GLOBAL DRILLING SERVICES

SONIC DRILLING FOR THE MINING INDUSTRY

BOART LONGYEAR™

SONIC OBTAINS THE BEST SUBSURFACE INFORMATION

Mining professionals around the world use our Sonic technology to obtain the best subsurface information and make the most accurate decisions. Sonic can drill and sample overburden and soft rock formations at or near 100% core recovery without the risk of refusal and without the use of fluids.

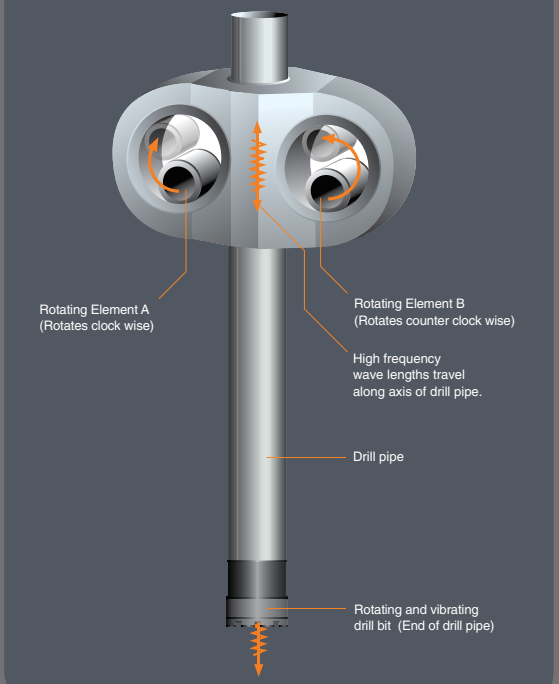
HOW SONIC DRILLING WORKS

Sonic drilling employs the use of high-frequency, resonate energy to advance a core barrel or casing into subsurface formations. During drilling, the resonant energy is transferred down the drill string to the bit face at various sonic frequencies. Simultaneously rotating the drill string evenly distributes the energy and impact at the bit face.

The resonant energy is generated inside the Sonic head by two counter-rotating weights. The Sonic driller controls the resonant energy generated by the Sonic oscillator to match the formation being encountered to achieve maximum drilling productivity.

When the resonant Sonic energy coincides with the natural frequency of the drill string, resonance occurs. This results in the maximum amount of energy being delivered to the face. At the same time, friction of the soil immediately adjacent to the entire drill string is substantially minimized, resulting in very fast penetration rates.

SONIC OSCILLATOR DIAGRAM



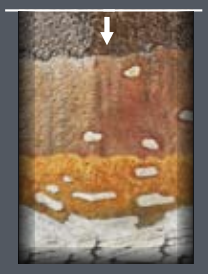
SONIC DRILLING ADVANCEMENT PROCEDURE

The Sonic drilling method advances a casing as the borehole is drilled. While there are several ways to drill a borehole with the Sonic drilling method (depending upon site-specific conditions and project objectives), the most common means involves advancing a core barrel, which is overridden by a larger diameter drill string that cases the open borehole and prevents collapse.

Core Barrel Advancement

No fluids, air, or mud used during coring.

Step 1



Casing Override

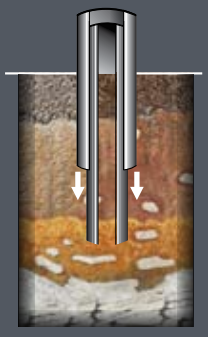
Water possibly used between casings.

Step 2

Core Barrel Retrieval

Barrel retrieval for sample extrusion.

Step 3



Repeat Core Advancement

Advancement following sample extrusion.

Step 4

- Core sizes of 3” through 8” are available.
- Standard borehole sizes of 3” through 12” can be drilled.
- Depths in excess of 600’ in a variety of formations and conditions.

MINERALIZED SANDS

Sonic can drill and accurately sample sand formations – normally an impossible task for conventional drilling methods. Sonic's dual tube system serves as a stabilizing force on unstable sand formations and a thin wall shearing process. This enables an accurate and complete high quality sample.

- Drill without use of fluids, mud or additives which can jeopardize sample quality.
- Recovery rate near 100%, revealing exceptional sample detail.
- Large sample size (4" to 6" diameter).

CASE STUDY

Location:	Fort Dauphin, Madagascar
Rig Type:	Sonic
Depths:	Up to 98 ft (30m)
Reference:	Rio Tinto Iron and Titanium, (QIT Division)

In a project with QIT Madagascar Minerals near Fort Dauphin, Madagascar, heavy mineral and sand deposits were sampled using Boart Longyear's Sonic drilling technology. Boart Longyear was contracted for two programs: validation drilling and bulk sample extraction.

- 30 holes were drilled without refusal.
- Boring depths ranged from 49 ft (15 m) to 98 ft (30 m).
- The standard 4" by 6" in-hole tooling system was used throughout the program which produces a 3-3/4" (95 mm) diameter sample inside of a 5-1/2" (140 mm) casing.
- The second phase of the project called for a 15 tonne cross-sectional sample of the full depth of the deposit. This simulated the actual mining results as closely as possible.

PRE-COLLARING

Sonic drills have excellent penetration abilities that can drill through deep, dense and unfriendly overburden formations to pre-collar borings. Once bedrock is reached diamond drills can drill deeper for mineral exploration purposes.

- **Collection of hydro-geological wetlands for potential open pit mine sites.**
- **Provides a detailed continuous overburden sample.**

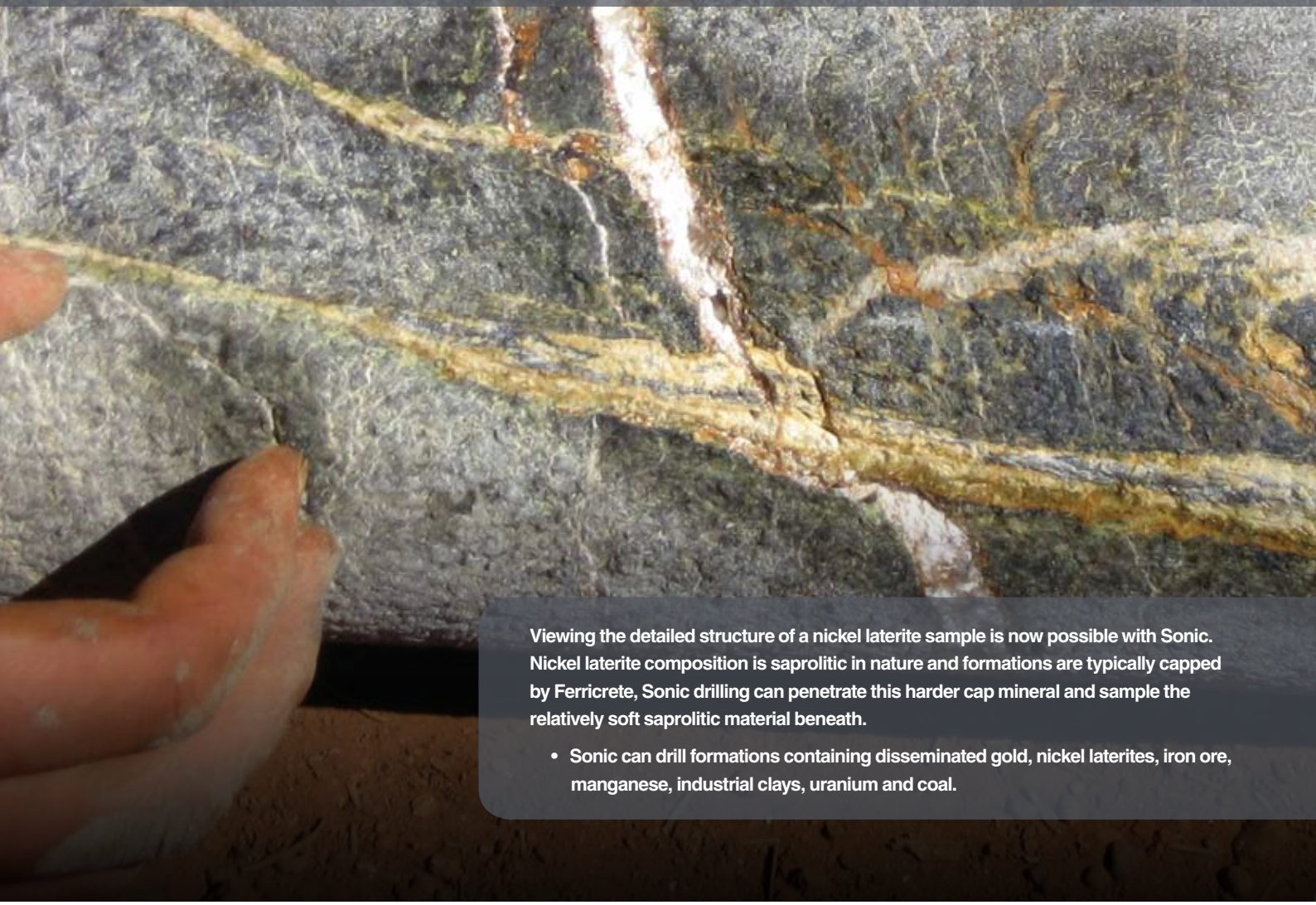
CASE STUDY

Location:	Northern Minnesota	Drilled:	Overburden Sonic – 2,615 ft (797 m) Diamond Coring – 10,501 ft (3,201 m)
Rig Type:	Sonic and Diamond Core	Reference:	Kennecott Exploration

In a Northern Minnesota project for Kennecott Exploration, Boart Longyear demonstrated how Sonic drilling technology coupled with traditional diamond core rigs can offer a unique service with added value to clients. The parameters of this project were twofold: first, achieve Kennecott's goal of 6,500 ft (1,981.2 m) of core drilling aimed at mineral exploration and secondly, to drill three monitoring wells to capture existing ground water and overburden information.

- Utilized Sonic technology to drill through the overburden, followed by diamond coring for the bedrock formations.
- 10,501 ft (3,200.7 m) of overburden and core were drilled with no injuries.
- This drilling approach nearly doubled the amount of seasonal footage drilled.

NICKEL LATERITE AND MANGANESE



Viewing the detailed structure of a nickel laterite sample is now possible with Sonic. Nickel laterite composition is saprolitic in nature and formations are typically capped by Ferricrete, Sonic drilling can penetrate this harder cap mineral and sample the relatively soft saprolitic material beneath.

- **Sonic can drill formations containing disseminated gold, nickel laterites, iron ore, manganese, industrial clays, uranium and coal.**

CASE STUDY

Location:	Emily, MN	Depths:	Up to 420 ft (128.02 m)
Rig Type:	Sonic	Reference:	Minnesota Manganese Resources Co/GMRC

The manganese resided in an iron formation overlain by nearly 200 ft (60.96 m) of glacial till. A new program using Sonic was created to more clearly define the extent of the deposit and the quality of the manganese ore. The samples yielded by the Sonic method were 3-1/2 " (8.89 cm), which enabled permeability tests, and downhole wireline geophysical measurements to be taken. These geophysical measurements provided deposit porosity, an indicator of its value.

- Recovered core from zones of high mineralization where little or none had previously been recovered.
- Virtually 100% of the 3-1/2" core sample was recovered at depths up to 420 ft (128 m).
- These large core samples permitted the client to conduct extensive new tests.

HEAP LEACH AND MINE DUMP SAMPLING

Sonic drilling has the ability to efficiently penetrate the semi crushed rock, cobbles, and clay found on heap leach pads and in mine dump sites. Our Sonic samples are accurate to depth and commonly drilled dry without fluid circulation to minimize risks in sample cross contamination. This creates a precise and continuous sample with near 100 percent recovery.

- Drills heap leach formations efficiently without fluids.
- Risk of cross contamination is minimized.
- Samples are extremely accurate to depth.
- Continuous samples with a recovery rate near 100%.

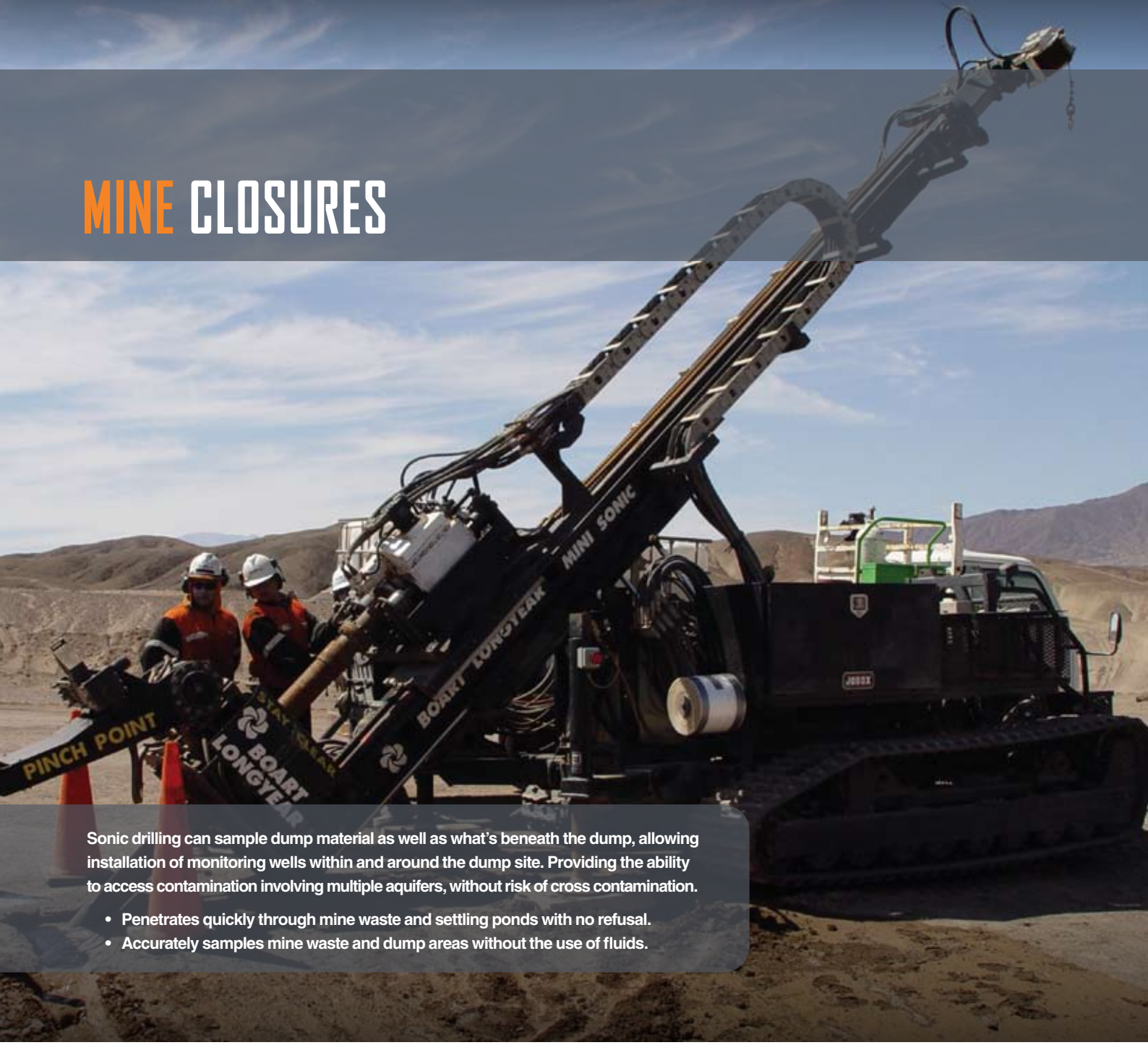
CASE STUDY

Location:	Yanacocha, Peru	Drilled:	19,488 ft (5940 m)
Rig Type:	Sonic	Reference:	Newmont Mining Corporation

Boart Longyear was contracted to continuously sample the ore deposit in order for the client to determine the gold content. It was originally anticipated that 32,808 ft (10,000 m) of drilling would be required to provide an adequate sample base. By utilizing Sonic technology, which yielded a high recovery rate, the crew was able to reduce the footage required to 19,488 ft (5,940 m) – 40% less drilling than anticipated.

- Obtained continuous, quality core samples of the semi-crushed ore at 99% recovery.
- Samples were drilled completely dry, without the use of air or fluid, so the gold content could be accurately determined.
- These formations ranged from consolidated to unconsolidated materials that varied in composition from crushed rock, cobbles to gravel in clays.

MINE CLOSURES



Sonic drilling can sample dump material as well as what's beneath the dump, allowing installation of monitoring wells within and around the dump site. Providing the ability to access contamination involving multiple aquifers, without risk of cross contamination.

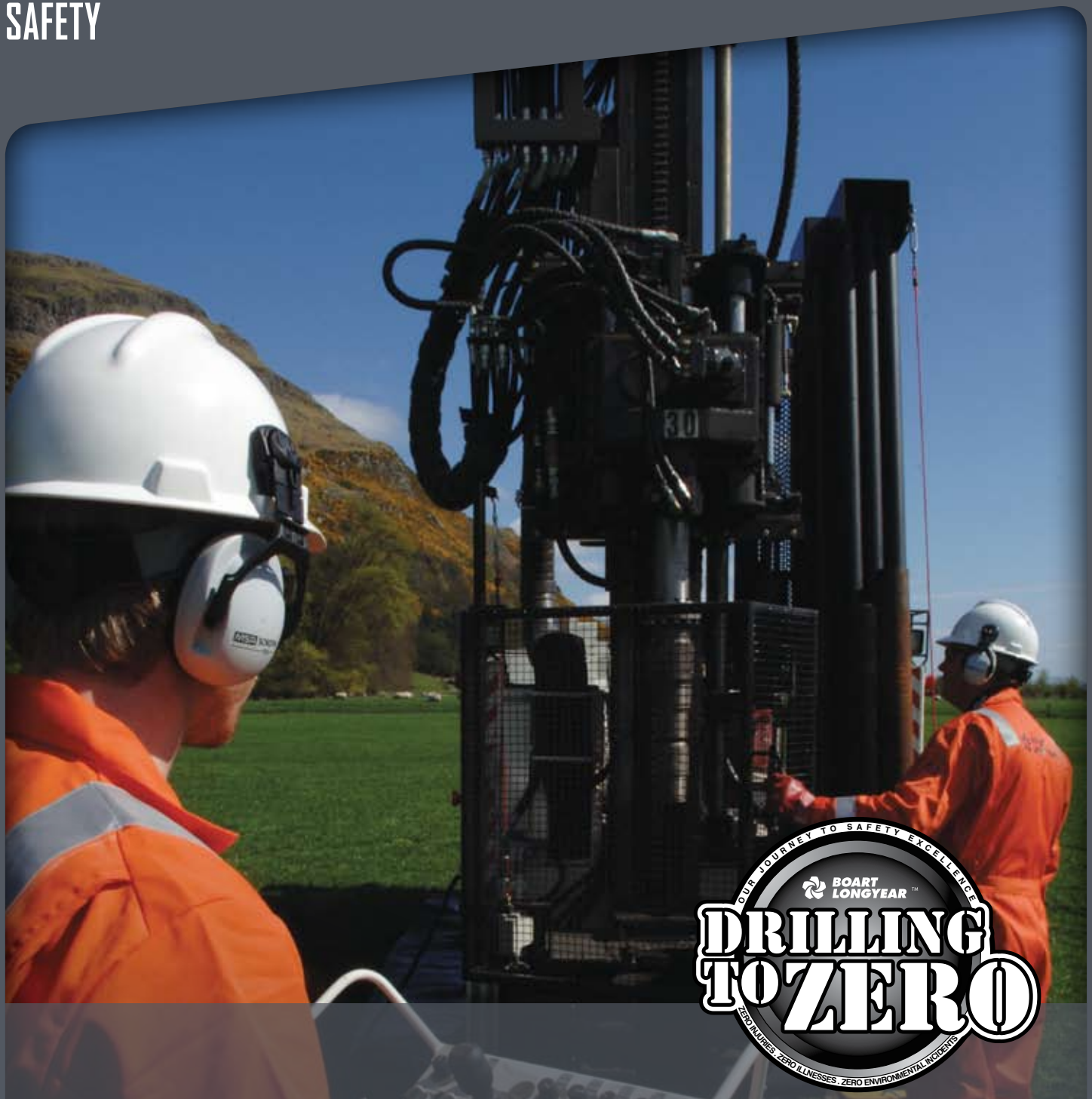
- **Penetrates quickly through mine waste and settling ponds with no refusal.**
- **Accurately samples mine waste and dump areas without the use of fluids.**

CASE STUDY

Location:	Summitville Mine, CO	Depths:	100 to 210 ft (30.48 to 64.01 m)
Rig Type:	Sonic	Reference:	U.S. Environmental Protection Agency

It was determined that the run-off of excess water from the heap leach pad escaped through a damaged pad liner and contaminated nearby creeks. This required the installation of monitoring wells to assist in a remediation plan for the site. By using dry Sonic drilling the amount of drilling waste was limited, which eliminated any chance of diluting existing contaminants and greatly reduced well development and purging time.

- Drilled through mixed formations, man-made and natural, which consisted of silts, clays, sand, gravel, cobbles and boulders.
- Borings were completed using "dry" Sonic drilling – no water, air, or drilling additives were used.
- 6 inch diameter continuous core samples were collected, averaging over 90% core recovery.



BOART LONGYEAR'S COMMITMENT TO SAFETY

Boart Longyear operates with a "safety first" approach to drilling. We recognize the value of well trained employees who can optimize production and efficiencies in a safe work environment. That is why Boart Longyear sets industry leading standards for driller training, equipment maintenance and world-class operations.

At our Driller Training Center, we instruct crews in safe work practices, fundamental operating procedures and advanced drilling techniques before they go to work on our clients' projects. This helps us achieve our goal of zero injuries, zero illnesses and zero environmental incidents.

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We invite you to contact Boart Longyear and learn more about Sonic drilling and how it can assist you in meeting your drilling needs.

www.boartlongyear.com

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