wassara

WATER-POWERED DRILLING
IN MINING

“When I joined LKAB straight from mining school, I believed that straight drilling and air DTH went hand in hand. I soon learned that there was a much better alternative available from Wassara. Today, drilling long and straight production blast holes is arequirement for the continuous improve-mentof our overall mining costs. And it’s with Wassara technology that we are achieving this..”

Monica Quinteiro, Production Manager LKAB Kiruna mine, Sweden

STRAIGHT FORWARD DRILLING

Wassara technology uses water to power the hammer. This provides unrivalledbenefits and possibilities in mining. Wassara meets the need for drilling deeper and narrower holes, more cost-efficiently and in a more environmentally-friendly way. This makes the water-powered technology the optimal choice.

Drilling technologies over the years

The mining business is in need of new drilling solutions to meet the challenges of mining deeper, bigger and narrower – and at the same time protecting the environment and reducing overall costs. Many existing underground mines are reaching extreme depths that current mining methods cannot manage cost-efficiently. New deposits lie deeper with leaner ores. These factors demand larger scale mining and resource planning based on facts, not assumptions – and new, more efficient and precise drilling. The straight forward drilling of Wassara delivers this.

Large-scale improvements

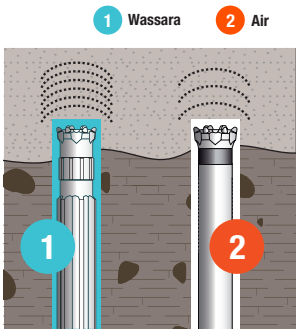
Wassara's water-powered drilling is the biggest improvement in drilling since the air DTH, providing accuracy that pushes mining boundaries and eliminates previous drilling limitations. Wassara technology is suitable for all types of mines and most drilling applications in mining operations. In short, it enables mining companies to scale up, improve safety, lower their energy consumption and minimize the impact on the environment.

How Wassara works

The Wassara technology uses high pressure water to power the DTH hammer. High pressure water delivers a high frequency rate and high energy per blow. When the water leaves the hammer it has sufficient velocity to force cuttings and debris to the surface, while cleaning the hole. Besides smooth and straight holes, with a minimum of deviation, Wassara offers extensive benefits like high productivity, borehole quality and minimum impact on the formation being drilled.

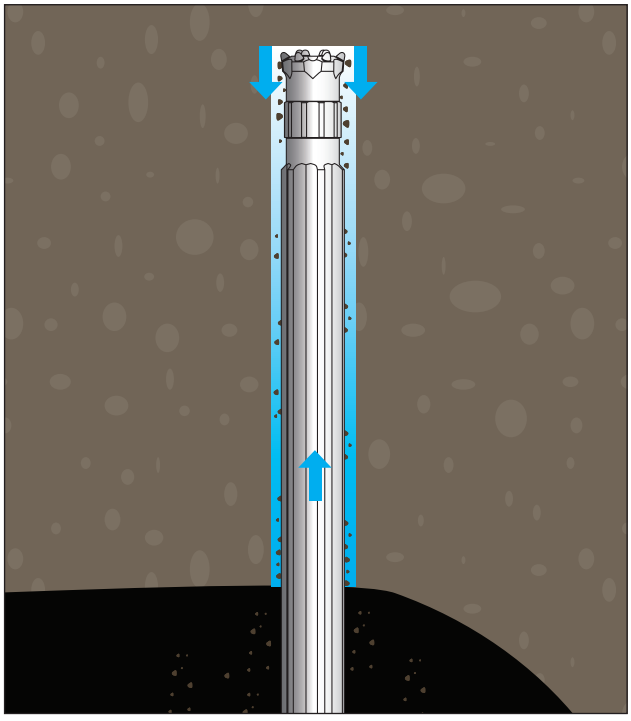
Extraordinary accuracy

Accuracy is the most crucial factor for the profitability since it dictates the borehole length and the scale of an operation. In this regard, Wassara is outstanding. With an average borehole deviation of less than 1%, Wassara is unmatched when compared to other technologies used for production drilling that average a 5 - 20% deviation. Such a high accuracy will lower the amount of dilution as well as improve ore recovery, fragmentation and overall productivity.



High and versatile performance with Wassara

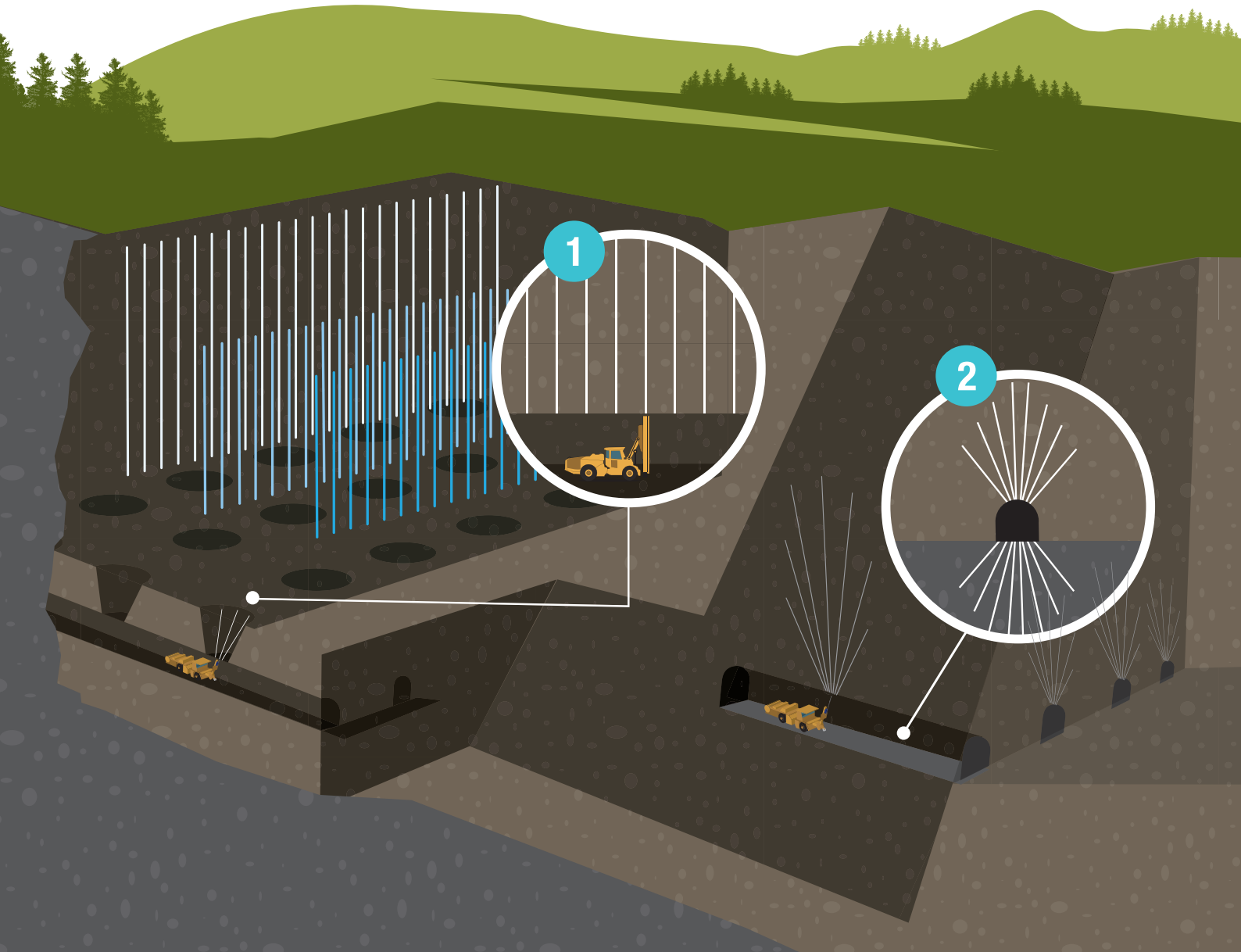
There are a number of reasons why Wassara is faster than diamond core drilling and top hammer drilling for long holes. The system is much more efficient with a higher frequency compared to an air DTH hammer (3,600 blows per minute compared to 2,000- 2,700 bpm with air DTH) and a costanct percussive force. And since the hammer is always at the bottom of the hole, no impact power is lost through the drill string, therefore the penetration rate is maintained even at significant depths.



The principles of water-powered drilling

STRAIGHT DRILLING MATTERS – REGARDLESS OF MINING METHOD

With Wassara you can base your mining methods on the ore bodies, rather than of the drilling limitations.



Underground mining

The need to drill accurately is common to all mines. The less accurate drilling is the more limitations are put on a mine. Wassara water-powered drilling technology offers unrivalled accuracy and efficiency. This gives mining companies the opportunity to choose the optimal mining method based on ore bodies rather than drilling method – a unique big step towards real optimized mining.

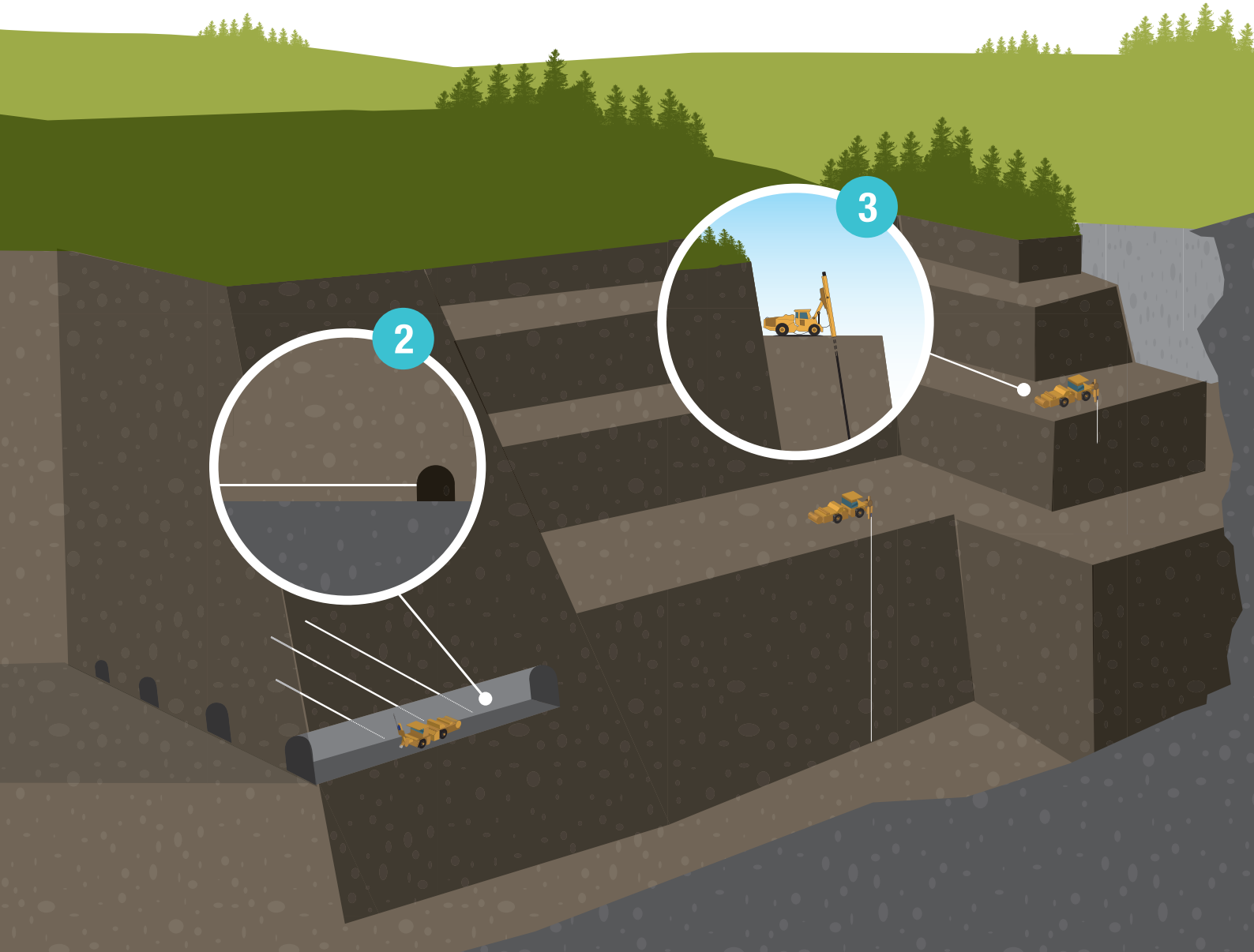
1 BLOCK CAVING

- Preconditioning/propagation
- Hydrofracture
- Drawbells / finger raises

LKAB KIRUNA AND MALMBERGET IRON ORE MINES IN SWEDEN

Mission: Scaling up production by drilling longer and straighter blast holes in two sub level caving mines.

Result: By extending the borehole lengths from 28 to 56 meters, the total production efficiency has increased by 500%. Wassara technology was fully implemented in 1995 and LKAB drills around 1.5 million meters, annually with Wassara.



2 SUB LEVEL CAVING

- Long blast holes
- Investigation holes
- Slot drilling / rises
- Raises
- Service holes (utility, drainage, backfill)

3 OPEN PIT MINING

- Drilling for dewatering
- Pre-split

The drilled holes for pre-split must remain parallel and cannot deviate from the plane of the proposed slope. Wassara technology gives you optimal conditions for this.

BLOCK CAVE MINING

Wassara's straight forward drilling solution is the only drilling method that can guarantee accuracy during the preconditioning/propagation process.

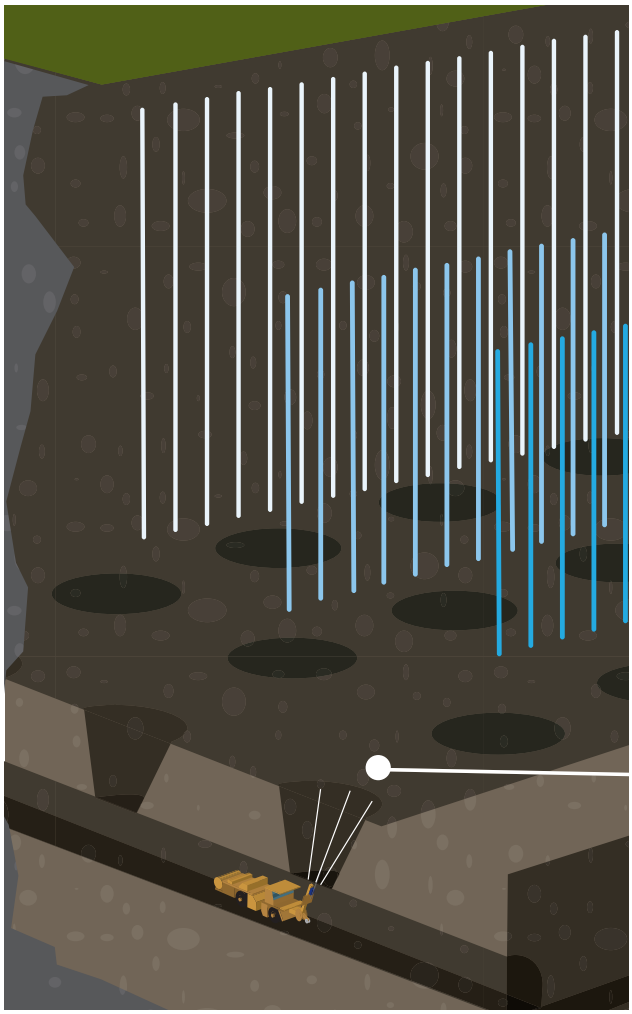
Preconditioning/propagation with higher accuracy

When gravity is not sufficient to fracture the rock, it is common to drill vertical holes for preconditioning/propagation purposes. The length of these holes can be as long as the ore body, in some cases longer than 250 meters; Accuracy is key. Wassara is the only production drill method that can guarantee accuracy at such lengths. Accuracy is also key for the parallel holes, which will ultimately determine the success of the preconditioning/propagation process.

A safer and more productive extraction level

In block cave mining, the main extraction level has to last the entire lifetime of the mine. This puts big demands on the team to achieve substantial rock reinforcement, for example by using steel arches, sprayed concrete, cable bolts, rock bolts and steel mesh, etc.

It's essential that the rock is not damaged at the beginning of the process, i.e. during the blast. Wassara's drilling method delivers the straightest holes and enables optimal cir-cumstances to achieve a successful presplit. By presplitting the draw bells, the additional rock reinforcement will further improve stability instead of forcing the team to fix any issues by blasting. In other words, Wassara can be the difference between having a safe and productive area or a hazardous area with limited production availability.



Straight preconditioning and draw bell blast holes with Wassara

ANDINA COPPER MINE , BLOCK CAVE MINE, CODELCO, CHILE

Mission & challenges: The mine wanted a drilling method that could deliver long and straight holes, while improving the work environment: less dust, no oil mist and lower overall temperatures.

Result: With the use of Wassara, the mine was able to drill 190 meter long holes with a diameter of 146 millimeter, while achieving a minimum hole deviation and an improved work environment. Given these successful results the mine is now planning on drilling even longer pre-conditioning holes with Wassara.

SUB LEVEL CAVING

The unique Wassara hammer was initially developed for sub level caving and can easily increase the length of blast holes way beyond 60 meters.

Scaled up production with longer blast holes

The LKAB mining company own the two largest iron ore underground mines in the world. When they made the transition from a regular top hammer to the unique Wassara hammer, the length of the blast holes was increased by 100%, from about 28 meters to 56 meters. This resulted in a decrease in the number of sub levels by 70% and the volume of ore per drilled meter increased by 500%.

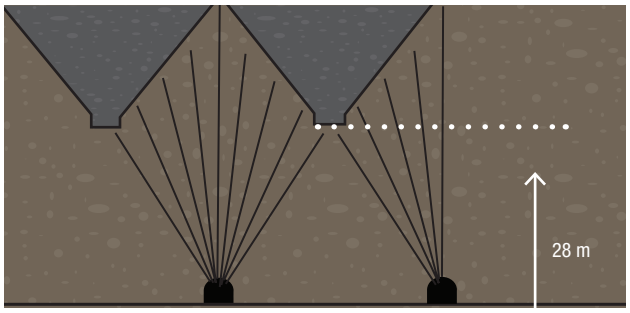
Due to the nature of the orientation and the shape of a typical ore body that is being mined with sub level caving, the mine design truly benefits from the advantages of using the Wassara hammer. The length of the blast holes can easily be increased to way beyond 60 meters, basically as long as the toe spacing allows. By increasing the length of the blast holes, the amount of sub levels decreases significantly.

Increased productivity

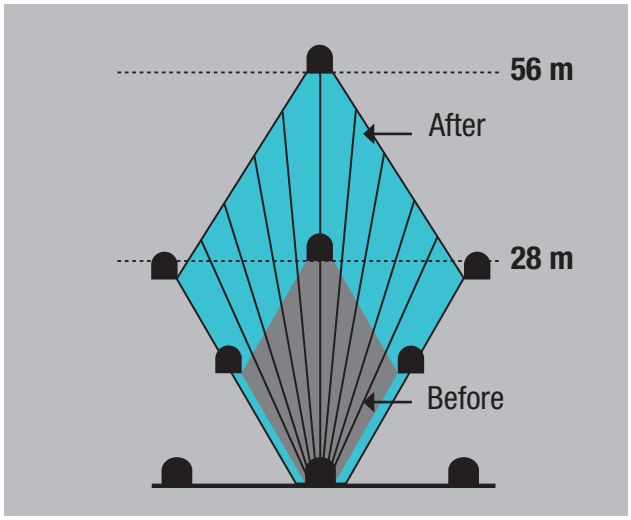
With the increased volume of ore per drilled meter, the overall productivity is significantly increased. Also, the controlled amount of deviation leads to a more homogeneous fragmentation which increases the overall throughput of the whole mining process. This is particularly beneficial for mass-scale mining methods such as sub level caving.

Higher accuracy increases ore recovery

Wassara delivers blast holes. The controlled amount of deviation results in a blast that enables optimal ore recovery, since the risk of getting stuck and left behind the dilution in the rock flow is substantially decreased.



Drill design that is possible to turn into reality with Wassara



Scaling up from 12 to 28 meters between the levels increased productivity and lowered overall costs at LKAB

RANA GRUBER, SUB LEVEL CAVE MINE, RANA, NORWAY

Mission & challenges: The top hammer drilling system was limiting the length of the blast holes. The mine wanted to minimize the amount of deviation in order to prevent unsuccessful blasts and low ore recovery.

Result: With the use of Wassara, the mine achieved significantly greater control of the deviation which led to an overall improvement of the entire mining process.

SUB-LEVEL STOPING

When mining adjacent to the ore boundary, the straightness of Wassara guarantees both improved ore recovery and minimal dilution.

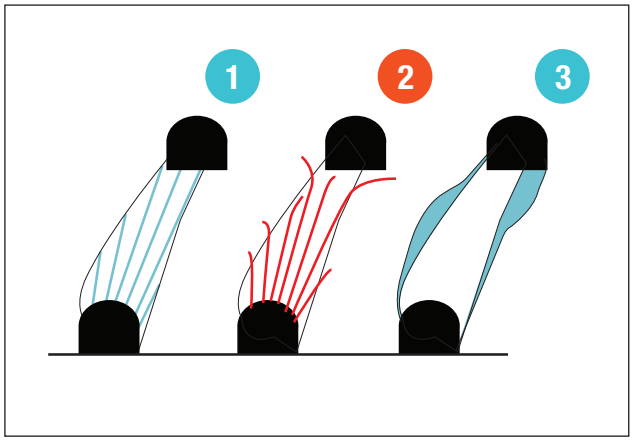
Improved blast results

In sub-level stoping, the holes are generally just a few meters apart and some of the holes are adjacent to both the foot wall and the hanging wall. If deviation occurs, it causes a decrease in ore recovery, an increased amount of dilution, and less homogenous fragmentation. In the worst case: this could result in a freezed blast.

In other words, the accuracy of the blast holes are the most important aspect a successful blast. Wassara delivers the straighter blast holes than any other production drilling method. It is therefore the best method to turn a carefully planned drill and blast design into reality.

No need for undercuts

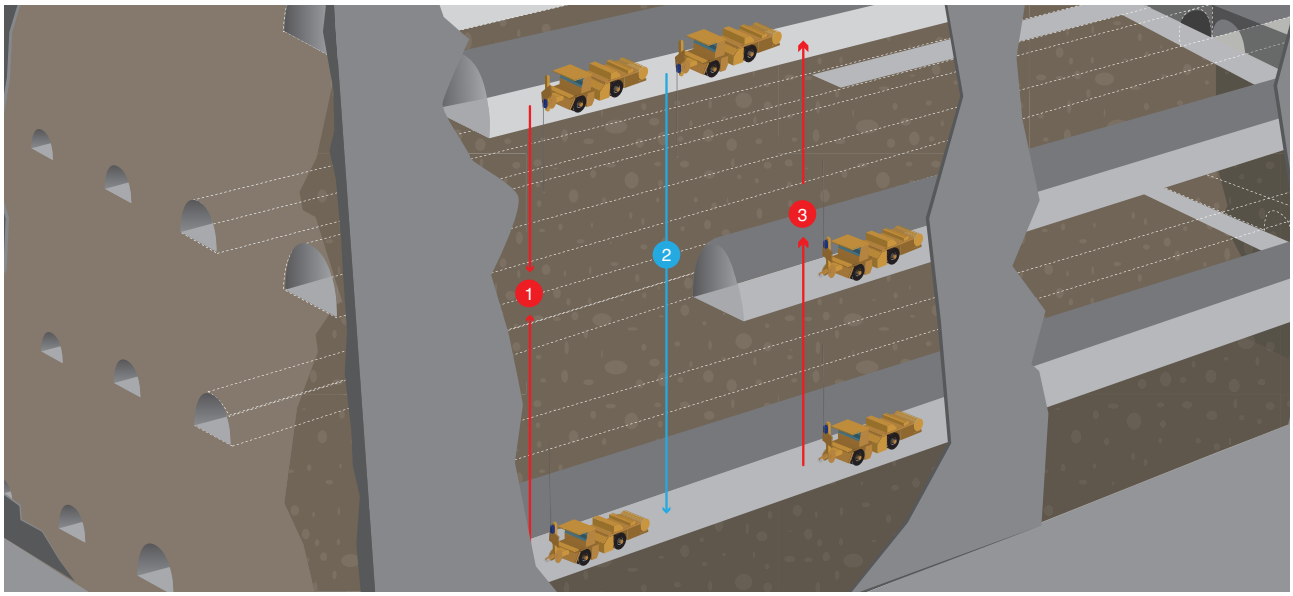
When conventional drilling methods are used for sub-level stoping, with long distances between the levels, it is common to drill an undercut to avoid the risk of high blast hole deviation. However, an undercut is both costly and time consuming since it literally turns one stope into two. With Wassara there is no need to drill an undercut since it will guarantee the necessary accuracy for all sub level stoping distances. So as well as improved profitability from increased ore recovery and decreased dilution, Wassara will significantly improve the productivity.



1. Drill design

2. Hole deviation with top hammer drilling

3. Deviation results in dilution and ore loss



1: Drilling an undercut with top hammer

2. Drilling the full length of the stope with Wassara

3. Extra sublevel with top hammer drill method

UNDERGROUND COAL MINING

Degasification holes can considerably slow down production, but Wassara can significantly increase productivity with a penetration rate of up to 5 times as much as traditional systems.

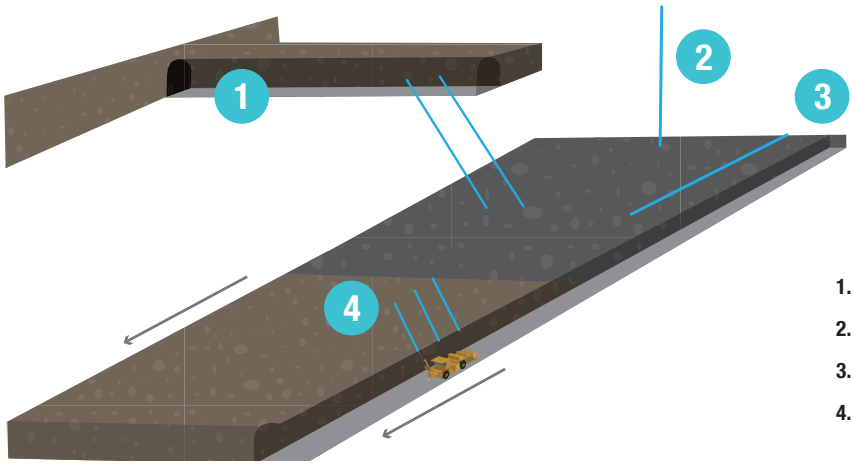
Increased productivity

Most underground coal mines suffer from methane gas releases from coal or surrounding rock strata, both during and after the mining process. The methane gas represents a severe mining hazard and extensive ventilation is crucial to provide a safe work environment. For that reason, up to 200 meter long degasification holes are usually drilled, and since top-hammers cannot handle such lengths and air DTH-hammers cannot be used due to the risk of explosions, slow and unproductive rotary non-percussive drilling is used.

Wassara on the other hand uses high pressure water to power the hammer, thus eliminating the risk of explosions. This makes it the ideal drilling method for degasification holes. Additionally, the rate of penetration is usually up to 5 times as high as the traditional rotary non-percussive drilling systems, even when the same drill rig is used.

Fewer and more stable holes

Many underground coal mines are also associated with unstable rock formations which can cause the degasification holes to collapse. A collapsed degasification hole needs to be redrilled immediately since it might be a potential hazard in the form of insufficient ventilation. With the Wassara system, a symmetrix or under reamer casing system can be installed in the fractured ground to prevent the hole from collapsing. Wassara therefore increases productivity even further since fewer holes needs to be drilled.



1. **Decasification gallery**
2. **Vertical gob wells**
3. **Horizontal in-seams holes**
4. **Cross mesure boreholes**

KWK PIOWEK MINE, UNDERGROUND COAL, ZOK, POLAND

Mission & challenge: The drill contractor ZOK was using rotary non-percussive drilling for their 200 meter long degasification holes and as a result they only drilled about 25 meter per shift. With this in mind, they started looking for ways to increase drilling productivity.

Result: With the help of Wassara, ZOK was able to achieve degasification holes of 64 millimeters in diameter and drill 100 meters per shift. Productivity increased four-fold, and the contractor saw the potential of reducing the total amount of drill rigs when changing from rotary-non percussive drilling to Wassara.

Wassara in degasification application

OPEN PIT MINING

Wassara's high accuracy drilling allows for an increased bench height and a higher amount of successful presplits, while at the same time reducing overall costs.

Increased productivity

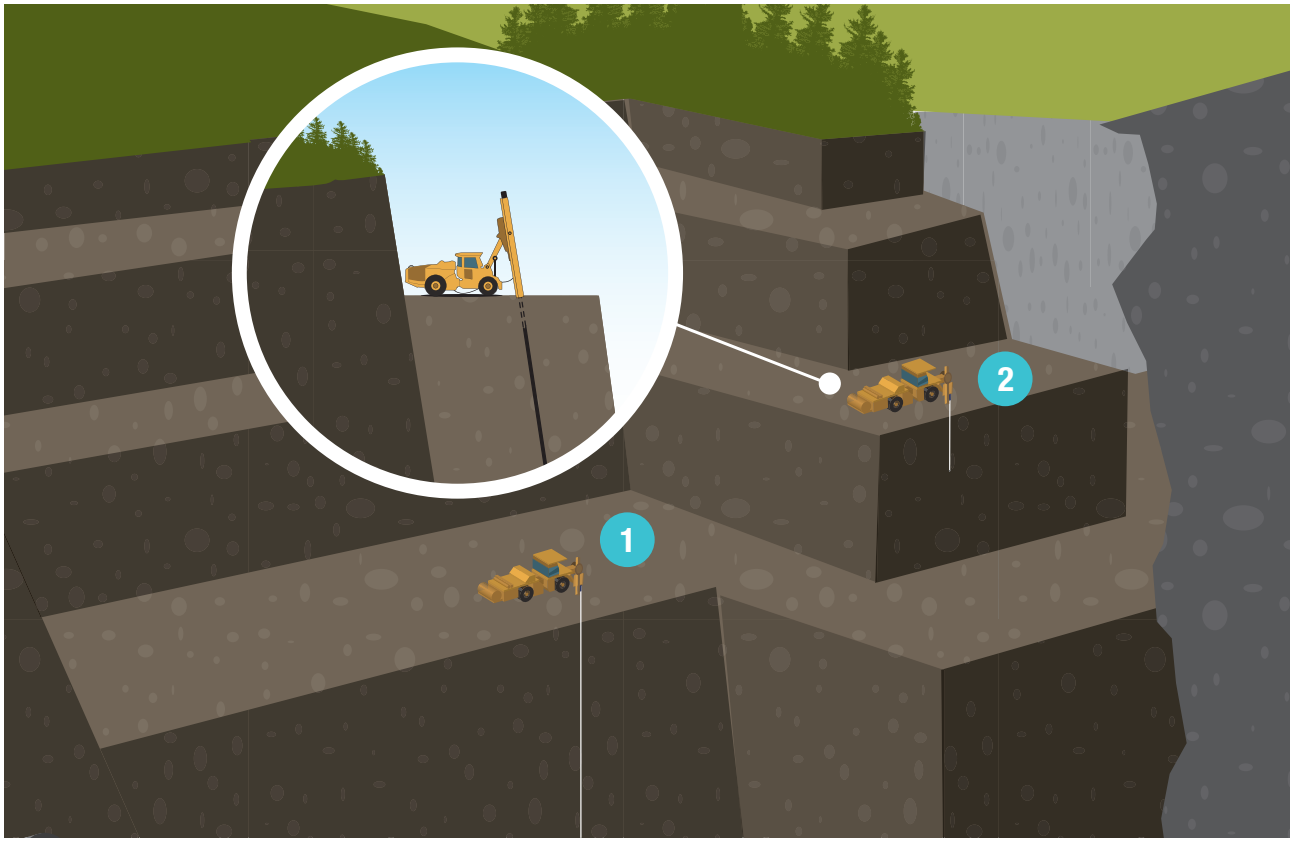
When the top hammer is used for drilling blast holes in open pit mining and quarries, the bench height is usually limited by the hammer's accuracy. With Wassara, not only can the bench height be increased, but the size of each blast can also be increased. This increases the overall productivity since the total amount of blasts can be decreased, resulting in lower operating costs. Parallel holes also improve fragmentation, which further increases productivity throughout the mucking, crushing and grinding processes.

Parallel and exact presplits

To improve the stability of the slopes it is common that a presplit, i.e. closely spaced blast holes, is drilled. These holes must remain parallel and should not deviate from the plane of the proposed slope. Since the Wassara hammer has the highest drilling accuracy of any currently available production drilling methods, it is the obvious choice for accomplishing a successful presplit.

Precise dewatering holes

The straightness of Wassara also enables very precise positioning of the long dewatering holes, which reduces the mining operation's overall cost of the water handling.



1. Wassaras straight drilling enables longer blast holes, hence increased bench heights in open pit mining

2. Shorter bench heights with top hammer

LONG HOLE RISES

Wassara's high accuracy drilling method is both safer and more productive when drilling long hole rises, a factor that significantly improves the success rate of the holes.

The importance of high accuracy

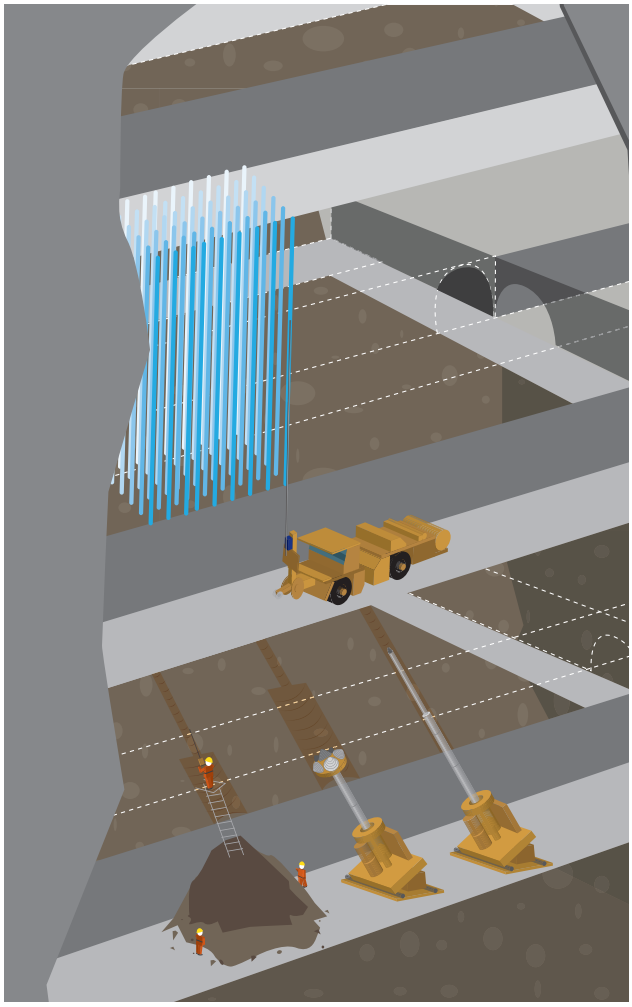
Long hole rises are very useful for creating the initial void to blast into. One of the key factors of a successful long hole rise is the parallel holes. The hole spacing is usually very tight, as low as 20 centimeters between the holes, and there is a severe risk that deviated holes will intersect other holes and interfere with the blast sequence, causing an unsuccessful blast. Because this application requires such high accuracy, Wassara is the ideal drilling method due to use.

Water-powered drilling improves the blast

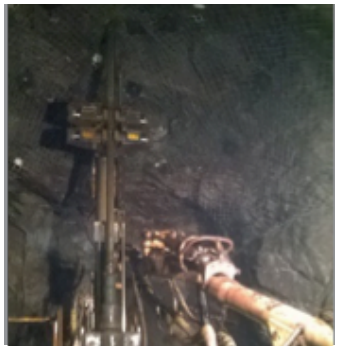
Since the water that leaves the hammer reverts to hydrostatic pressure, Wassara does not pressurize the formation. This is beneficial when blasting holes in close proximity. If air-DTH hammers are used, there is a considerable risk that the compressed air will pressurize and extend any existing cracks between the holes as it leaves the hammer. As a consequence, explosives might enter the cracks and open voids and connect the charged holes. This will lead to an interrupted blast sequence that is likely to make the overall blast unsuccessful, resulting in a freezed long hole rise.

A more effective method

Long hole rises are the most effective method of performing opening slots, and the best way to do this is with Wassara drills. Compared to air leg rises, long haul rises are much safer and more productive, and compared to box hole rigs, the capital cost is much lower since an additional drill rig is not required.



Straight and parallel holes in Long hole rises with Wassara eliminates the need for other techniques



SAN GERONIMO, UNDERGROUND COPPER MINE, OPENING SLOTS, CHILE

Mission & challenge: The mine was facing the challenge of creating 20 meter opening slots in a safe and productive manner. They were looking for a method to replace the air-leg rise miner method they were currently using.

Result: With Wassara, the mine was able to drill long hole rises with 82 millimeter blast holes, up to 20 meters in height, at a deviation of less than 1%. The productivity increased 4 - 5 times and a safe work environment was accomplished.

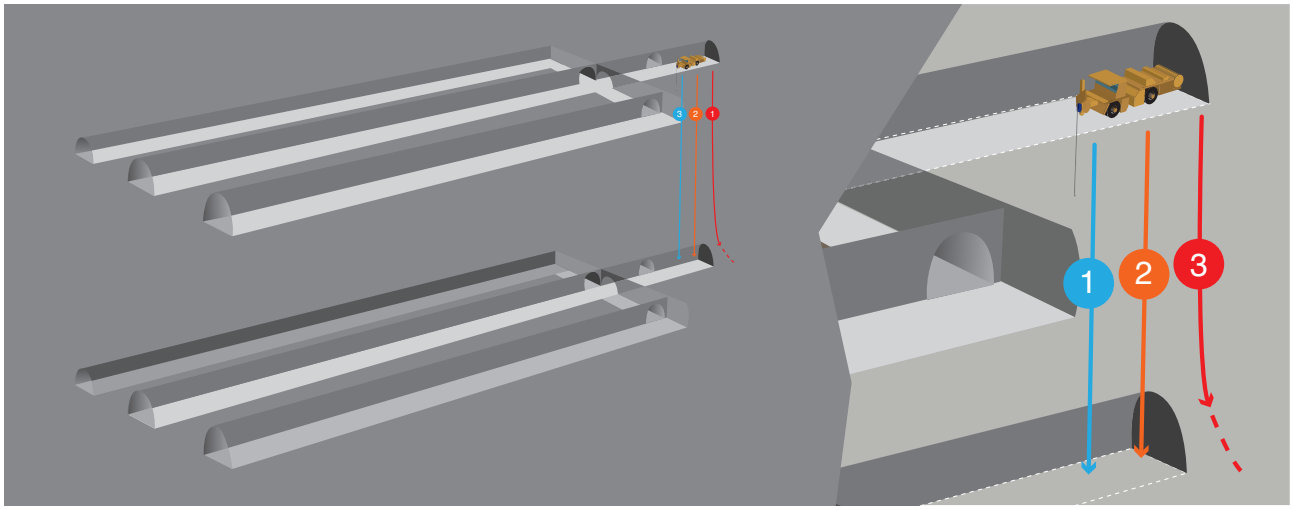
UTILITY HOLES

Wassara delivers utility holes with the same precision as rotary non-percussive drilling but much more efficiently, resulting in increased productivity.

Greater precision at faster pace

Utility holes are always required in mines, particularly when they expand with new levels. The drilled holes are required for cables, power-supply and drainage to manage the water. Utility holes have to be drilled with virtually perfect accuracy in order to reach the desired target. This is the reason traditional drilling methods used for regular production drilling, such as top hammers, are not optimal. Therefore, diamond-core drill rigs tend to be used instead.

This method however is not very productive as it takes a long time to achieve the desired results, and thus time spent on the core-drilling applications is reduced. This method can also cause logistical problems if drilling is blocking an entrance to a level etc. With Wassara, similar accuracy is achieved with a 4-5 fold increase in productivity. In other words, the benefits of Wassara are long and straight holes with very high productivity.



1. Wassara

2. Rotary non-percussive drilling

3. Top hammer

Wassara in utility holes application

MCARTHUR RIVER MINE, UNDERGROUND URANIUM, FREEZE HOLES, CANADA

Mission & challenge: The rock strata surrounding the uranium ore contained a large amount of water which made it impossible to drill with conventional air-powered drilling methods. The idea was to use Wassara for drilling freeze holes and then freeze the entire section in order to encapsulate the uranium and prevent leakage of radioactive ground water.

Result: Since the water in the ground did not affect Wassara's drilling method, they were able to drill 120 meter long freeze holes while maintaining high productivity and precision. With Wassara, the mine increased the uranium ore production and they have successfully continued to use Wassara for over 10 years.

ENVIRONMENTAL IMPACT

Wassara's unique water-powered drilling solution is the most environmentally friendly drilling method for underground mining.

Lower energy demands

It takes 3-5 times less energy to power a Wassara hammer compared to an air-powered DTH hammer, a comparison based on the pump and compressor used at the drill rig. However, when it comes to air-DTH hammers, the compressor is usually just a booster compressor, i.e. it boosts the pressure from about 7 bar up to about 20 bar to power the hammer. To obtain the initial 7 bar, a much larger compressor is required owing to the high air leakage on the way to the drilling area. This is a major energy cost that can be eliminated by using a Wassara hammer.

Cleaner work environment

All mechanical machines used in mining need some kind of lubrication to be fully operational throughout their lifetime. As well as using the pressurized water to drive the hammer and bringing the cuttings to the surface, with Wassara the water also acts as a lubricant. In other words the hammer does not need any oil. Furthermore, this suppresses and eliminates dust. As a result there is no oil mist or dust in the air during drilling, leading to a significantly improved work environment.

Reduced heat levels

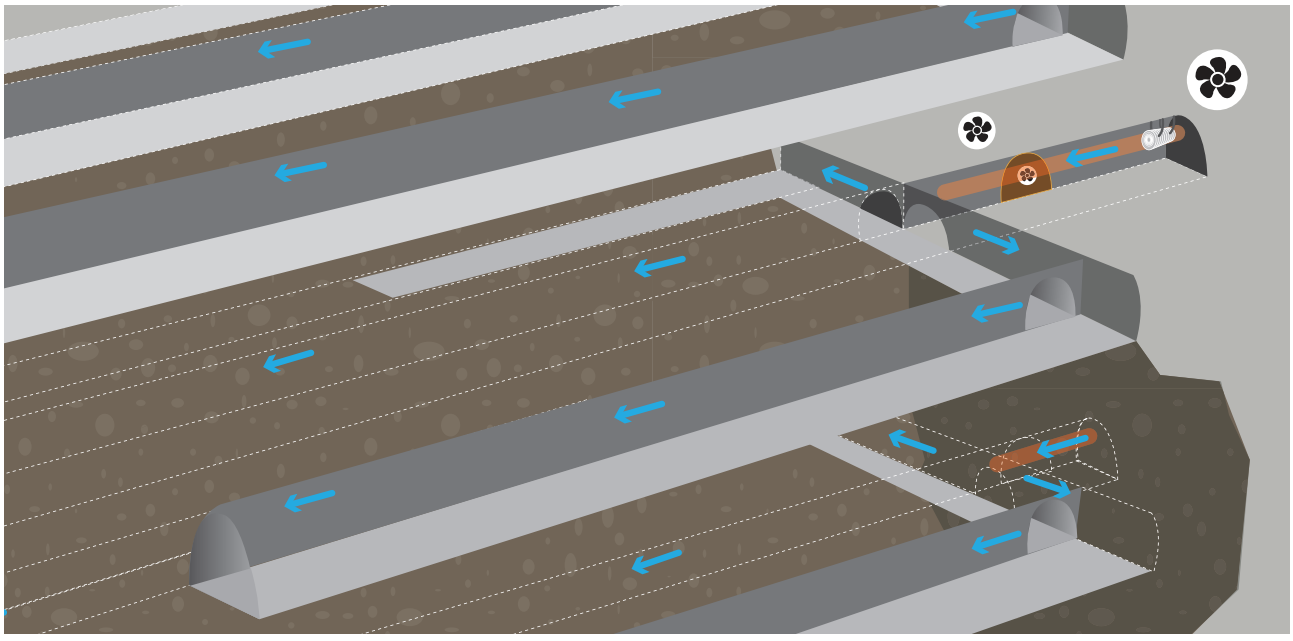
The compressors that normally power air DTH hammers produce a lot of heat. When drilling with Wassara hammers, a high-pressure pump is used instead of a compressor, resulting in substantially lower heat levels.

Lower noise levels

Underground mining, and especially the drilling process, tends to produce very high levels of noise. Top hammers in particular are known to generate high noise levels. And while DTH drilling is quieter as the percussion unit follows the bit through the hole, Wassara's water-powered drilling is even quieter since the water column dampens the noise from the hammer.

Reduced ventilation requirements

The combination of oil mist and dust-free air, as well as lower heat levels, make a significant difference to the ventilation requirements during drilling. This is yet another major factor as to why Wassara is the most environmentally friendly drilling solution for underground mining.



Since Wassara minimizes dust, oil mist and heat levels, ventilation requirements are reduced.

WATER HANDLING

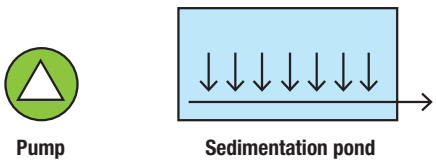
Most underground mines can implement the Wassara technology with their current water handling system.

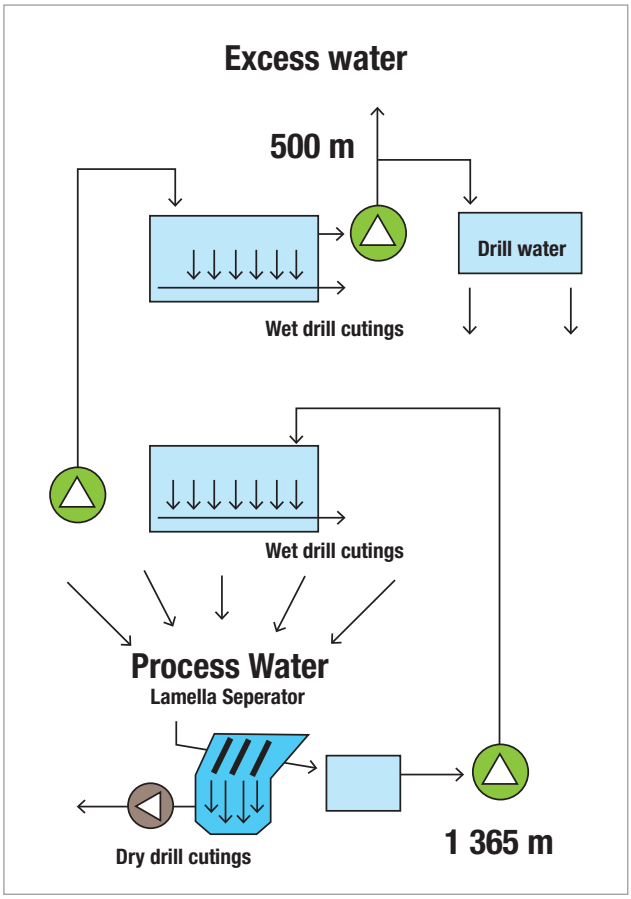
Using the process water of the mine

To power the Wassara hammer, the general recommendation is to use process water that does not exceed the maximum particle size of 50 micron and maximum suspended solid of 150 mg / l. This quality level can be achieved by traditional water handling system commonly used in underground mining. In other words, water is first pumped from the bottom of the mine upwards, step by step, where it usually goes through a couple of sedimentation ponds before it can be can be reused as process water.

Kiruna mine

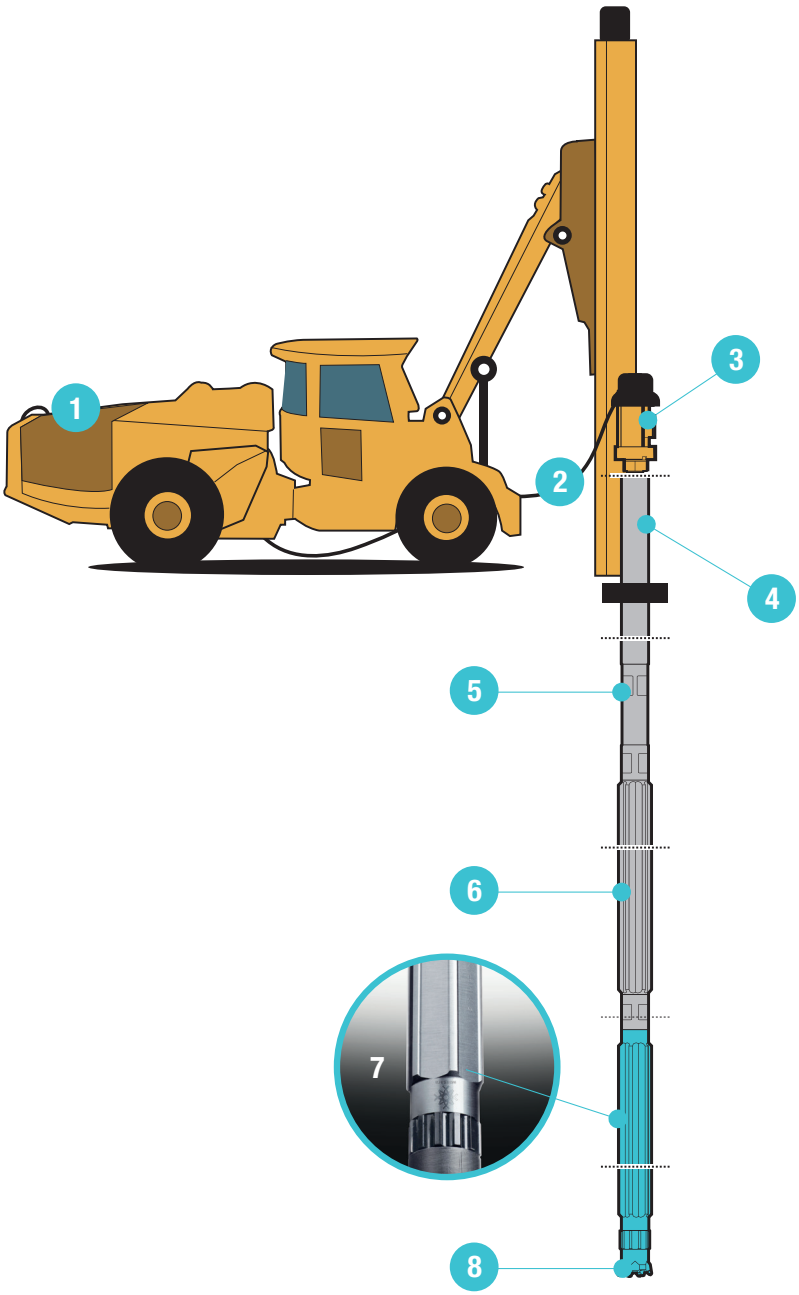
In the Kiruna mine where Wassara is used, flocculants are added to the process water that contains drill cuttings. A lamella tank is used to seperate the dry cuttings from the waste and the relatively clean water is then transported through a couple of sedimentation ponds. These step reduce the amount of suspended solids in the water down to 20 mg/l and 40% of the process water is reused to power the Wassara hammer, whereas the rest is used in the processing plant.





The water handling process at the Kiruna mine which uses Wassara

THE WASSARA SOLUTION



1. High-pressure water pump
2. High-pressure hose
3. Swivel
4. Drill rods
5. Check valve
6. Guided drill rod
7. Wassara DTH Hammer
8. Drill bit

Hammer range

Hammer	Ø Drill bit	Water consumption	Max operating pressure
W50 (2")	60mm, 64mm (2 ⅜'', 2 ½")	45-150 l/min (12-40 USgpm)	170 bar (2500 psi)
W70 (3")	82mm, 89mm (3 ¼", 3 ½")	70-270 l/min (18-70 USgpm)	180 bar (2600 psi)
W80 (3.5")	95mm, 102mm (3 ¾")	70-270 l/min (18-70 USgpm)	180 bar (2600 psi)
W100 (4")	115mm, 120mm, 127mm (4 ½", 4 ¾", 5")	130-350 l/min (35-95 USgpm)	180 bar (2600 psi)
W120.G3 (5")	130mm (5 ⅛")	240-500 l/min (63-130 USgpm)	180 bar (2600 psi)
W150 (6")	165mm (6 ½")	270-570 l/min (70-150 USgpm)	180 bar (2600 psi)
W200 (8")	216, 254mm (8 ½", 10")	280-744 l/min (73-197 USgpm)	150 bar (2200 psi)
W280 (12")	305mm, 311mm (12", 12 ¼")	1 200 l/min (317 USgpm)	150 bar (2200 psi)

Wassara – cost-efficient and environmentally friendly drilling

LKAB Wassara is a Swedish company developing and manufacturing unique water-powered drilling systems for high performance in surface- as well as underground drilling operations. The heart of the Wassara drilling system is the world patented water-powered down-the-hole hammer.

The drilling systems have been used for more than 30 years in various applications within many industries; mining, exploration, ground engineering, dams, geothermal, marine, oil & gas storage. Our experience covers more than 30 million drilled metres working in different locations around the world. Reference studies can be found on our website.

LKAB Wassara was founded in 1988 and is owned by LKAB. LKAB is an international high-tech minerals group that produces iron ore products for the steel industry and other mineral products for many other industries and applications.

Explore more at www.wassara.com

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