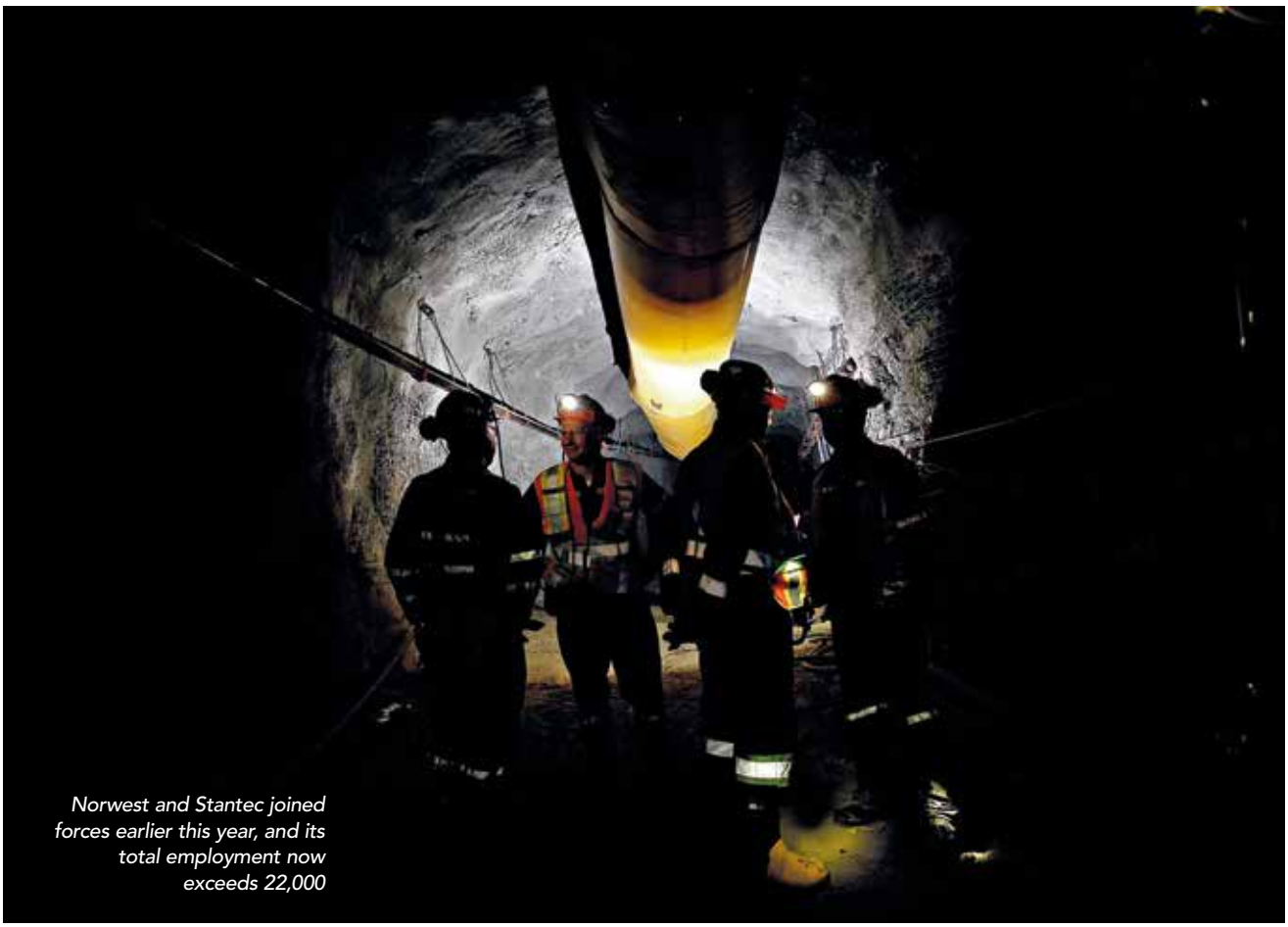

Norwest and Stantec joined forces earlier this year, and its total employment now exceeds 22,000

Rethinking the future of underground mining

Donna Schmidt finds out how some top underground engineers are tackling changing conditions, orebodies with more challenging obstacles, and the technological opportunities that lie ahead

"Today's mining operations do not have the benefit of ease in gaining access to ore deposits"

It was not long ago that it took far fewer decisions to run an underground mining operation than it does today. The overall positive turns in the markets for many commodities has necessitated those decisions as mines make plans for their futures, be it a modernisation of plans, a rehabilitation or an entire expansion.

In some cases, these projects can add several years to a mine's lifespan and, in others, operators have opted to begin work on a brand-new project because the financial aspects of doing so simply now makes sense.

Two cases in point: first, the announcement in September 2017 by Dominion Diamond that a planned expansion of the Ekati mine near Yellowknife, Northern Territories, Canada could keep it in business until 2042. Another is Turquoise Hill's sizeable Oyu Tolgoi copper-gold complex in Mongolia, which after years of planning is coming to fruition and has big plans ahead – so big, in fact, that it has dedicated a web presence to keep stakeholders updated of progress.

In the case of the latter, about 80% of the mine's value is located underground, and the workforce at peak construction that will be needed to help extract that value is more than 3,000.

Significant plans, however, also require significant planning and, in many cases, significant costs. This is especially true considering that today's mining operations do not have many of the benefits their predecessors did in terms of ease in gaining access to ore deposits. Additionally, a shift in overall geology has left engineers with taller expectations than ever before, all while the potential is increased for lower grades and quality.

Three large engineering firms with active underground portfolios recently ►

shared with *Mining Magazine* the differences in projects below the surface versus above it, how these changing elements and factors are impacting the industry and what opportunities the industry has ahead of it.

EXPLORING CHANGE WITH SRK

SRK Consulting Australasia's principal mining consultant Anne-Marie Ebbels points out that, when it comes to rolling out an underground engineering project, there are different considerations to be made at different times compared to that of a surface project.

Specifically, she says, the footprint of the mine's underground infrastructure needs to be excavated, which in itself increases the financial requirements but can also limit the size of that infrastructure in some cases, if placed underground.

Those taking on underground engineering projects also have more decisions to make early in the process versus a surface project, such as determining what is economically mineable. In order to make sound decisions there must be accurate, useful geological information and details available.

Those taking on underground engineering projects have more decisions to make early in the process compared to surface projects, according to SRK

As for the impact that deeper and lower-grade target ores are having, Ebbels says it ultimately results in cost pressures for the project's development. Because of that, alternatives are often needed, such as alternative means of material handling other than a traditional system. SRK says companies are also examining the need, or not, for waste to be transported to the surface, along with the use of ore sorting to minimise the dilution being transported to surface, and hydraulic hoisting technologies.

"Ventilation requirements increase as mines get deeper from both higher quantities and cooling requirements, so alternatives are being considered in the type of equipment required and how it can be modified, and options to reduce the ventilation requirements are being considered," she points out.

In this case, alternatives will need to focus on reducing equipment heat and emissions, or the potential for removing personnel from the environment and replacing them with electric trucks and other autonomous and remotely operated equipment.

Ebbels says that as underground mining depths increase, it will also provide opportunities to rethink the look of an underground mine. For example, is there a way to install backfill plants below the ground to integrate with waste that is not being hauled or hoisted to the surface?

Additionally, Ebbels advises evaluating if it is possible to move processing functions below ground and, if possible, how much should be taken below ground for it to make more sense to the mine's bottom line.

With each answer received, though, there always seem to be more new questions when it comes to the most significant issues of underground engineering. Ebbels poses one of her own: "While large orebodies are already becoming automated successfully, how can we adapt automation and robotic technologies to mine deeper and narrow vein mines?"

WORKING THE WOOD WAY

Like the other companies interviewed for this article, global consultant Wood says that the main divider and variation between surface and underground engineering projects is the project development duration. When developing underground projects, it is not uncommon for the pre-production development time to be extended for a logistical purpose – in order to access the deposit beneath the ground, there needs to be access to it, usually via shaft access or using a ramp.

The ripple effect of that, however, is a longer project payback period, which in turn impacts both the net present value (NPV) and the internal rate of return (IRR).

What has helped reduce the scope of the challenges of an underground engineering project is the ability to gain information on a deposit before the access phase ever begins using technology such as 3-D seismic programs.

"Using 3-D seismic programs [helps] to obtain detailed subsurface structural information for bedded deposits like coal and potash, and understanding the locations of geological disturbances provides information at the design stage to permit changes in the design to avoid these areas," Wood technical director of underground mining Bill Bagnell notes. "The use of technology to place equipment operators in safer or even remote locations has improved overall safety and increases productivity."

According to the firm, just one top issue as mines continue to get deeper and target ores are diminishing in grade is no surprise: economics. If the deposit is deeper and has a lower overall grade, gaining access to it becomes capital-intensive because of deeper shafts and longer declines or access ramps. The

supporting infrastructure is affected due to the increased depth, and ventilation and the dewatering process have increased power consumption for that same reason.

"Engineering for these projects has to consider the impacts of changing stress conditions over the life of the project and the life of the mine that occurs at depth," Bagnell notes. "Furthermore, engineering has to consider these impacts earlier in the design phase to minimise the impacts to the project schedule and the project costs."

He adds, however, that there are tremendous opportunities still ahead for all involved in these crucial underground projects. One major step in the process is the implementation of semi-autonomous and autonomous equipment, which he says is just beginning to roll out across the world. The potential is certainly there for not only increased productivity, but also reductions in operating costs, as well as safer working environments, in these deeper operations.

"The use of technology to place equipment operators in safer or even remote locations has improved overall safety and increases productivity," Bagnell concludes.

STANTEC'S SHIFTING FOCUS

The newly joined forces of Norwest and Stantec – the latter acquired the former earlier this year and now boasts a combined workforce of about 800 in the mining business line and 22,000 globally – are seeing underground engineering projects taking on a larger and more complex nature.

"The studies that we at Stantec are completing implement a significant focus in two areas to the development programme: 1) safety by design, and 2) integration of the full mine site," regional business leader for mining Greg Gillian notes.

"On the topic of safety, mining has evolved to a more mature industry, with tolerances or motivations approaching those of the industrial and manufacturing industries. We have seen not just the recognition that safety is inherent to a cost-efficient and productive mine, but also its transformation to a leading indicator at the mine site. Ensuring that labour and staff are safe and accounted for at all times has helped to reduce those incidents."

Gillian says that Stantec has found placing a focus and consideration on safety at the onset of a project, as well as in its design phase, serves to ensure ideas are captured and considered. This, in turn, leads to a reduction in initial capital costs and a subsequent capacity to realise future efficiencies via risk mitigation and labour productivity.

Stantec is seeing that not only are teams entering more remote locations, but are also going deeper underground. A decision to progress with these kinds of projects, Gillian points out, involves several factors.

"Rock mechanics and geotechnical work often dictates the level of effort we can put in to the development of the mine at these depths, but also involves

According to Wood's Bagnell, the challenge that comes with underground engineering projects is that the locations of new mines are becoming more remote and staffing those mines is becoming more difficult

Stantec has found placing a focus and consideration on safety at the onset of a project as well as in its design phase serves to ensure ideas are captured and considered

the ventilation and transport or access means," he says. "Naturally with more challenging underground environments, including the depth as well as grade, are an evolution of the mine. Often, the typical run of mine or head grade of an orebody is lower now than in the past."

That scenario is found in brownfield mine cases as well as greenfield. No matter the type, the full mining system must be considered, from mining method and underground geotechnical, to the transport method, to the surface handling and mill, and form an optimisation process.

"This can include designing head frames and shafts with the foresight for the full mine buildout, but also to recognise that the project location may require alternative design and manufacturing techniques," Gillian states. He notes that the firm recently led a project for one of the tallest headframes as well as the operator's use of an alternative manufacturing and construction process. Pairing those elements reduced time onsite as well as work at heights.

The ultimate impact was a cost reduction for the overall construction project.

As for the future, Gillian says one challenge will be identifying ways to ensure the industry is effectively utilising the right resources. While Stantec is looking at various ideas of elements to consider, one of the most significant is bringing in the right team with the right tools for the project.

"As the industry continues to evolve, we are implementing handheld technology to gather field data on mobile tools, developing ways to share the data at the mining face, and working with new partners to bring experience from other industries to the mining and mineral processing fields," he points out.

Taking the work underground

The first three quarters of this year has been notably active in the area of underground engineering for a stretch of projects across the globe, and in some cases the details have been unique. For example, in late August, Codelco inked a contract with Rockwell Automation to help it transform from one of the world's largest open-pit mines to one of the globe's newest underground supercave operations.

The project, which could add a staggering four decades to the Chuquicamata copper mine's life and include block caving extraction, will without a doubt help the mine's owners to realise higher production yields and lower costs at the same time.

Rockwell's contract work will include four systems, from engineering to assembly, that will make up the Chilean mine's control system and provide it with its ultimate goal of higher throughput and lower operating costs with the ability to gain additional value at every step.

The project in the Antofagasta region of Chile is expected to see start-up by the middle of next year and produce 320,000t/y of fine copper and 15,000t/y of molybdenum.

While the mine is not the first to take on the growing trend of taking a historically open-pit operation beneath the surface – many tackling such work cite the production, costs and sustainability as top contributors to the decision – it is arguably one of the oldest. Chuquicamata was first launched in May 1915 and will officially be a safe, modern and sustainable underground operation by the end of the decade.

Another project that exemplifies the laudable goals of the changing industry is a March deal between consultant Pöyry and the Agnico Eagle Kittilä gold mine in Finland. The firm has signed on to manage engineering, procurement and construction management (EPCM) for the expansion that will occur between this year and 2021 at Europe's largest gold operation.

Financial terms of the deal between the pair was not released, though it is known that Kittilä is planning the construction of a 1,044m-deep shaft along with a simultaneous capacity increase at the mine's processing plant from 1.6Mt/y to 2Mt/y. The end goal is an increase in yearly gold production from 50,000oz/y to 70,000oz/y.

"The shaft will make it possible to utilise the deeper parts of the gold deposit in an economically sensible way, and it will improve our energy efficiency, as well as decrease our emissions," Agnico Eagle Finland managing director Jani Lösönen said earlier this year.

"The efficiency advantage of the shaft combined with the raised production rate will improve the [mine's] competitiveness."