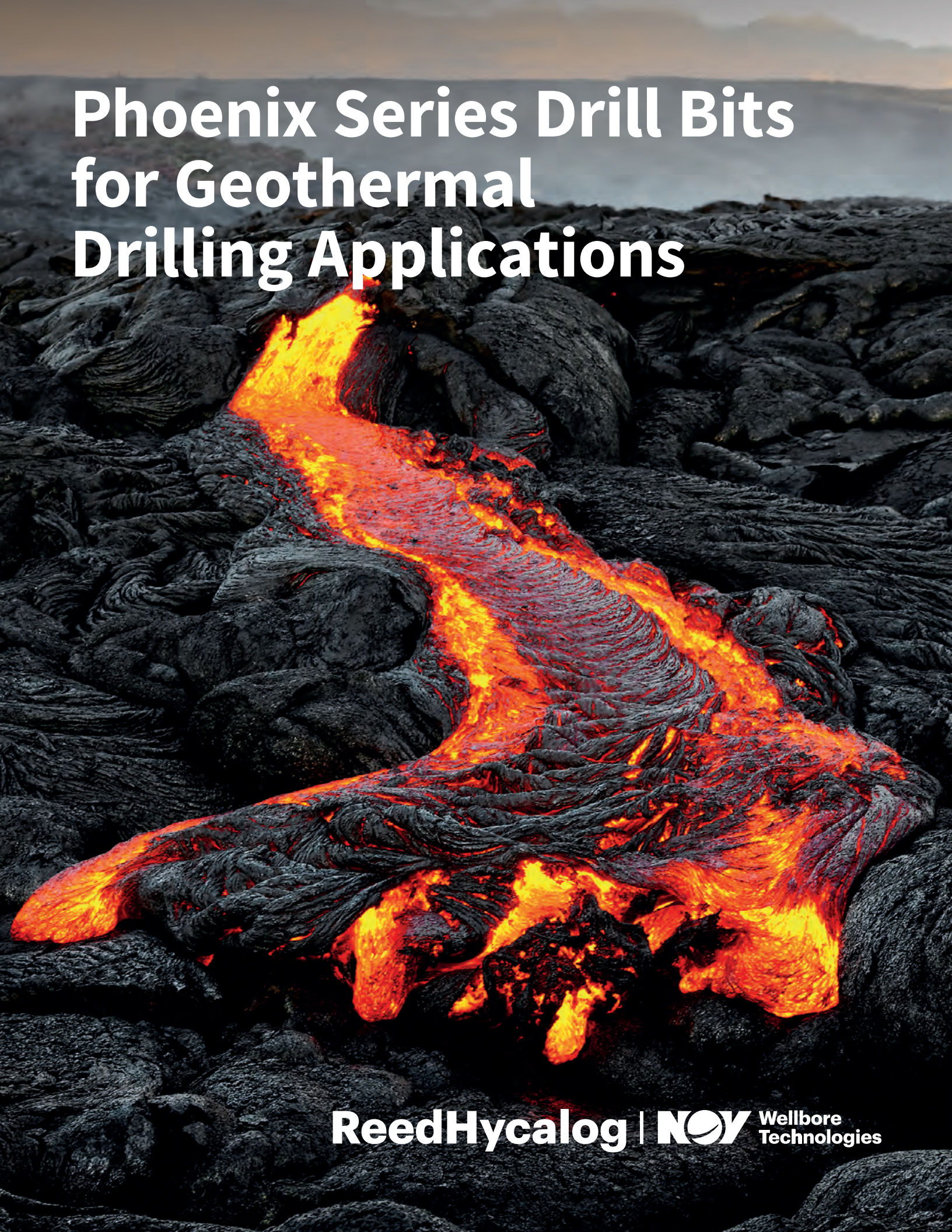
Phoenix Series Drill Bits for Geothermal Drilling Applications



ReedHycalog | NOV Wellbore Technologies

Empowering sustainable energy

ReedHycalog is proud to introduce the next generation of high performance drill bits for geothermal applications. Our Phoenix™ series drill bits are based on the field-proven, technically advanced Tektonic™ drill bit platform, which is customized to drill farther and faster in hard rock environments.

High levels of formation hardness and abrasiveness are the hallmark of igneous and volcanic rocks that are typically encountered in geothermal wells. When drilling such hard rocks, the frictional energy that's generated due to the high weight-on-bit (WOB) requirements can lead to thermal degradation of polycrystalline diamond compact (PDC) cutters and inhibit drill bit performance.

The Phoenix series drill bits incorporate ION™ PDC cutter technology, which is the most advanced cutter design available in the industry. ION cutters feature formation-specific, high-performance diamond grades that are fine tuned for increased thermal stability and impact resistance. We've also developed formation-specific, multidimensional shaped cutters that can deliver unmatched performance.

Our custom-designed Phoenix bits utilize specialized design tools, including computer analysis of torque response, simulations of heat generation and cutter temperature, bit lateral stability analysis, and material enhancements to maximize downhole performance and enhance efficiency in hard rock formations.

Effective torsional stability is one of the primary objectives when drilling hard, interbedded formations. Phoenix series bits reduce the risk of torsional oscillations through enhanced depth-of-cut control. Using patent-pending components, innovative depth-of-cut analysis, and uniquely shaped cutter geometries, Phoenix bits provide improved torque response in your toughest drilling challenges.

ION Cutter Technology

Our range of high-performance, shaped PDC technologies is fine tuned to overcome critical failure modes in hard rock drilling.

HydroShear Nozzles

Our advanced nozzle design maximizes cutting evacuation and cooling rates of the PDC cutters.

Thermal Index Modeling

Our drill bit designs utilize patent-pending thermal analysis and optimization software to analyze heat transfer on every single cutter for improved cutter and bit life.

TORC Components

Our patent-pending, superior depth-of-cut control technology increases torsional stability.

ION cutter technology

We've developed the best cutter technology in the industry to help overcome the challenges in Geothermal drilling and deliver record breaking performances.

ION cutters utilize NOV's patented thermal-stabilizing deep-leach technology with refined diamond feeds, and increased sintering pressures provide denser diamond with improved toughness and abrasion resistance. Our high-performance, thermally stable cutters minimize chipping and breakage common in porous and brittle rock and reduce wear from typically fine-grain, abrasive formations to stay sharper longer.

Further optimizing our solution, the ION platform offers application- and formation-specific geometries designed to maximize rock failure by balancing fracturing and shearing rock failure mechanisms. These mechanisms are highly effective and efficient in volcanic rock formations, providing increased drilling efficiency without sacrificing durability.

ION 3D cutter

Planar face with a V-shaped (chisel / scribe) profile.

Designed for carbonates, but benefits are observed in a wide range of competent formations. The chisel cutting-edge profile produces point loading in the axial (WOB) direction improving fracture propagation.

ION 4DXC cutter

The 4DX shape coupled with 3D profile.

Designed for applications with both crushing and shearing action.

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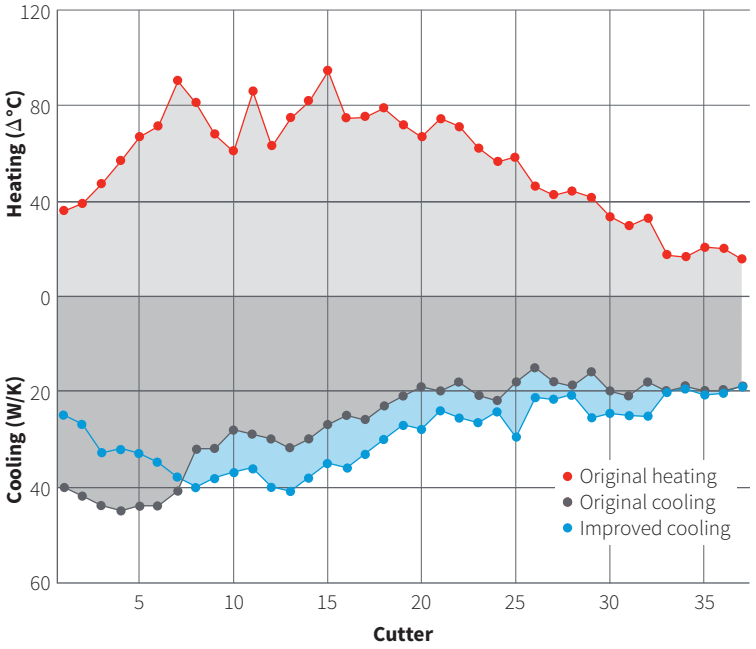
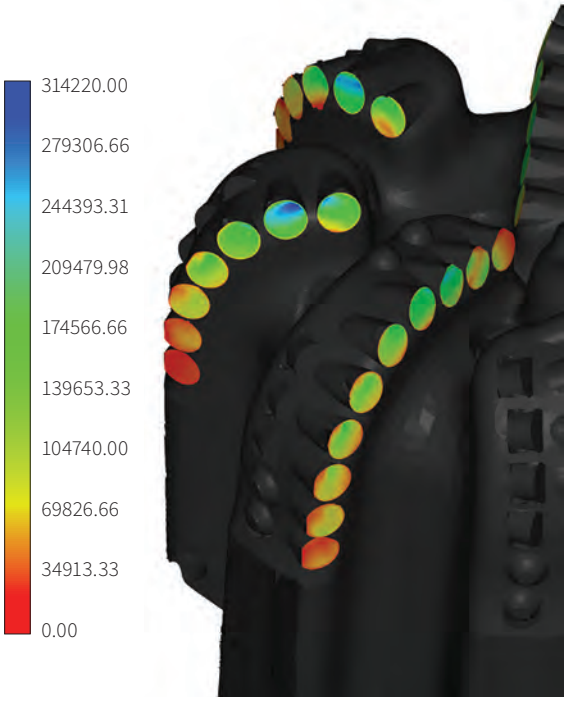
Thermal index modelling

Unique computational fluid dynamics analysis is used to evaluate the thermal effects of drilling on PDC cutters. Cutter temperatures while drilling and hydraulic cooling rates are evaluated to maximize cooling effects at the hottest cutters, which increases ROP and durability by preventing thermal degradation.

Thermal drilling analysis



Heat transfer coefficient <W/(m^2 K)>

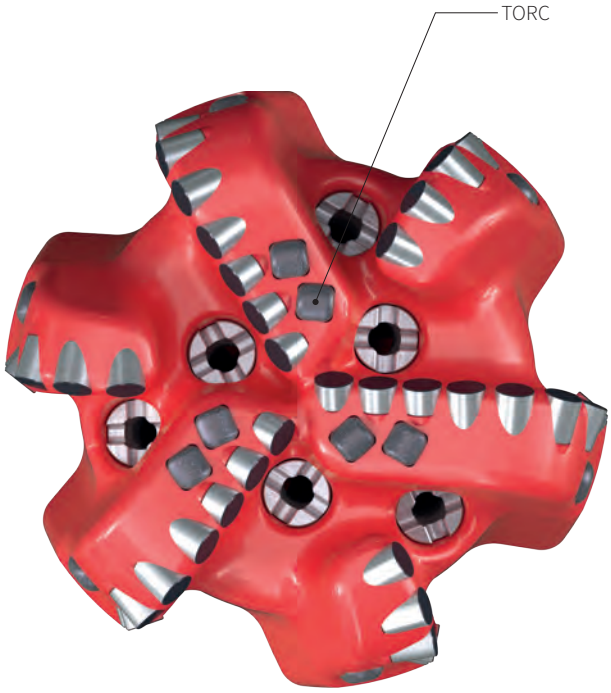


Phoenix Series Drill Bits for Geothermal Drilling Applications

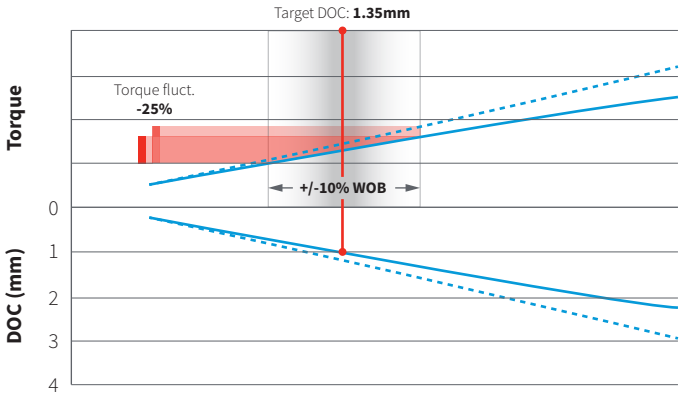
TORC - Torsional stability through precise and effective depth-of-cut control

Our Phoenix series bits use patent-pending TORC™ components to provide improved torsional stability.

The unique geometry is designed to match the cutter size and cut shape to increase the available contact area, improving the torque response compared to conventional round depth-of-cut controllers. Proprietary cutter analysis software simulates the WOB and torque relationship for bits, employing enhanced depth of cut control features that reduce torque fluctuations while transitioning through hard formations with high interfacial severity. The result is an improvement in bit durability and overall ROP.



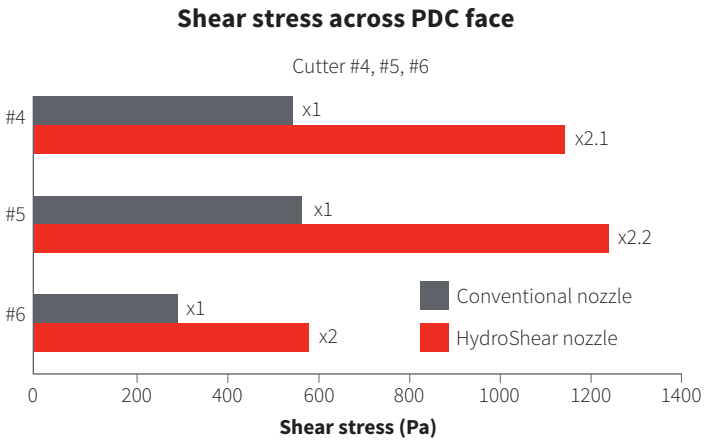
Torque response analysis

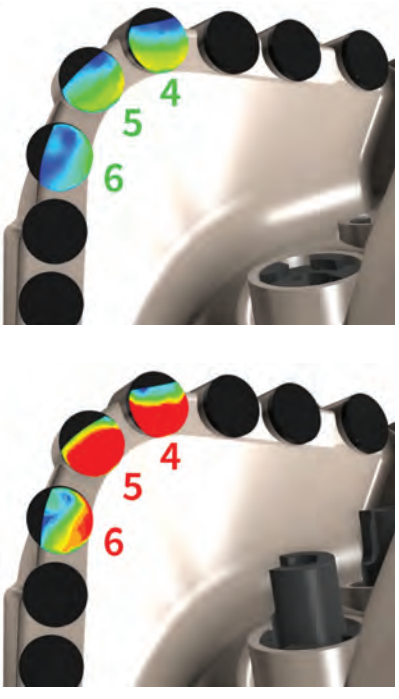


HydroShear nozzles

HydroShear™ nozzles increase fluid velocity across the cutter face to reduce heat accumulation, mitigate thermal wear, and improve cuttings evacuation.

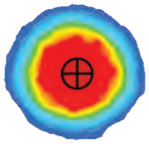
Our HydroShear nozzles focus hydraulic flow to reduce cutting size and to help limit balling. Additionally, the nozzles increase hydraulic velocity at the cutter-formation interface, improving cutter cooling and cuttings evacuation. HydroShear nozzles can be combined with other Phoenix bit features, such as shaped cutter technology, to further reduce cutting size, quickly remove cuttings from the cutter face, and enable the bit to drill more efficiently for longer intervals.





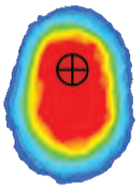
Comparison of shear stress across polycrystalline diamond compact (PDC) faces for conventional and HydroShear nozzles.

Conventional nozzle



Shear stress pattern from conventional nozzle

HydroShear nozzle



Shear stress pattern from HydroShear nozzle

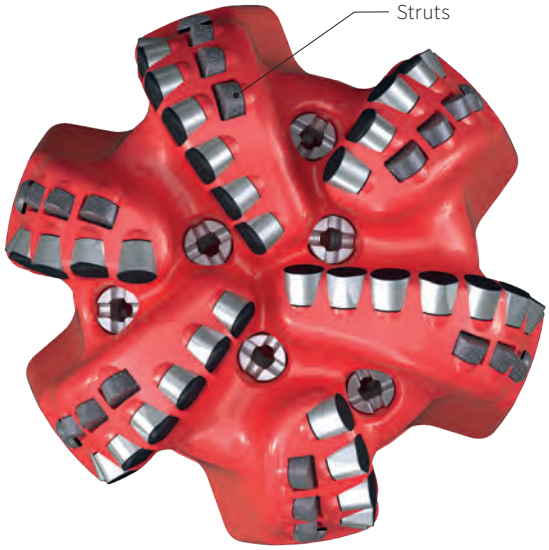
Struts HDI elements

We apply continuous material technology development in our Struts™, which are high-density impregnated cutting elements that are aimed at overcoming the challenges of harsh rock drilling.

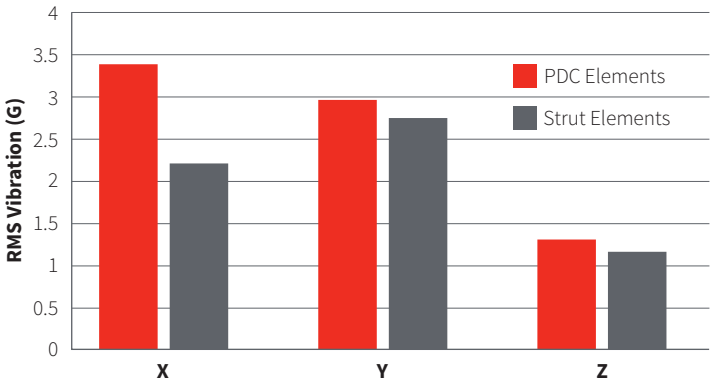
Struts HDI elements combine the toughness of carbide with the hardness of diamond to provide a flexible element that's tough yet wear resistant. These elements can be incorporated into steel and matrix drill-bit designs, enhancing drill-bit durability, stability, and impact resistance.

Struts come in two forms, either as a secondary cutting element or as an impact arrestor. An optimally placed secondary cutting element applies vibration-reducing characteristics to provide bit stability and enhanced durability. When struts are placed as an impact arrestor, they can reduce impact overload damages to the primary cutting structure.

Our Strut technology, in combination with the Phoenix series features, can decrease drilling time and costs, reduce trips needed to change bit types, and overcome the limitations of conventional bit designs in hard and unpredictable rock environments.

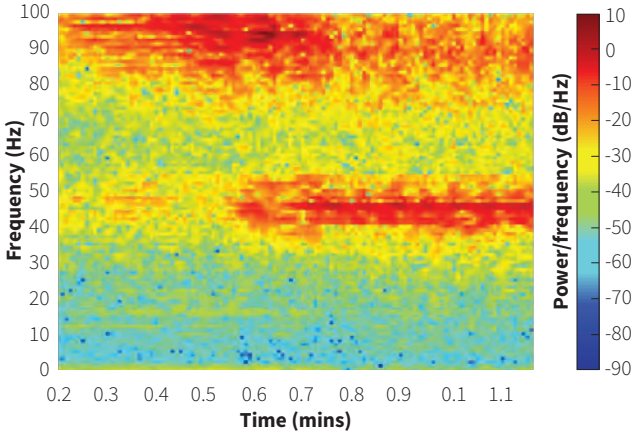


Vibration level comparison

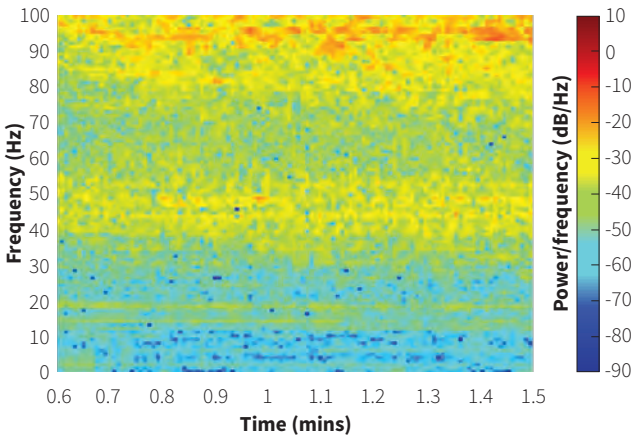


Spectrogram images

PDC as secondary element



Struts as secondary element



Delivering efficiency in your geothermal operations

As a leading provider of drill bits to the oil and gas industry, we've leveraged that same technology and experience to establish our Phoenix series bits in the geothermal market.

ReedHycalog has drilled some of the longest and fastest intervals in geothermal wells around the world. From a 67% higher ROP with a single bit run in New Zealand to drilling 8% farther and 36% faster in an Indonesian operation, we're positioned to equip you with the most advanced drilling technologies for your geothermal applications.

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