The Art of Long Hole Drilling

Production holes and utility holes have something in common. They are both long holes – and the longer the hole, the greater the risk of deviation. Today, long hole drilling is more accurate than ever.

It is reasonable to assume that long drill holes can never be 100 % straight, regardless of the miner's experience or the drilling equipment being used. A certain degree of deviation is simply unavoidable due to a variety of factors. However, much has been done in recent years to help the miner keep the drill bit on course and as close as possible to its planned destination. In long hole mining, deviation is mainly due to poor hole alignment, a lack of guide tubes, too-high feed, badly selected drill steel, poor collaring, deflection caused by various rock types or voids as the bit attempts to make its way through the orebody.

Deviation may also be a result of successive bending of the drill rods in the extended drill string during the first and most important part of the hole. To a great extent, however, this deviation can be calculated for and minimized. Sometimes a simple measure such as slower drilling may be an adequate solution.

Why deviation is important.

Deviation is the long hole driller's enemy, not to mention the charging engineer whose charging plan is based on perfectly straight holes. It has a direct impact on the effectiveness of blasting, which, in turn, increases the risk of poor rock fragmentation or, in the worst-case scenario, freezing rock. Conversely, straight holes are the key to optimal blasting results.

In order to achieve the desired rock fragmentation, the long hole driller must therefore drill as straight and as accurately as possible – in short, within the limits specified by the drill plan. This means that the holes must be collared in exactly the right position, and then drilled in the right direction and to the exact depth. Whether for long or short holes, a poor setup will greatly increase the risk of unwanted deviation.

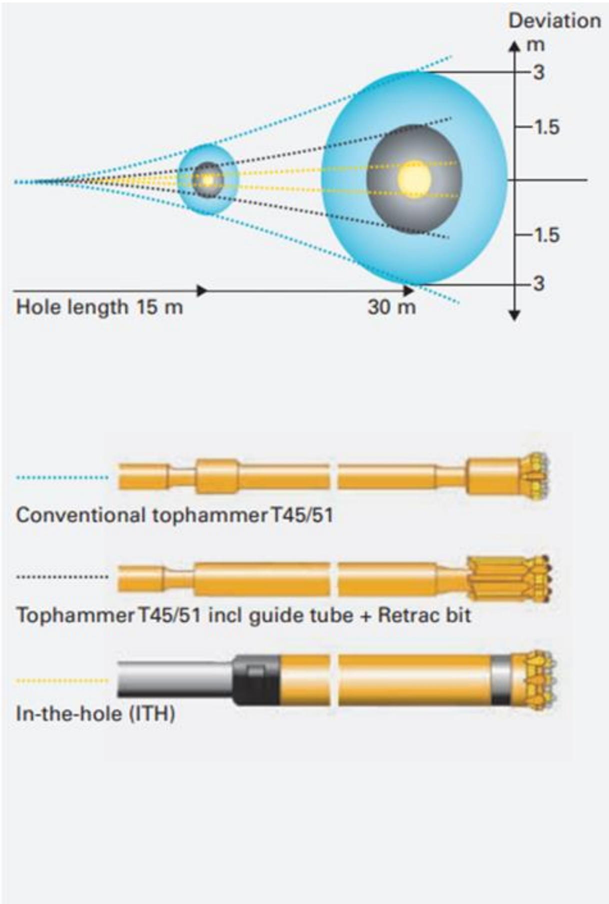

Figure 1: Three drilling methods and typical deviation to be expected.

Drillstring bending.

Aside from geological conditions, other, perhaps less obvious in-hole factors can have a marked influence on hole deviation, such as the selection of drill rig technology. Drill rigs equipped with RCS (Rig Control System) adjust automatically to rock conditions and fractures. The choice of bits and drillstring design will also have an impact, as demonstrated in Figure 1.

During drilling, the friction generated between the drill bit and the rock induces a torque in the drillstring above a certain rotation rate. The larger the drillstring diameter and the greater the rotation rate, the higher the torque and feed force will be required to keep the drillstring joints sufficiently tight.

It is often claimed that the amount of deviation is proportional to the depth squared. At a certain point along the hole, the drillstring will buckle, so rather than being straight in the hole, it is supported by the hole wall close to the midpoint between rock drill and hole bottom. This means that the dimension of the hole and the size of the drillstring are crucial parameters. If a small drillstring is used in a big hole, the drillstring will bend.

For a COP 1838ME rock drill, with a drillstring diameter of 38 mm and a feed force of 6,400 N at a percussive pressure of 200 bar, this bending length is approximately 11 m. In practice, bending occurs at a somewhat shorter interval since the drillstring is never perfectly straight at the start of drilling. When the drillstring has been extended to twice the theoretical bending length, it will buckle once more so that it is now supported at two points along the hole. At three times the theoretical bending length, the drillstring will once again buckle, and so on with increasing hole depth.

Drill bits and regrinding

Another factor to consider is the geometry of the drill bit face and its condition, particularly with respect to regrinding. From an accuracy point of view, a flatfront bit or a drop center (concave) frontbit results in a straighter hole than a drill bit with a convex front.

It must also be remembered that to obtain the best hole accuracy with all drill bits, they must be reground so that their faces are restored to their original shape in terms of both the buttons and the steel. In this regard, drop center drill bits are, once again, preferable to convex bits. This is because the concave shape needs only to be reground so that the profile of the central buttons is restored to its original pattern without adversely affecting hole straightness, even when the concave face eventually wears flat through normal operation.

Therefore, if the drill bit is reground correctly and frequently, the feed force will be directed to the periphery of the bit so that the whole cutting face is in contact with the base of the hole, even if the drillstring buckles.

With poor and infrequent regrinding, the drill bit may “wiggle” on the hole bottom and will, sooner or later, result in hole deviation.

In general, the larger the diameter of the drillstring for the smallest possible hole, the straighter the hole will be since the drillstring diameter has more of an influence on the bending length than the feed force, as shown in Figure 3.

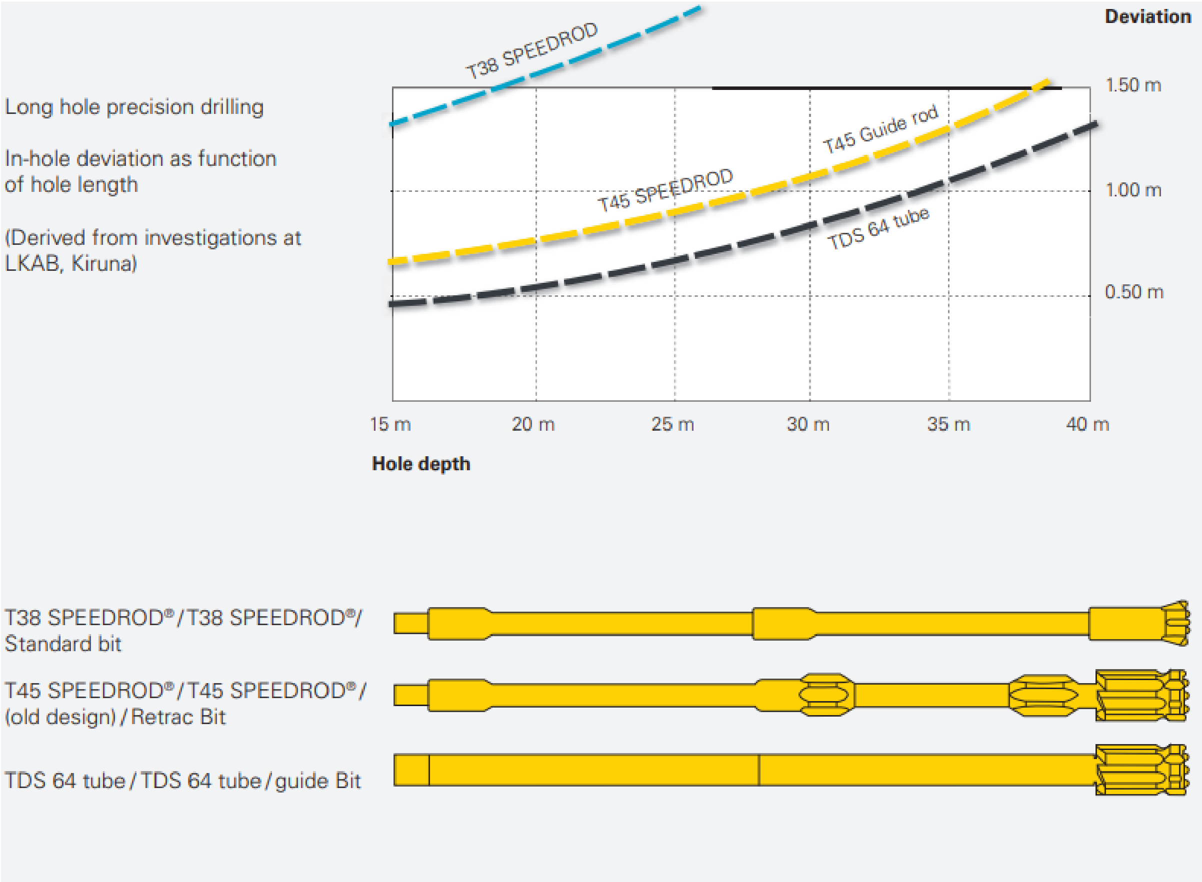

Figure 3: Larger diameter drillstrings result in less in-hole deviation as a function of hole depth.

Since drill tubes have larger diameters than drill rods, they result in greater hole straightness. A complete drillstring of tubes is often necessary in downward production drilling underground in order to achieve sufficient flushing capacity. The use of water mist can also be a solution.

An attractive alternative is the adoption of a guide tube connected to the drill bit, which, owing to its larger diameter, reduces the possible amplitude of drill bit "wiggle" compared with rods. Also, as the possible angle of wiggling decreases with increasing length of the guide tube, the guide tube incorporated into the drill bit should be as long as possible.

Unlike a drillstring comprised solely of tubes, where the stress waves are transmitted via "shoulder impact", stress waves in a drillstring incorporating a guide tube are transmitted down the rods to the guide tube via "bottom impact". Another way to minimize "wiggling" is to use Retrac bits (above right). Characterized by a bit skirt with the same outer diameter as the bit head, it is, in effect, a very short guide tube with maximum possible diameter. Retrac bits have been developed primarily to improve retraction of the drillstring in difficult rock conditions, where the tendency for jamming frequently occurs.

Debris from the hole is flushed through slots machined along the bit, and the rear end of the skirt has a cutting edge between every slot. Since the Retrac bit cannot wiggle as much as a standard bit with a skirt that is significantly smaller than the bit head, hole straightness is, once again, improved. However, the use of full length guide tubes will normally result in straighter holes than those drilled using Retrac bits.

Beating deviation

Here are four ways to combat and minimize hole deviation:

- A stiff drillstring and small clearance between the hole and the drillstring components will result in straighter holes.
- For tophammer drilling, tubes that can be added behind the drill bit to improve the flushing and reduce the risk of the drillstring becoming stuck.
- ITH, COPROD and rotary drilling are even more accurate than tophammer drilling and result in less deviation.
- Less deviation can be obtained through a combination of reduced feed force and increased rotational speed. This can be managed automatically through RCS.

It is impossible to eliminate hole deviation completely, but with the right choice of equipment and by utilizing this equipment in the right way, it can make a big difference.

Long hole drilling with SIMBA

Since the 1990s, great advances have been made in computer technology to meet the needs of the mining industry, especially with regard to fully computerized drill rigs for automated long hole drilling. These units, known worldwide as Simba, have enabled mines to make substantial improvements in drilling accuracy and productivity.

They are equipped with the Atlas Copco Rig Control System (RCS), which offers varying degrees of automation and, ultimately, the possibility of fully automated, remotely controlled and remotely monitored drilling. Options such as Advanced Boom Control (ABC) Regular, ABC Total, Drill Plan Handling, Full Drill Data Handling (FDDH) and communication products are also available.

RCS, which is a CAN-bus based system using standard PC-computer technology, represented a quantum leap forward with respect to logging capabilities, serviceability and drilling accuracy. CAN-bus systems use a single cable that interconnects a series of electronic components, allowing them to communicate with each other. In production drilling, the rigs can be adapted and configured for different applications.

Drill rig setup

A hole alignment accuracy of within ± 0.1 degrees is attainable with the Simba L and M rigs, with electronic sensors displaying the drill's rotation angle, tilt angle, or fan inclination on the operator's screen. The operator can configure the rotation direction and locate the zero points according to the drill plan. If the drill quality logging option is installed, collaring angles for each hole can be logged and stored.

At the ABC Total level, the rigs' stingers and feed extension can be deployed automatically during anchoring and deanchoring, and the rod handling system allows the operator to use either Speedrods or TDS tubes. TDS tubes improve hole straightness and flushing speed, while minimizing the risk of the rods becoming stuck in the hole.

Operators need only to key in the required depth to initiate automatic collaring and drilling of a hole, including automatic addition of rods during the drilling sequence and removal when drilling reaches the pre-determined depth. To simplify drill bit changes in mid-hole, the system will automatically feed rods into the hole after the bit change and continue drilling to the required depth in one sequence.

Integrated and Remote Controlled

All Simba drill rigs can be equipped with a series of major automation options, such as Measure While Drilling, Drill Plan Handling, Drill Plan Adaptation, Mine Navigation, Full Drill Data Handling, Rig Remote Access, and Ore Manager.

The most efficient method of handling drill fans and planning production drilling is to integrate the Simba rigs with the planning system at the mine site. This means that there is no need for manual handling or design of fan plans in the mine. The fan plan is generated in the system and transferred to the Simba via the mine network or by means of a PC card.

Modern drilling is associated with very precise requirements, to get the best fragmentation and not to unnecessarily dilute the ore. To ensure efficiency in the mining process, the Simba production rig can be used to drill only in the ore and avoid drilling, charging and blasting areas with pure waste.

For operators, the learning time is short, and beginners and experienced drillers alike are capable of production drilling after a couple of days of training.

Long Hole drilling at LKAB

The Simba long hole drill rig is a central element of the mining fleet used by LKAB, one of the world's leading iron ore producers. Its mines at Kiruna and Malmberget in northern Sweden are models of modern mining methods, with high levels of automation in rail transport, loading and production drilling.

Since 2002, production at Kiruna has increased by more than 40 %, and the number of drill meters required has increased accordingly, recently surpassing 1 M m/y. The combined production of both mines is approaching 1.5 M m/y. The Simbas used at Malmberget are equipped with multi-teleremote functions, which allow remote operation in a variety of ways.

High-capacity drill rigs are a must, and the fleet of Simba rigs has been expanded to six production hole rigs at Malmberget and two in Kiruna to meet the current long hole drilling demand. Apart from production drilling, the Simbas are being successfully used for service hole drilling and slot drilling. Slices of the ore are drilled with Simba rigs equipped with fan automation. From a control room, operators control several rigs in the production areas via remote control. The production drilling machines can continue to operate unmanned during shift changes, lunch breaks and night shifts, adding valuable drill meters.

The rigs drill upwards into the ore at 80 degrees front inclination, forming fan-shaped patterns of holes. There are normally 8–10 holes in each fan that are drilled from 10–55 m in length. The drilling burden is usually 3 m, but in some parts of Malmberget there are burdens of 3.5 m.

Conclusion

Precision drilling, high productivity and swift availability are the criteria for low cost and successful long hole production drilling.

With RCS technology, Atlas Copco gives the driller the opportunity to undertake long hole drilling with faster and more reliable control of the entire operation. This improves drillstring life and reduces cost per drill meter.