A vertical shaft is an efficient way of accessing either a deep orebody or one situated below a ‘worked out’ open-pit mine. Alon Davidov, CEO of Shaft Sickers, says: “Hoisting rock up a vertical mine shaft is by far the most cost-effective method to get rock to the surface on a life-of-mine basis. It is more efficient than trucking rock to the surface via a decline and does not suffer from the substantial ventilation challenges that arise when using declines.”

Raise boring and shaft sinking are the main methods of shaft excavation, and each method has its pros and cons; there are a number of factors that dictate which is chosen. These factors include, but are not limited to, access availability at top and bottom, geology and rock mechanics, end use and the life span of the shaft.

RAISE BORING
Generally, raise boring is used to develop ventilation raises for fresh and return airways and for ore and waste pass excavations. Larry Zucchero, VP business development and international operations at Dumas, says: “There has also been an increasing trend towards raise boring for hoisting shafts – either excavated in a single pass to the desired diameter, or in conjunction with drill and blast as a two-pass system.”

Raise boring’s main advantages are the speed and the quality of tunnel development, and it is also a relatively safe method. In competent ground, the circular bored hole produced is fundamentally a more stable design than a square or rectangular opening with respect to underground rock stresses. Generally, the shape also delivers better ventilation characteristics for airflow than the irregular rock profile that can result from a blasted rock wall.

The latest trends in raise boring focus on bigger diameters, longer raises, high-capacity machines and directional drilling for pilot holes. In addition, with many new block-cave mines being developed, the need for boxhole raises is increasing – Redpath’s South American operations in Chile notes that Codelco is moving forward larger-diameter blindhole slots for larger cave production blasts (2m diameter and up to 70m in length).

New products and projects
Dumas has a joint-venture partnership for raise boring with Bergteamet, which has several active raise-boring projects for clients including Norsk Gronkrift in Kvemma, Norway, Leonhard Nilsen & Sanner in Rössåga, Norway, Boliden in Tara, Ireland, and Hindustan Zinc in India.

Herrenknecht’s boxhole boring machine (BBM) was recently developed for the excavation of vertical and inclined slot holes in underground mines. The prototype was tested in 2011, and now there are five BBMs successfully operating in Australia and Chile. The company’s raise-boring rigs have drilled both production and ventilation shafts in mines in Bolivia, Chile, Italy and the US.

Redpath has expanded its machine offerings to meet growing demand at block-cave mines. It now offers Redbore 30, 40 and 50 machines in boxhole form, which it states allows each client to select the optimal machine for their application. Sandvik recently launched new cutters (CMR 41/77, CMR 52/77, CMR 501) to improve overall performance, including the penetration rate and service life of raise borers. Sandvik reaming heads and cutters are used for ventilation raises, ore passes and slot raises in various different global raise-boring projects.

TRB Raise Borers’ new Rhino 100HM raise borer, which uses Sandvik tools, was recently launched in two different mines. It is a highly mobile slot-hole boring machine utilising raise-boring technology that is ideal for mines using block or sub-level caving methods. Using only one operator, mines can substantially improve stope development times; from 2-3 weeks (long-hole drills only) to 5-6 days using Rhino 100HM and long-hole drills working together.

Jarko Salo, managing director at TRB Raise Borers, notes: “It has been discovered that more than three long-hole drills are required to keep up with the Rhino – otherwise they become the bottleneck in the mine production.”

TRB Raise Borers has also launched a boxhole borer and some prototype downhole raise borers that use water for flushing and conveying the cut material out of the borehole.

SHAFT SINKING
Blind or conventional shaft sinking is the most common way to excavate a shaft, and it can be done as the initial mine access opening or before the primary mine infrastructure is in place. In addition, where ground freezing and grouting techniques are required, shaft sinking is the preferred method to advance through adverse conditions, especially if specialty shaft liners are required.

Davidov says: “The latest trends in shaft sinking have focused on ‘doing more with less’ while providing a safer environment with non-concurrent activities in the sinking shaft. As a result, developing and improving mechanised sinking methods remains a long-term priority for the industry.”

New products and projects
Dumas is currently active at Agnico Eagle’s Pinos Altos project in Mexico. The top portion of the shaft, which is nearing completion, is a pilot-and-slash 4.9m-diameter concrete-lined shaft on a previously directionally drilled raise borehole. The second leg will be completed as a conventional blind sink.
with the establishment of a twin-bin loadout arrangement for future permanent hoisting.

Zuccherato comments: “Agnico Eagle has been a long-term client of ours and this is fourth shaft that Dumas has been contracted to excavate. Additionally, we are mid-way through completing another shaft-slash project in Peru for Minera Aurifera Retamas (MARSA).”

In 2014, Dumas has already completed two other shaft projects in Canada. The first is a production shaft for North American Palladium at its Lac des Iles site near Thunder Bay, Ontario. It is a 6.1m-diameter concrete-lined shaft to a depth of approximately 825m. The second is a 6.7m-diameter production shaft that was sunk and commissioned for Hudbay Minerals at its Lavor project in Snow Lake, Manitoba. This shaft was part of a US$402 million mine-development project, and is designed to hoist at a rate of 6,000t/d. Wayne Mohns, VP operations, Canada at Dumas, says: “We see 2015 being an active year for shafts both in Canada and abroad.”

Herrenknecht developed the shaft-boring machine (SBM) with Rio Tinto to provide rapid construction of shafts with a high level of safety. It can create blind shafts with diameters of up to 12m in stable rock down to depths of 2,000m.

In July, the company launched its new shaft-boring machine for shaft enlargement (SBE). The SBE works like a modern hard-rock TBM, but vertically. Benjamin Künstle, deputy division manager, mining at Herrenknecht, states: “The shaft-sinking time is reduced by 20% to 30% compared with conventional shaft-sinking technology.”

Other advantages of the SBE include high precision in terms of verticality and the circular shape of the shaft cross-section, as well as virtually vibration-free ground treatment. The sinking cycle runs continuously and is not interrupted by drill-and-blast times or dispersal of explosion gases.

Shaft diameters of up to 9.5m can be bored in hard rock for a wide range of applications. Künstle says: “The shaft depth is only limited by the technically feasible length of the pilot borehole.”

Redpath has completed two shafts on the Oyu Tolgoi project in Mongolia’s Gobi

Shaft Sickers is currently engaged in sinking or equipping eight shafts around the world
UndeRgRoUnd development

Desert (one of which is the deepest shaft in Mongolia), and is sinking another two (one of 7m diameter and another 10m diameter and 1,200m deep) for the planned 85,000t/d operation.

In Indonesia, Redpath has completed the Big Gossan production shaft (the country’s first shaft-hoisting facility), at the remote Freeport Grasberg operation in West Papua.

In Canada, Redpath has completed shafts at Hudbay’s Lalor mine (Manitoba), at Goldcorp’s Cochenour mine (Ontario) and at Goldcorp’s Éléonore mine (Quebec). Sinking projects are taking place in Quebec and Saskatchewan.

The projects in Saskatchewan, led by Redpath’s joint-venture company, include sinking three complex ground-freeze potash shafts at 1,000m depth. These potash projects are employing Redpath’s newest technologies for shaft mucking, and hoist controls and safety systems.

Shaft Sinkers is engaged in sinking or equipping eight shafts around the world for major mining companies such as Randgold Resources, Vedanta, Lonmin, Impala Platinum, Royal Bafokeng Resources and Kazchrome. Davidov adds: “We are also involved in tenders for many shaft-sinking projects which are currently at various stages of development.”

Inclined drifts created using tunnel-boring machines (TBMs) can be used to replace vertical shafts to improve the accessibility of an underground mine. Martin Rauer, general manager of Robbins Asia Pacific, says: “In such a case, transport for men and material would not be restricted to a fixed number of shaft winches and hoists, which improves safety and logistical aspects.”

Drifts into mines can be excavated at a very high advance rate compared with drill and blast, and the underground mine infrastructure can be developed a lot quicker when using TBMs, often accessing the ore or raw materials two to three times faster when compared with conventional mine-access methods.

NEW PRODUCTS AND PROJECTS

Herrenknecht has recently developed TBM solutions for the coal-mining industry, and the company sees potential growth in North America, Eastern Europe and Australia.

Redpath is undertaking a novel hybrid TBM project in Queensland, Australia, the first of its kind in Australian coal fields. The tunnel boring machine will mechanically excavate both the conveyor drift and the transport drift.

Redpath’s South Africa team was involved in a first-of-its-kind sand tunnel worth US$6.1 million at Gem Diamonds’ Ghaghoo diamond mine in Botswana. Here, the company’s scope of involvement in the project included the development of a concrete-lined decline tunnel to 112m below the surface at an inclination of 8°, using a 50t open-faced tunnel shield (OFTS), which is 6m in diameter.

Robbins has recently designed and built a TBM for a mixed-ground coal-mine drift. Rauer notes: “This hybrid hard-rock single-shield/earth pressure balance (EPB) TBM has successfully finished its first drift and will be launched very shortly to start the excavation of a second drift.”

Another recent development was a machine for a gold and copper mine starting with a steep slope instead of using a shaft. This machine will be driven around an orebody spiralling down all the way to the bottom using a Robbins improved logistical concept. Concurrently with the excavation, different mining levels can be developed to start accessing the ore as fast as possible. The machine is planned to start operation soon.

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