Sizeable investments, measurable benefits

Ore passes and shafts are key features of many modern underground mining environments, and although they require substantial investments, the benefits are undeniable.

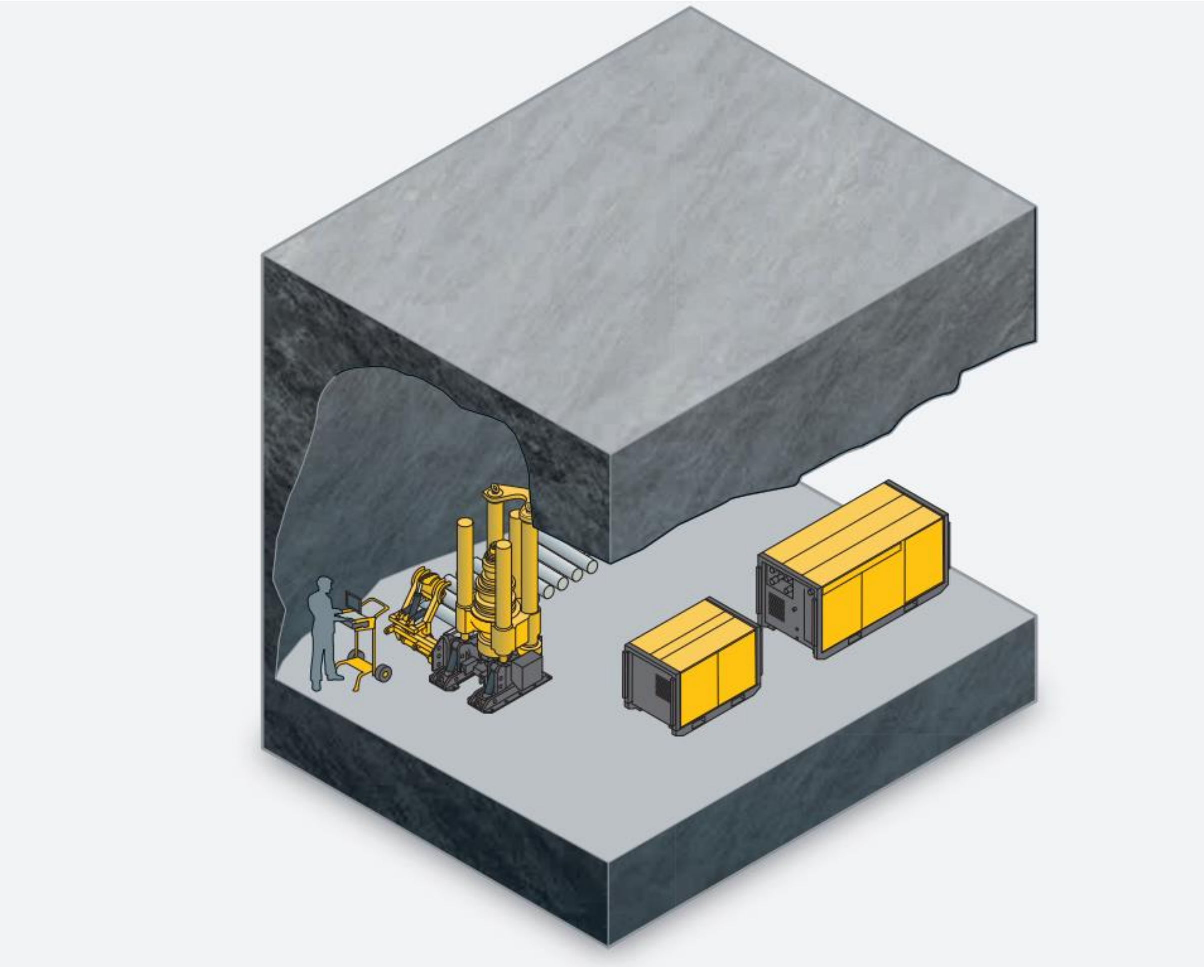

Figure 1: Raiseboring technology, with typical setup shown above, is widely considered a fast, economical and safe way of installing ore passes in mines.

There are many different types of underground mines and not all of them make use of ore passes. Those that do, however, enjoy important advantages. An ore pass is a type of shaft that is installed between two mine levels and is specifically designed to be a conduit for blasted ore. They can be square, rectangular, or circular and vary in length from 10 m up to 300 m and sometimes more. They can also be either vertical or steeply inclined. Well-constructed ore-pass systems form an integral part of material handling in many modern mines and provide several important benefits to the mining process. Firstly, as the ore is tipped into the chute immediately after blasting, it serves to keep the mining area clear.

This reduces the presence of loaders and trucks in the production areas, which in turn reduces diesel fumes and improves the environment. Moreover, with fewer vehicles in the vicinity, it reduces the possibility of congestion and the risk of collisions and accidents, all of which will disturb and delay the mining cycle.

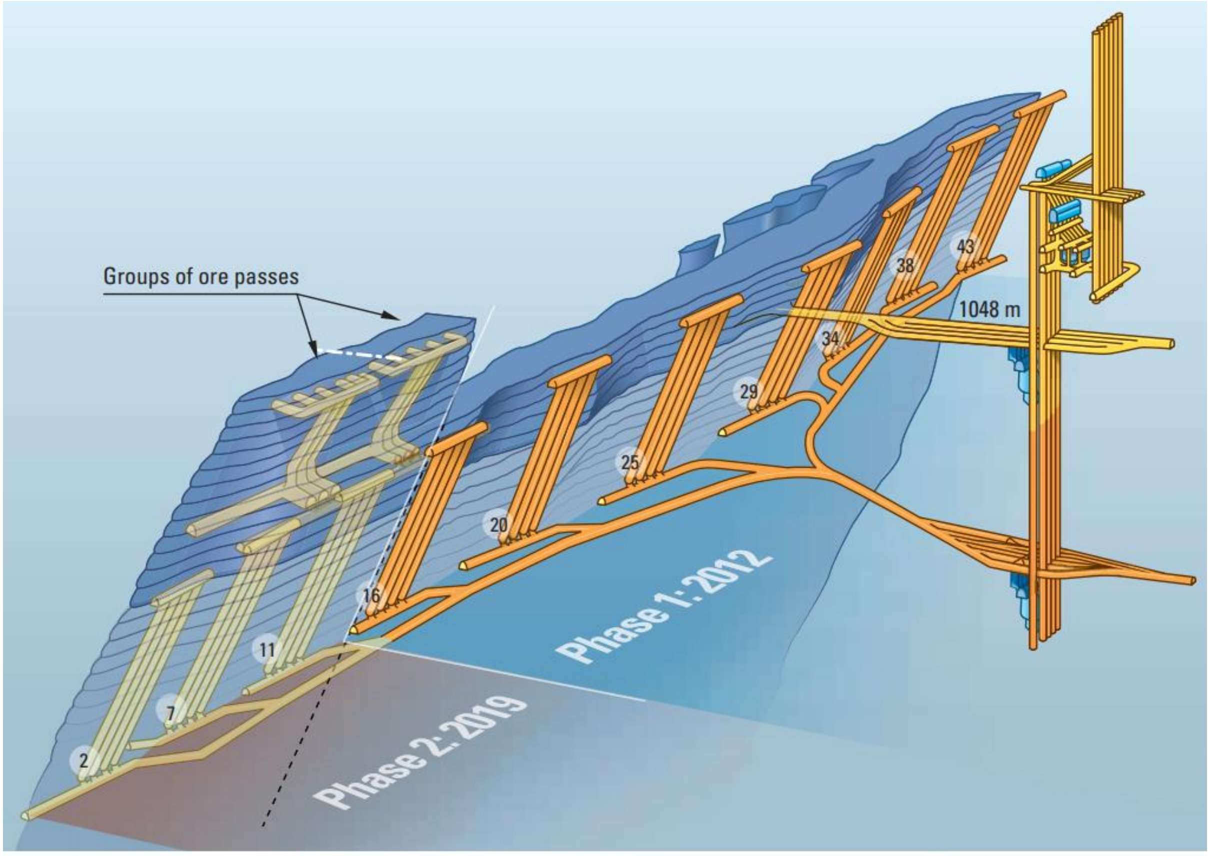

Figure 2: A modern ore-pass system enables a continuous flow of material to haulage levels in the mine. Illustration courtesy of LKAB.

Good economic sense

The most outstanding benefit is that ore passes make good economic sense. Quite clearly, they offer the most cost-effective alternative for mucking and haulage operations.

By conveying the ore away from the production area to a dedicated loading depot on another lower level, a continuous flow of material is made available to the loading and haulage fleet. This means little or no interruptions to the haulage operation and that these vehicles never have to stand idle, waiting for the next blast.

Another advantage is that shorter ore passes are easy to monitor. This is done either by visual inspection or by automated systems using lasers. Whatever technique is applied, the purpose is to keep the pass constantly filled with an even flow of blasted material.

Installing ore passes

Ore passes are developed in two ways, either by drill and blast or the raiseboring technique. In drill and blast, handheld rock drills and ladders are still used in some countries, despite the obvious dangers. More common is the Alimak method that makes use of a rising driller's platform, which can be used from a single access point but still requires mine personnel to be inside the raise during construction, subjecting them to the risk of falling rock.

Raiseboring, on the other hand, using a remote-controlled raiseboring machine, is now considered to be the safest and, arguably, the most effective technique available, even though it presupposes that both the top and bottom levels to be linked by the ore pass can be accessed.

Today's modern raiseboring technology offers a wide range of other important advantages, not least great precision, and speed irrespective of the length of the pass to be driven. As a result, raiseboring is now accepted as the world standard for mechanical raise excavation.

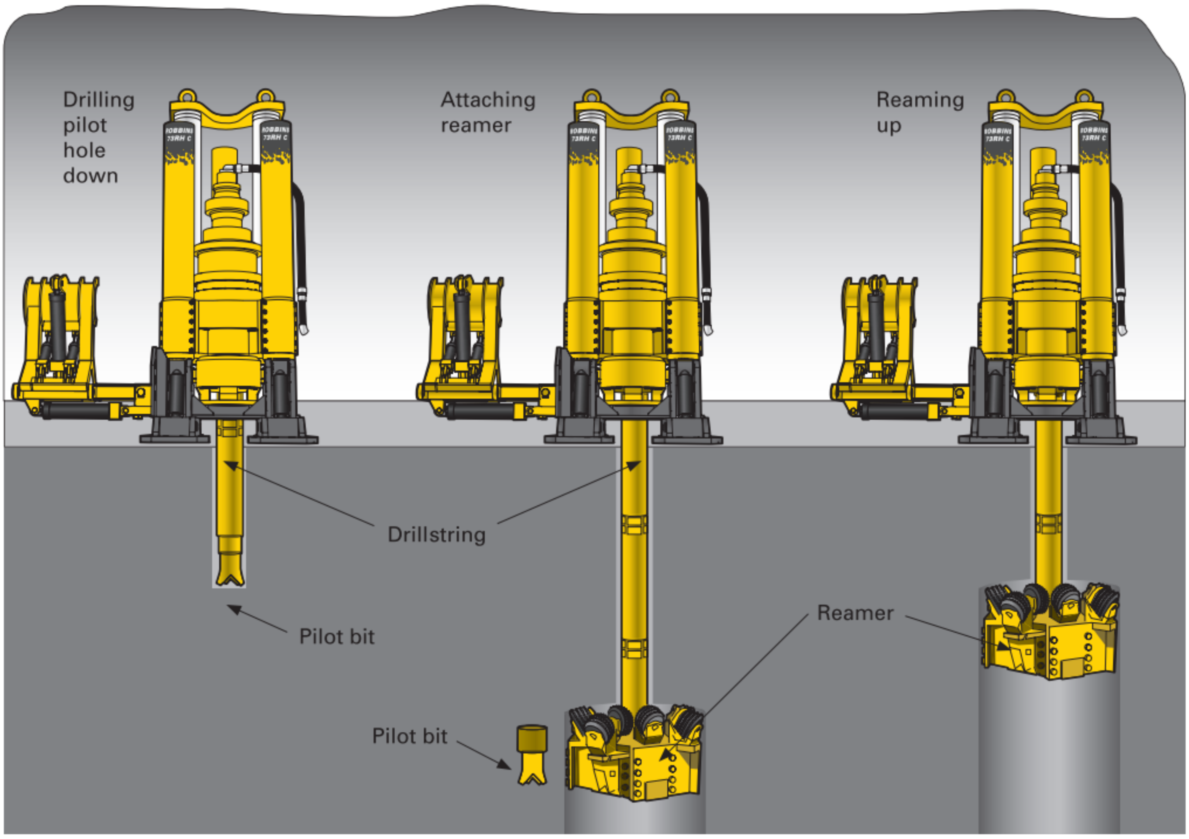

Figure 3: The principles of raiseboring from initial pilot hole to upward reamed hole.

Raiseboring technique

The benefits of raiseboring extend well beyond ore passes and include the construction of several types of shafts, such as for ventilation and hoisting. It can also be used for backfills, drainage and slot holes. In other words, the technique is a vital tool for constructing fundamental infrastructure in mines. A raiseboring machine is typically set up on the surface or on the upper level of the two levels to be connected as shown in Figure 1. A small pilot hole is first drilled down to the lower level using a drill bit attached to a series of cylindrical drill pipe pieces, which form the drill-string.

Once the pilot hole is completed, a reamer with a diameter larger than the pilot hole is attached to the drill-string at the lower level. The pilot hole is then reamed back to the machine on the upper level. As the reamer moves upwards, the cuttings fall to the lower level and are removed. Raiseboring machines have been used for holes in the range of 0.6–6.0 m in diameter and up to 1,000 m long. Standard raiseborers are capable of boring raises from vertical to angles of 45° to horizontal. Raises from 45° to horizontal have been completed with the addition of only a few accessories and minor adjustments to the standard machine.

In addition, raiseboring is by no means limited to boring ore passes. It is also used for a wide variety of underground mining applications from boxhole and blind shaft boring to down-reaming, pilot down–ream down, hole opening, pilothole drilling for long drainage holes, and shafts for ventilation and hoists.

Blind shaft boring

Blind shaft boring is used where there is access to the upper level of the proposed raise but limited or no access to the lower level. With this method, the raise is excavated from the upper level downward using a down-reaming system connected by a drill-string to the machine above. Weights are added to the reamer mandrel as shown in Figure 4.

Stabilizers are located above and below the weight stack to ensure vertical boring. A reverse circulation system, or a vacuum system, is typically used to remove the cuttings out of the shaft.

Down-reaming begins by drilling a conventional pilot hole, and then enlarging it to the final raise diameter by reaming from the upper level to the lower level as shown in Figure 5. Larger diameters can be achieved by conventionally reaming a pilot raise, and then enlarging it by down-reaming. During reaming, the cuttings gravitate down the pilot hole, or reamed hole, and are removed at the lower level. To ensure sufficient down-reaming thrust and torque, the down-reamer is fitted with a non-rotating gripper and thrust system and a torque multiplying gearbox driven by the drill-string. Upper and lower stabilizers ensure proper kerf cutting and reduce drill-string oscillations.

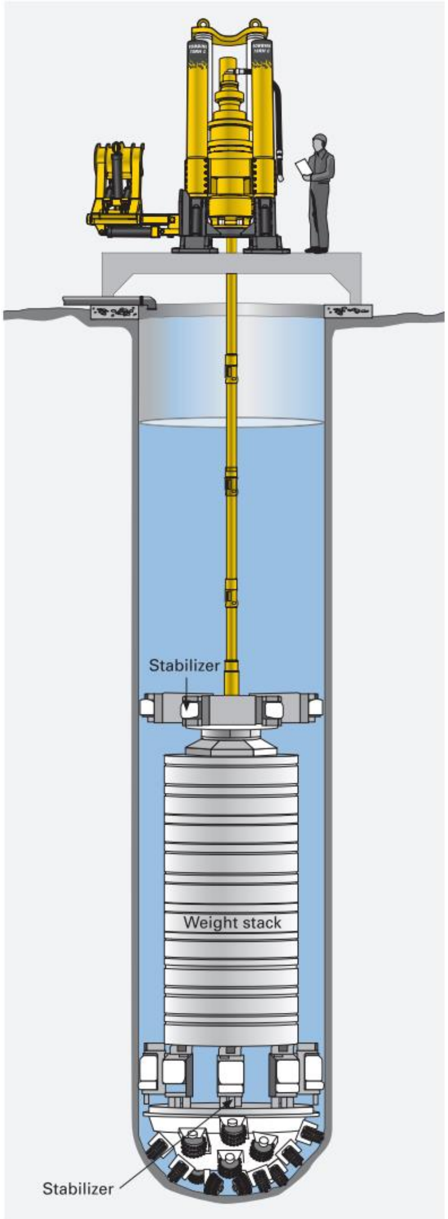

Figure 4: Blind shaft boring.

Pilot down, ream down

This method, also known as hole opening, is used to enlarge an existing pilot hole with a small-diameter reamer. The operation is like pilot hole drilling, the only difference being that a small reamer is used instead of a pilot bit. The small reamer is designed to use the existing pilot hole to guide the drilling.

Stabilizers are used in the drill-string behind the reamer to prevent it from bending. Pilot down-ream down hole opening is only used when a standard reaming system is either impractical or impossible, as shown in Figure 6, next page.

Box hole boring

Box hole boring is a technique that was first employed in the gold mines of South Africa in the early 1970s, following the delivery of modified Robbins raiseborer machines. A box hole is a type of ore pass raise that is typically driven upwards from haulage levels situated below the orebody. At the bottom of the raise, in the haulage area, is a chute base with a guillotine gate to control the feeding into haulage cars, using gravity.

Boxholing is aimed at releasing miners from hazardous manual raising. It eliminates the need to drill pilot holes and involves minimum site preparation. Today's technology in raiseboring provides unique solutions for all types of raising purposes.

Modern raiseborers include different machines that are specifically designed to cater to boxhole drilling needs. For example, the Robbins 53R is a unique multipurpose raise drill that can perform both upward boxhole boring as well as conventional raiseboring without any modifications to the drive assembly.

Another dual-purpose machine is the Robbins 34R, which is a low profile, small diameter machine that, similarly, allows a quick conversion from raiseborer to boxholer. It comes with a 720 mm reamer head installed through the worktable or, as a wide version, with a 1 060 mm head. While boring upward, stabilizers are periodically added to the drill-string (see Figure 7) to reduce oscillation and bending stresses. The cuttings are carried by gravity down the hole and are deflected from the machine and removed at the lower level.

Dual-purpose machines are especially useful in mine layouts that allow boxholing and conventional raiseboring from the same place, giving multiple holes from one location.

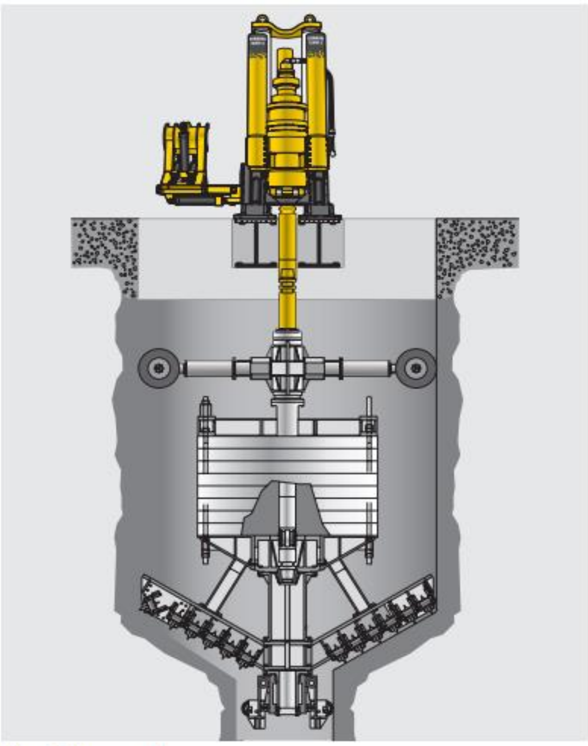

Figure 5: Down reaming.

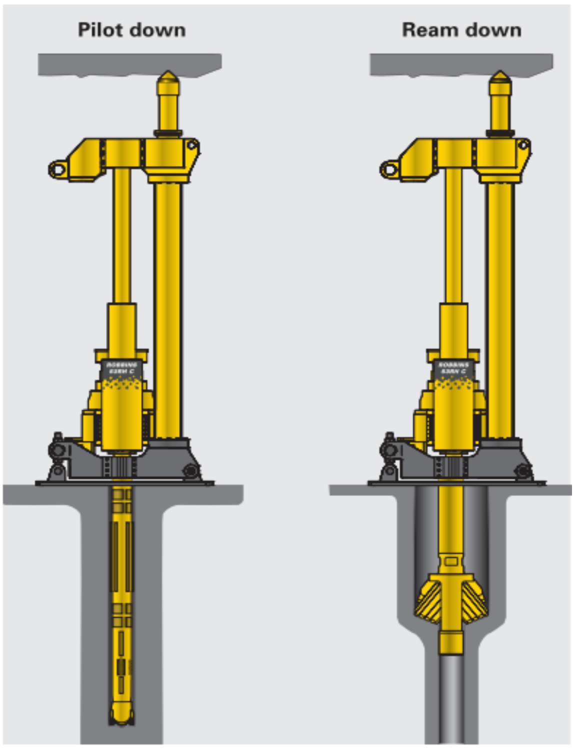

Figure 6: Pilot down-ream down.

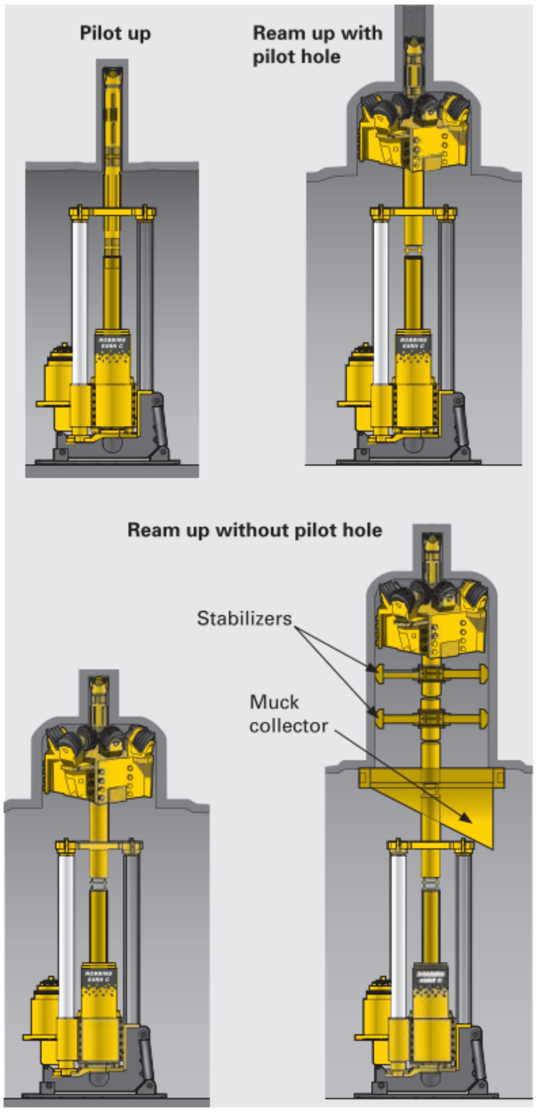

Figure 7: Boxhole boring.

Figure 8: The Easer machine is a flexible rig for small diameter raises.

Opening holes with Easer

The possibility to use the same machine for several tasks in underground mining is becoming an important factor that is driving technological innovation. A case in point is the new, small diameter raise drilling unit called the Easer machine.

The main purpose of the Easer is to assist drillers in the crucial task of drilling successful opening holes, or slot holes, that provide free space for blasted rock to expand into. These can be particularly demanding when using the block caving, sublevel caving and sublevel stoping methods as all require a vast number of short raises.

A key feature of Easer, shown in Figure 8, is how it fills the gap that has existed between the largest holes that Simba drill rigs can drill and the smallest diameter capacity of the current raiseborers. It also has the unique benefit of mobility and doesn't require the time-consuming setup procedure of raiseborers, which need a concrete pad to be poured to bolt the rig to the ground, as well as electricity, lighting and ventilation.

The Easer L is flexible and designed to work in drifts of 4.5 x 4.5 m ± 0.5 m and can drill holes up to 750 mm in diameter and up to 60 m long, for both boxhole and down-reaming purposes. Its drill angle from vertical provides a minimum range of 90–60° in all directions. The second model, Easer M, has the same capacity but has been specially designed for smaller drifts of 3.5 x 3.5 m.

While the Easer enables drillers using any caving or stoping method to achieve that all-important, first blast through in the stope, it can also be used for precondition holes, pastefill tube holes, long drainage holes, utility holes and other applications. And the time needed for setup or take down is less than one hour.

Releasing blockages

Despite its many advantages, the ore-pass technique is not flawless, and problems do occur from time to time, the most common being hang-ups and blockages. Normally, all material is screened before entering the ore pass, and oversized boulders are trapped in the grizzly at the opening of the pass and broken up by a hydraulic breaker mounted on a pedestal boom system.

However, even if the fragmentation is well managed, such large volumes can sometimes clog together and become jammed in the system. This can occur at any point in the network, and the mine must be prepared and take action to release these blockages and restore the flow. This involves identifying the exact location of the blockage and drilling holes into the side of the section to free it up.

Water may be injected into the holes or directly into the ore pass from above, or, in the worst-case scenario, explosive 81 charges may have to be used, and it may take several attempts before the blockage is released.

The true value of the ore-pass technique also depends to some extent on the shape of the orebody and the mining method employed. In cut and fill mining, for example, the advantages may not be as significant as the method itself is dependent on having a large fleet of trucks, which is often used to truck the ore all the way up to the surface. In this case, the installation of ore passes will probably not reduce the number of vehicles in the mining area and would, therefore, not be regarded as a viable alternative.

The same can be said of smaller mines where trucking is often the most competitive solution, but in most larger mines, the advantages of a total solution based on a well-constructed ore-pass system far outweigh the disadvantages.

And despite the investments required for installation and the occasional problem of blockages, this is now common practice in large mines around the world. A typical example is the LKAB iron ore mine Malmberget in northern Sweden, where LHDs are used to collect the blasted ore from the draw point and tip it directly into the ore-pass to a lower transport level where it is loaded onto trucks for transportation to the crusher station and thereafter to the hoisting system. In this way, the haulage fleet is guaranteed a constant stock of ore to draw from.

Round the clock haulage

Furthermore, ore-pass systems are essential for the continued development of automated loading and transport solutions. Driverless LHDs are increasingly used for hauling ore from the draw points during the night, or even on a 24/7 basis. The ore-pass system is a requirement to enable the permanent and constant supply of ore to the transport level. Such a system has been in operation at Sweden's LKAB Kiruna Mine, and the latest project active since 2011 shows promising results.

But that's not all. The use of safe equipment to construct ore-pass systems is in tune with the future aspirations of the mining industry. Hand-held technology, not just for constructing raises but for scaling and other mining tasks, is coming to an end. Safety regulations will continue to increase, and younger people entering the industry demand a safer, better working environment and more interesting jobs.