shaped cutters placed strategically across the drilling profile. These durable, multidimensional cutters apply point loading to increase ROPs. A durable edge cutter in the cone of the bit absorbs loading and resists breakage when high weight-on-bit (WOB) is applied. A chisel-shaped edge on the nose profile and ShockWave cutters on the shoulder both improve drilling efficiency and durability.

Designing the optimal bit

Satisfied with these design features, the operator agreed to put the Vulcanix PDC design methodology to the test in its well.

The run objectives required the bit to drill a 500-foot section of a 9 ½-in. wellbore with a 60° inclination, with good ROP and a good dull.

Baker Hughes created three designs for the application. The first, a six-blade, 13 mm cutter frame with dual row cutters, provided maximum diamond density and reliability. A second, more aggressive frame with single row cutting structure would withstand loading and achieve higher drilling efficiency. A third design incorporated larger 16 mm cutters for increased penetration rates.

The operator selected a larger diameter (5 5/8-in.) drill pipe for effective torque transfer and stick-slip mitigation.

The BHA included a mud motor and a 9 ppg water-based mud at flow rates up to 600 gallons per minute. Insulated drill pipe and three mud coolers helped control the circulating temperature.

Challenges

- Efficiently drill in 9 ½-in. tangent well type
- Maximize drilling penetration rate in hard granite
- Extend drilling runs beyond BHA limit of 500 ft

Results

- Drilled 670 feet—34% farther than planned
- Achieved average ROP of 78 ft/hr—55% higher ROP than offset averages using eight-bladed frames
- Achieved maximum ROP of 142 ft/hr
- Improved drilling efficiency, even with the secondary back-up cutters removed

Efficiently drilling farther and faster than plan

All three Vulcanix PDC bit designs exceeded expectations in the hole to drill out a longer section in less time. The drill bits reached a maximum rotation of 240 RPM, 24,000 ft-lbs of torque, and 60,000 lbs weight-on-bit (WOB).

The first bit drilled 670 ft—34% farther than the operator’s target of 500 ft—in just 8.5 hours. The average ROP of

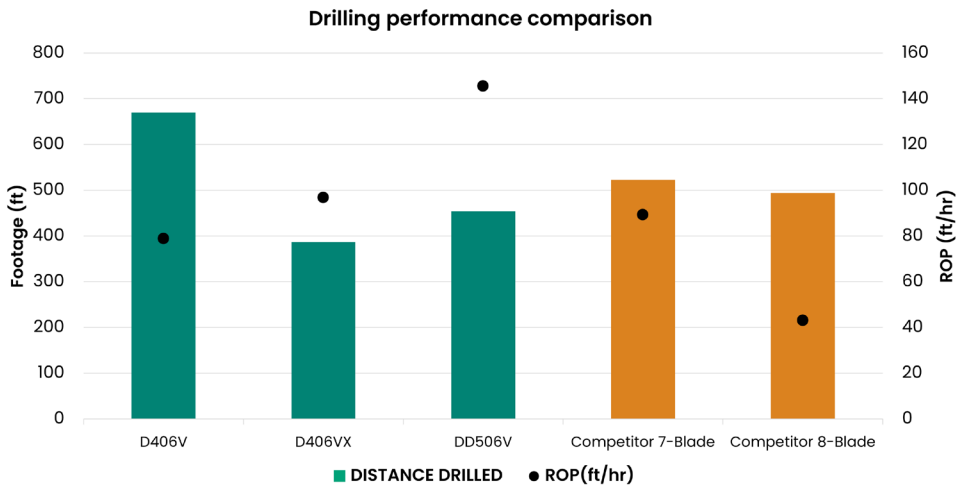
78 ft/hr was 55% faster than offset averages from eight-bladed frames. The second Vulcanix bit design with backup cutters maintained the same high level of drilling efficiency. The third design set a ROP record of 142 ft/hr.

The high ROP signaled minimal wear of the Vulcanix’s cutting structure, giving the operator confidence to continue drilling to the next core point.

After drilling, an examination of the Vulcanix bit’s 1-1 dull at surface displayed smooth

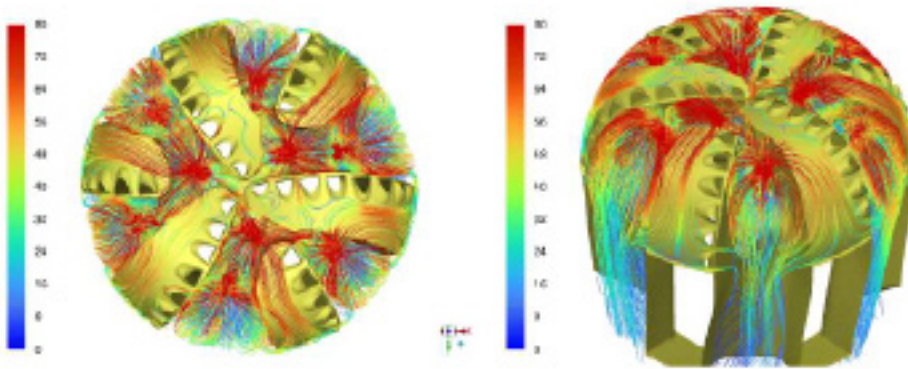
wear—demonstrating that the cutters held up to the heavy loading drilling of the 40,000-psi UCS granite.

Ultimately, this geothermal drilling operation showed that Vulcanix PDC drill bits tackle challenging rock formations, high temperatures, and harsh well conditions to make geothermal projects economic and successful.

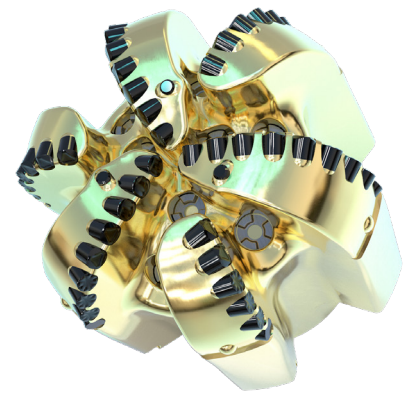


Dull photos show minimal 1-1-WT wear

Vulcanix design methodology enables high penetration rates.



Computational fluid dynamics ensures proper cooling of cutting structure.



Vulcanix geothermal PDC bit with strategically placed cutters.

Baker Hughes 