

The El Teniente conundrum

Chile's El Teniente mine is one of the world's largest underground mines, however due to its location - 2,500 m above sea level - and the fact that it is at the core of a volcanic mountain, the expansion that owner Codelco is pursuing needs careful planning. *IM* looks at the strategy that one of its contractors, SKM, designed for obtaining the extra 2,000 Mt reserve situated below the current mine

The El Teniente mine is located 80 km south of Santiago. Being active as a mine since 1904, it has 2,400 km of underground drifts. The mine produces "404,738 t/y of fine copper as fire refined lingots and copper cathodes", according to the owner Codelco. It has previously been developed on multiple levels, situated around an intrusive volcanic, non-mineralised formation, called the Braden pipe, where the infrastructure for each level is located. A substantial reserve has been verified through a prefeasibility study by the company's contractor SKM, with a feasibility study commencing soon. SKM's challenge is making the most of this reserve whilst also being able to continue mining at the already established level. It says that "project efforts have concentrated on maximising the use of new technologies for both construction and operations, along with the selection of the best mine infrastructure, to keep El Teniente operational for the next 50 years."

The new mine level project (NMLP) plans to start



The El Teniente mine is located 2,500 m above sea level, a fact that has, historically, affected the roads coming into and out of the mine

extracting the 2,000 Mt reserve in 2017 using panel caving and the progressive sinking method, with an end date planned for 2070. There is a ramp-up

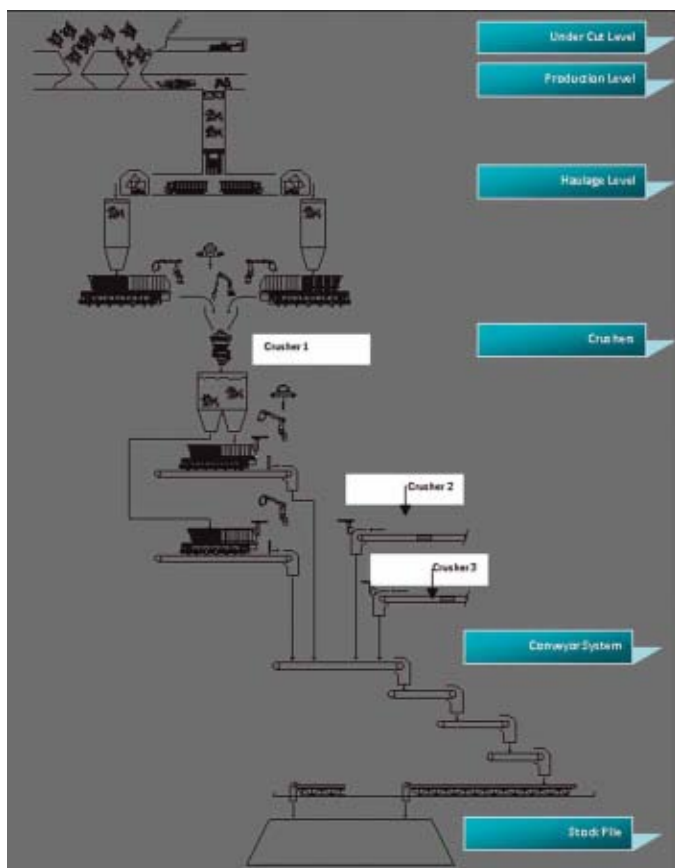
period of 13 years to reach maximum throughput of 180,000 t/d, which will then be maintained for 18 years. SKM sees the NMLP as "totally transform[ing] the way the mine has previously operated, which is in effect a 'greenfields' project, with respect to the implementation of fundamental changes in the labour and business environment."

Codelco views the NMLP as "environmentally, economically and socially sustainable – set in the future and utilising new technologies within the context of ore production." By using certain new technologies and operations SKM aims to improve:

- Safety
- Working conditions and access for workers
- Risk management e.g. from rock falls
- Productivity
- Energy efficiency e.g ventilation on demand
- Materials handling
- Maintenance.

The existing underground operation includes six mining sectors located at different elevations around the Braden pipe. Access to the mine is through a 3.5 km tunnel with ore being hauled to the surface through a railroad system. On the surface it is dumped into crushing plants and from there conveyed to a concentrator where copper concentrate is produced to then be sent on to a smelter. A previous expansion at El Teniente in the 1960s identified the level eight railroad as the main material handling system, which has subsequently constrained development.

Expansion has also been restricted by the location of the reserve. The deepening of the mine and the increase of litho static pressure with a subsequent



A diagram of the NMLP production process at the mine featuring three crushing stages and the conveyor belt system, which gives the operation the future potential to expand throughput to some 240,000 t/d

increase in rock mass stresses may create hazards that include collapses, rock falls, seismicity and rock bursts, water and mud floods, fire and machine injury. This had to be considered when SKM drew up its proposal and it saw an implementation of technology throughout the life span of the project as the way to solve these problems.

Innovative design

One way that the expansion will counter these forces is by having a centralisation of services. With a single, undercut level - as opposed to mining smaller sectors arranged on different levels (the current strategy) - services and logistics can all be centralised in the Braden pipe. Services including the management, underground maintenance workshops, refuelling, worker's changing rooms, dining facilities and explosives storage will all be centralised. This will result in time savings, more effective maintenance, simplification of access and a reduction in personnel.

The mine's current drainage system is also a focus of the SKM study for the new level expansion. At the moment the drainage of water from snow thawing and mine operations is facilitated via various systems, raisers, shafts and pumps. The NMLP is instead considering introducing an additional drainage level to collect water, separate solid particles and pipe it along the main conveyor belt to the surface, resulting in greater efficiencies.

Access to the mine has been a problem for many years due to its height above sea level. SKM, with the NMLP, has proposed a new access road to the mine which will halve travel times for both personnel and materials delivery. As the new road will be at a lower elevation the previous problems of snow fall will be diminished, allowing for a more reliable transport route.

The expansion will be independent of current mining operation at El Teniente. As the new mine will be below the existing transport level and the ore will be handled via conveyor, the existing mine can work as normal whilst the NMLP is being constructed. This will enhance productivity levels and ensure that Codelco gets the most from its operation whilst also building upon a substantial new reserve.

The conveyor belt system is one technology that is incorporated within the new design; moving ore to a stockpile located near the concentrator. This addition will be a significant improvement upon the existing rail haulage, with higher availability, a reduction in operation cost and improved flexibility, giving the operation the future potential of expanding throughput to some 240,000 t/d.

Automation and remote control is being integrated into many mines nowadays and the NMLP will also benefit from this system. This also represents one of the ways that SKM is tackling the problems related with the litho static pressure. The use of automation with remote control will significantly reduce the workforce exposure inside the mine, allowing the monitoring of real-time rock mass

behaviour. The remote operation will be conducted from a new building 50 km from the mine site.

Ventilation throughout the mine is also being redesigned by SKM, with a somewhat novel approach. A system monitors and quantifies the amount of air required through tags carried by each operator in the mine. This will allow an efficient use of energy as well as monitoring personnel within the mine. SKM has also advised of installing new management information systems, including online and real-time information, GPS and radio frequency identification, which will be included in the feasibility study. It hopes that this will ensure optimal maintainability of equipment and facilities.

Drilling and blasting has previously been used at the current operation, however the NMLP will use

tunnel boring machines to simultaneously excavate and support the access and main belt conveyor tunnels. This tactic, according to SKM, "eliminates the risk of explosives handling and results in a reduction in ventilation requirements due to the non-use of blasting gases."

SKM has built upon what Codelco has already established at El Teniente and many companies could use such design in their own operations. The use of new technologies has ensured that Codelco makes the most of El Teniente and a reserve of 2,000 Mt that when copper prices recover will ensure the company stays near the top of red metal producers. This approach has focused on a key awareness of current and emerging technologies within the industry and recognises what can be done with such expertise. *IM*

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