SRK News
Focus on Caving

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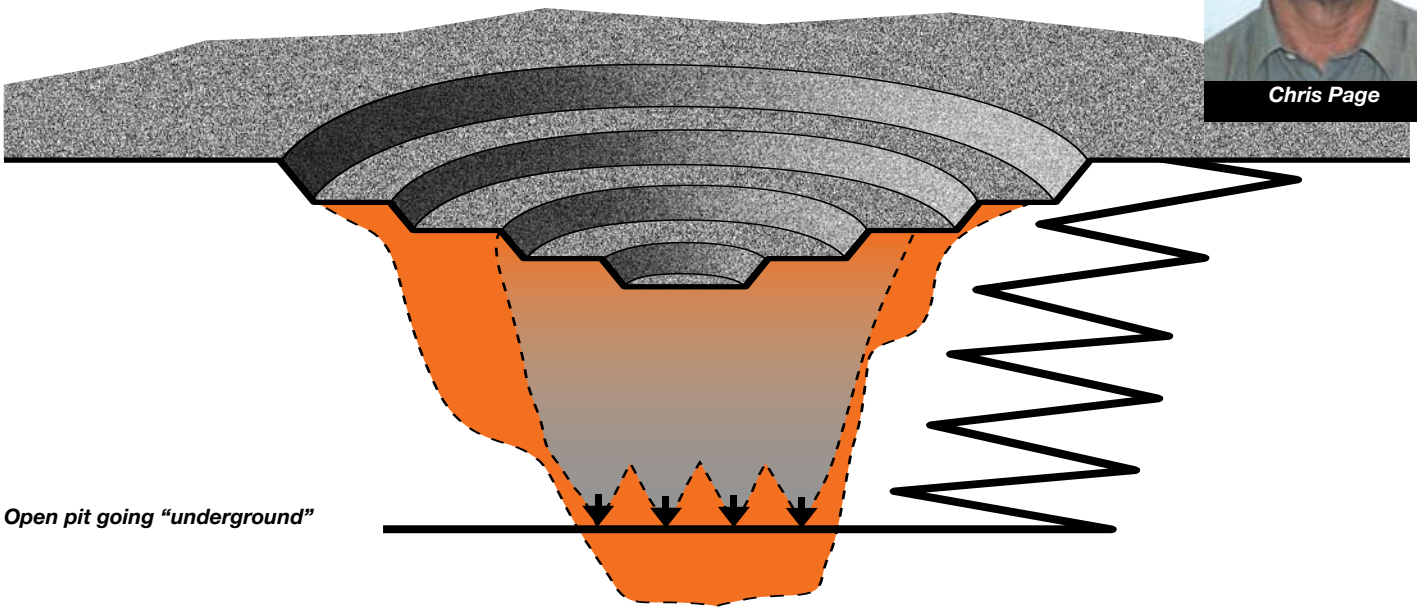
International
Newsletter

Open Pits Going Underground

Some of the world's major mining companies, currently comfortably mining from large efficient open pits, are looking into the future when these pits come to an end. To maintain a competitive position on the cost curve, these organisations will have to take open pit efficiencies underground. Only caving methods can challenge open pit efficiencies.

Chris Page



Open pit going "underground"

But many of these pits are in, or will be going into, very good ground. This creates major challenges for the operators: should they opt for a pre-break, like sublevel caving, at considerable additional cost? Or go for natural caving, and fight the resultant coarse fragmentation?

The jury is still out, and probably will remain so at least until the results from the envelope-pushing Palabora caving operation are known.

"This South African mine epitomises the major challenges for caving," remarks SRK's Chris Page. "Firstly, achieving a cave and, secondly, efficiently handling the coarse fragmentation."

"The International Caving Group has considered many of the challenges and also some of the solutions. However, none of the answers are going to be easy. A whole range of issues, from pre-conditioning to cave stimulation, present some very challenging situations.

"However, the cost efficiencies achieved at Northparkes mine, and the success that recent sublevel caves have achieved in Australia do give some reason to be confident."

A critical issue, Chris points out, will be achievement of the levels of control taken for granted in an open pit. "Tele-remote technology and specialised communications systems will make this possible," he observes. "The industry is almost there. It just needs some brave souls to embrace the concepts.

"But," he cautions, "cave mining in the future is going to require a totally different way of operating, both technically and managerially, if it is to compete with open pit efficiencies."

SRK Consultant Profile: Geoff Bull

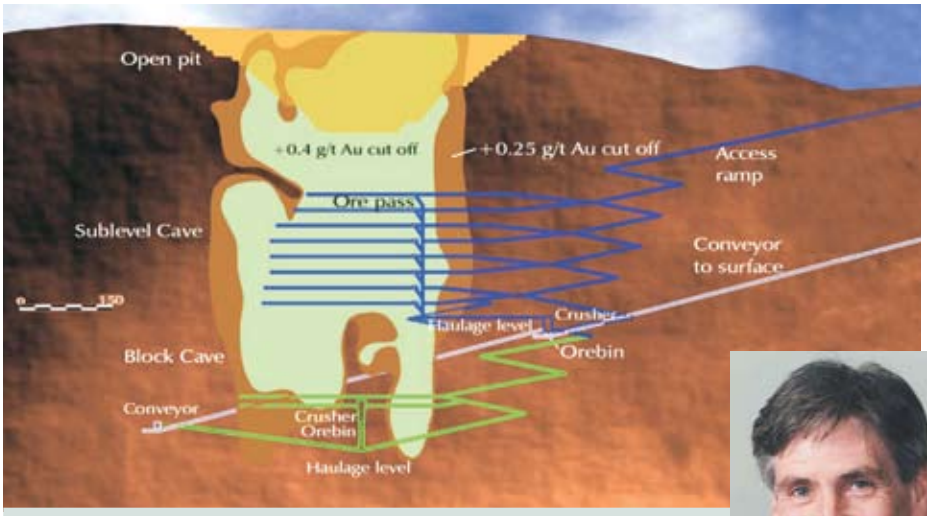
Geoff Bull's mining career started in the 'caves' at Shabanie Mine in 1968. Since then he has accrued experience in production, technical planning, project management and rock mechanics in underground mining. In numerous operations, in Zimbabwe and South Africa, he worked up through the ranks from learner mine official to General Manager. He served as rock mechanics engineer for Roodepoort Durban Deep Gold Mine in South Africa and Shabanie Mine in Zimbabwe, and for five years prior to moving to Australia, Geoff was director of his own company in Zimbabwe providing mining, rock engineering and blasting consultancy services.

Geoff Bull

Geoff joined the SRK team in Perth, Australia in 1998 as a Principal Mining Engineer. He provides specialized consulting services in block caving and sub-level caving methods. More recently he has been involved in block cave and sub level cave studies for Newcrest's Ridgeway and Telfer Projects, operational and study reviews for Northparkes block cave, a block cave assessment for Olympic Dam, due diligence review of the Didipio block cave (Philippines), and operational reviews and improvement programmes for the sub level caves at WMC's Leinster Nickel Operations and Copper Mines of Tasmaina's Mt Lyle mine.

Geoff is also currently serving as a consultant to the International Caving Study Stage 2, specifically involved in aspects relating to flow characteristics of broken rock and draw control. "SRK's aim is to participate in initiatives directed towards improving the effectiveness and efficiencies of caving methods" says Geoff, "and in encouraging those who desire to 'push the limits' in caving the lower grade, stronger, deeper and more challenging ore bodies."

MRMR modelling for Skouries gold/copper project



Section through proposed skouries open pit and cave mine

Allan McCracken

Block caving combined with open pit mining and sub-level caving will be employed at the proposed Skouries gold/copper mine in Halkadiki, north-east Greece, owned by SRK client TVX.

TVX commissioned SRK to integrate geotechnical data gathering with the exploration drilling programme at the pre-feasibility stage. This ensured the project had an excellent coverage of geotechnical information and that a full geotechnical model – as comprehensive as the geological and resource model – could be produced. At the pre-feasibility stage, the mining rock mass rating (MRMR) model was critical in selecting the optimum mining methods.

Skouries is a classic pipe shaped porphyry. Mining is proposed by open pit down to 200 m then by sub-level and by block caving at depths to around 1000 m. Two main rock types are present: a relatively weak sheared argillaceous schist and a very strong quartz porphyry. The open pit and the cave mining will intersect both of these lithologies and will therefore encounter significantly different mining conditions.

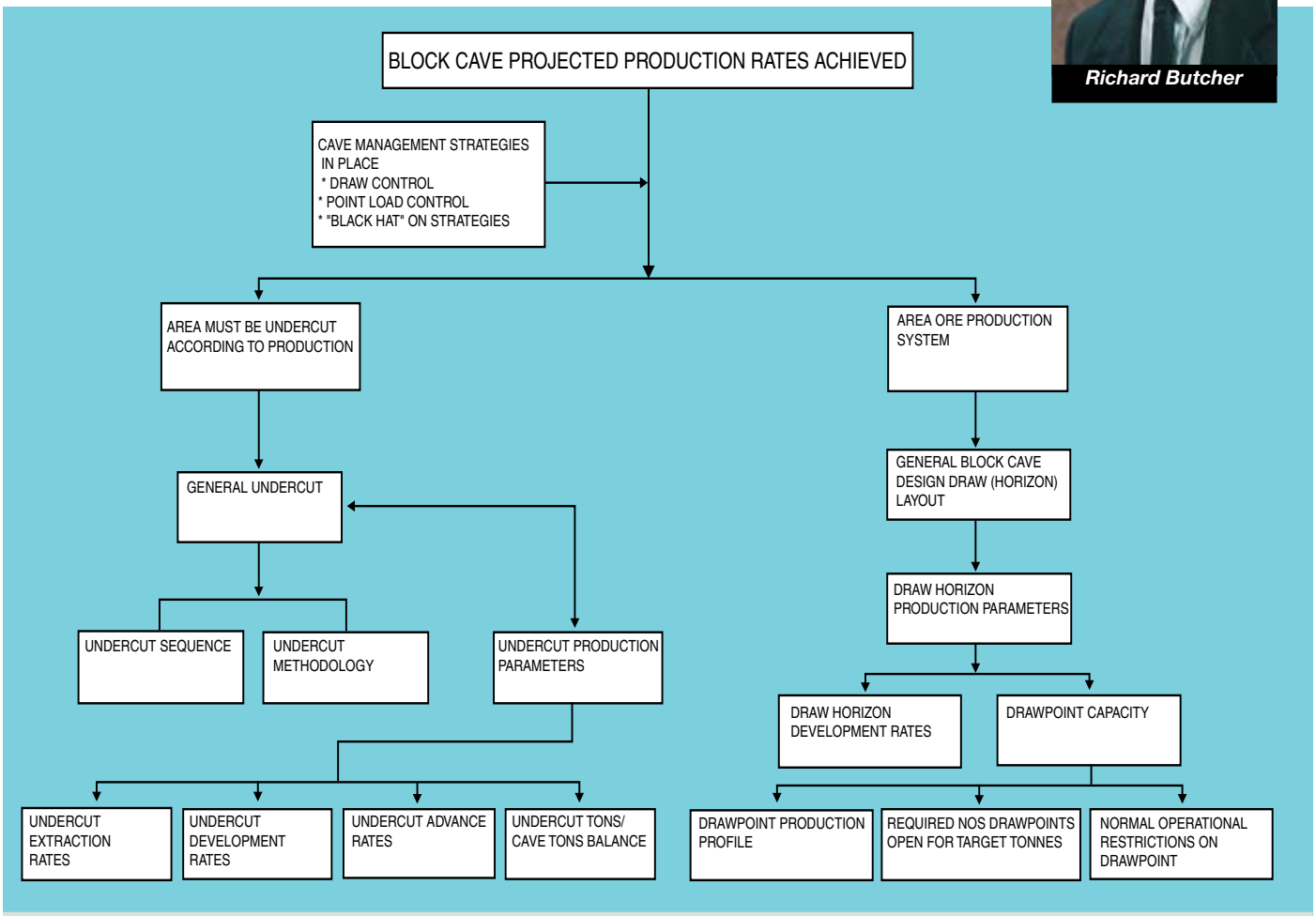
"Collection of sufficient geotechnical data at the exploration stage of a project can be vital to its optimum design, "says SRK Cardiff managing director and principal geotechnical engineer, Allan McCracken. "The fact that SRK and TVX integrated the assay and geotechnical data collection at the pre-feasibility stage meant the programme was cost effective. Drilling solely for geotechnical purposes was avoided and an excellent database was obtained. This proved to be very important in the subsequent modelling and design studies."

The data was evaluated using the MRMR system, with adjustment factors to model the different mining conditions in the open pit and cave. A 3D block model of the geology and MRMR was created by weighting techniques in the GEMCOM PC-MINE software. The circular nature of the pipe required that 'hoop stress' factors were used which have the potential to raise the MRMR and hence require greater undercut areas to induce caving.

The Skouries project is scheduled to follow TVX's other nearby Olympias gold mine project into production.

Technical auditing of block caving projects

Richard Butcher



Flow diagram to show factors that affect the annual production rate from block caves

SRK recently undertook a technical audit of a major block caving project, partly aimed at verifying that the proposed block cave production tonnages are achievable.

SRK's Richard Butcher recalls the audit was complicated by the fact that the client required confirmation inside a month that cave production tonnages were achievable.

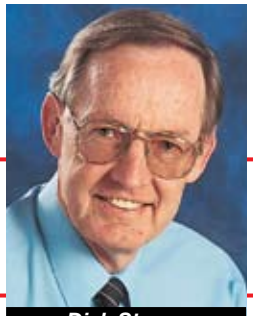
"In terms of production rate," says Richard, "auditing experience has shown that a number of factors can adversely affect the ability of a block cave to achieve target production tonnages. Factors include incorrect selection of block caving strategies and lack of design detail for both the undercut and draw horizons.

"Other issues include the selection and use of unrealistic parameters in project production schedules (for instance, designing production tonnages for a hard rock block cave based on mature draw rates immediately after undercutting), and lack of cave management strategies related to draw control, undercut lag control and so on."

Taking cognisance of these factors, SRK devised the audit method shown above, whereby the general design rationale was scrutinised for strategy correctness and design detail. In addition, production parameters were inspected for correctness.

"The guiding principle behind the audit was that if the caving strategies, designs and design inputs were correct/ realistic, then production tonnages were achievable," Richard notes.

Support for deep block cave layouts under rockbursting conditions



Dick Stacey

While deep block cave mining operations present tough challenges in a number of areas, provision of adequate support – in theory at least – represents less of a problem than might be imagined.

"This," explains Dick Stacey, SRK Consultant, "is because the results of large-energy dynamic testing of support have shown that available support elements and systems can withstand the large static and dynamic deformations encountered without failing.

"The tests have also shown that incorporation of special yield capabilities in mesh and lacing elements allows large deformations and massive amounts of energy to be absorbed without failure of the support," Dick continues. "Further, addition of wire rope lacing greatly increases the energy absorbing capability of all support types."

The recommended support for deep block cave production layouts in hard rock environments is a system of retainment elements (rockbolts, cables etc). These should have a significant yielding capability, of the order of 200 mm as a minimum, to enhance their performance and life under both axial and shear deformations.

"Diamond mesh, with shotcrete, which has the proven toughness and yield capacity, is the recommended containment support," Dick remarks, adding that at present the performance of fibre reinforced shotcrete under large, on-going deformations has not been sufficiently proven.

"Wire rope lacing is recommended in addition to the mesh and shotcrete. The wire rope should be lightly tensioned, to take up the slack but not to stress the rope. As an alternative to wire rope lacing, tendon straps, which work well in large static deformation situations, are expected to be very effective. As general principles, all elements must be matched in terms of capacity, while connecting elements must be compatible."

Chris Page

Australia's Ridgeway takes shape with SRK's help

After assisting Newcrest with the design and evaluation of the sub-level caving method (SLC) for the Ridgeway project, and providing ongoing senior review, SRK is privileged to be part of Newcrest's realization of their vision of 'an underground ore factory'.

"A very large footprint, steep geometry, good ground conditions and waste that carries good grades characterise Ridgeway as one of the first of the new breed of SLC mines in Australia that has what might be considered almost an ideal mining context," comments SRK's Chris Page. "Newcrest is focused on technical and managerial excellence," Chris reports, "as they have recognized that there are some very important areas that have to be done well."

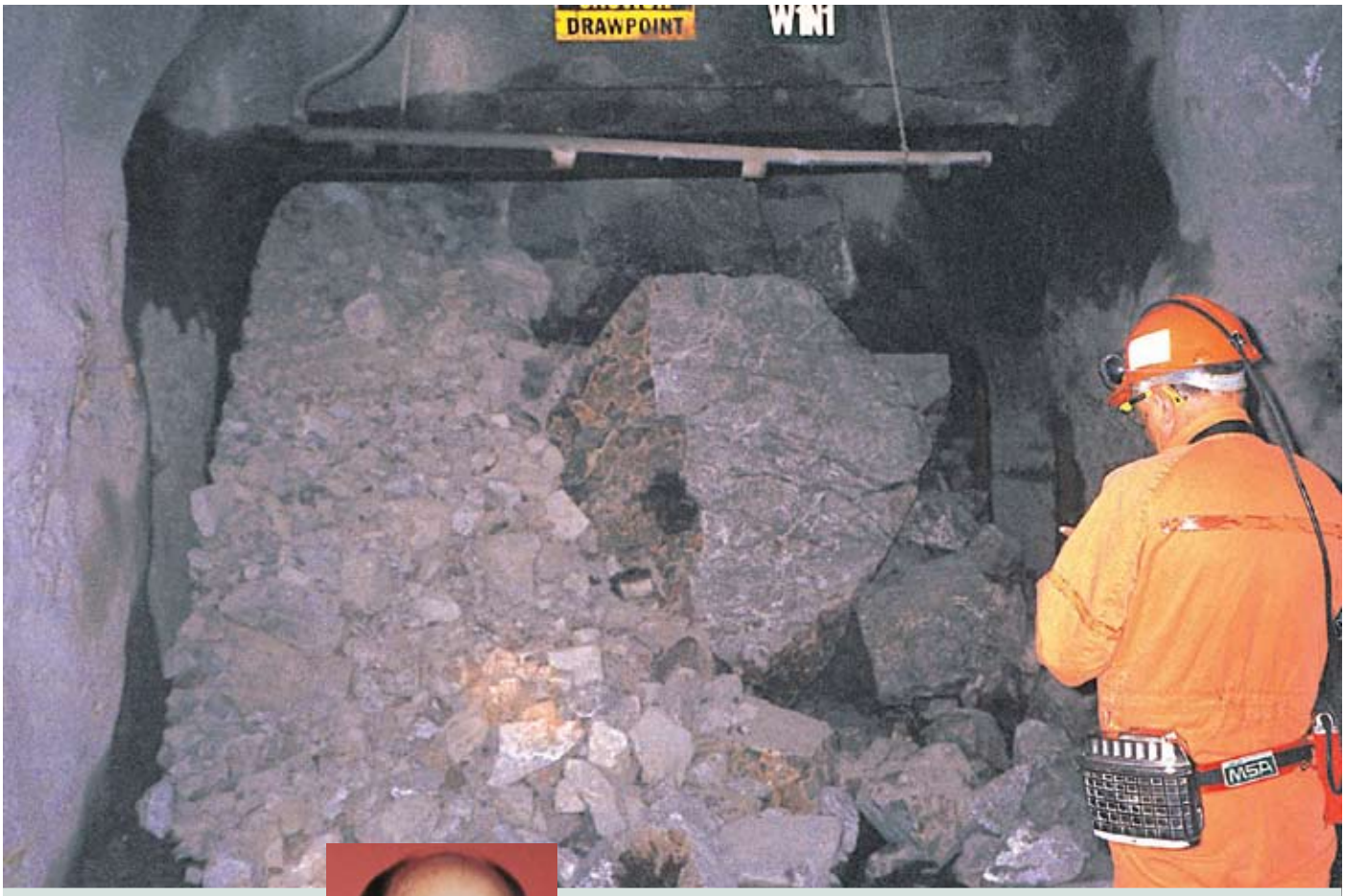
Ridgeway are aware of how little is actually known about draw behaviour in SLC, as it has been a method that generally went out of favour in the 70s and 80s and has been, until recently, confined largely to the massive Swedish underground iron ore operations. These, in several important respects, are very different from a gold mine in Australia.

So, while Ridgeway has been able to draw on many of the successes of these operations, they are still left with areas where they must build their own knowledge base: draw modeling and monitoring and cave management.

"After a positive feasibility study in late 1999, Ridgeway is now at the point of completing the first level (forming the undercut for a cave)," Chris concludes. "Ridgeway are on track to show the mining world that, if the context is suitable, then SLC is a method that can really deliver in terms of cost to finished metal. If anyone can, Ridgeway should be able to unlock the true potential of the SLC method and become a showcase operation."

Example of excellent fragmentation at Ridgeway Mine (note: Tyre to be used as a marker for seeding the cave)

Predicting caving fragmentation with BCF software



A large rock fragment in a drawpoint at the Northparkes mine, Australia

Essie Esterhuizen

Block Cave Fragmentation (BCF) is an SRK-codeveloped software tool in which rock engineering principles and empirical experience are combined to predict caving fragmentation.

The BCF program enables block cave operators to assess the very complex process of caving fragmentation and plan accordingly. The existence of the BCF program is largely the result of Dr Dennis Laubscher's contribution in initiating its development and his unique understanding of the caving process.

Recently, BCF was used to predict fragmentation and hang-ups in draw bells for the Northparkes Lift 2 block cave in Australia.

Dr Essie Esterhuizen of SRK's Denver office, who helped build BCF, assisted with a review of the fragmentation prediction that had been carried out by the Northparkes Technical Services Unit. The review was carried out by first comparing BCF predictions of fragmentation to actual fragmentation measured in the first lift.

"The comparison showed that BCF overestimated the percentage of oversize blocks," Essie recounts. "For example, BCF predicted 5-6% of the ore would be oversize in 1999, while actual oversize was about 2%."

An assessment of the uncertainty associated with the input data and the BCF modelling technique showed that the predictions would most likely be affected by the interpretation of discontinuity frequencies in the rock mass, rock block strength estimates and the field stresses. BCF results have been used for layout planning and equipment selection for the second lift where, according to BCF models, fragmentation will be slightly coarser.

SRK Consultant Profile: Jarek Jakubec

Jarek Jakubec

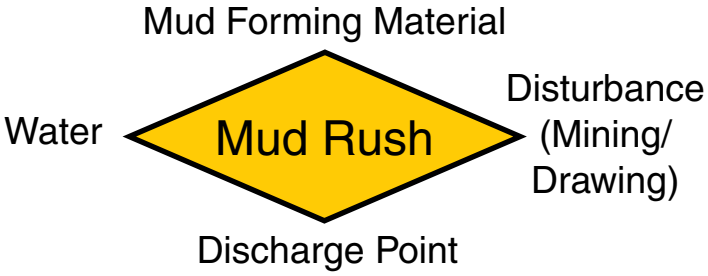
Jarek Jakubec joined SRK's Vancouver office in 1997 after 14 years in the mining industry. He brings a very focused and effective view of rock mass characterization that enables clients to choose mining methods, procedures and systems that are based on their appropriateness to the "real" context. He has found too often that mining problems have been due to a lack of understanding of the conflict between the "natural" in situ resistance and the "man-made" disturbance. He has concentrated on the practical and economic "management" of this conflict.

Jarek includes in his wide experience spells as Coordinator of the Geotechnical Section at Cassiar's front cave operation in British Columbia and De Beers Senior Geotechnical Engineer managing the company's Geotechnical Section for large open pits in Botswana. With SRK he has been involved in a wide variety of underground and open pit projects as well as several training programs for clients' geotechnical and engineering staff. Jarek has also been involved, through his association with Dr Dennis Laubscher, with the International Cave Research Study and the ongoing development of the rock mass characterization system.

Mudrush prevention in block caves

Richard Butcher

Elements of a mudrush



Mudrushes (or wet muckruns) have plagued block caving operations for over 50 years, with many fatalities being attributed to these events.

For a mudrush to occur, four elements must be present: mud-forming material, water, disturbance and a discharge point through which the mud can enter the workings.

SRK has developed a mudrush prevention approach focused on three aspects ('the three Ds'):

- Distance – keep the mud material away from the mining operations;
- Drain – prevent water ingress into muckpiles, stopes or workings, boxholes and passes to stop the fluidisation of mud-forming materials; and
- Draw – correctly draw down ore reserves to prevent the discharge of mud pockets and layers.

Richard Butcher, Principal Mining Engineer at SRK, explains that a requirement for the first aspect (Distance) is that mud must be distant from the mining operation. Therefore, tailings dams must be sited such that there is no risk of the material flowing underground; and open pit slopes must be designed to ensure that weatherable material will not accumulate in an area where it has the potential to flow underground.

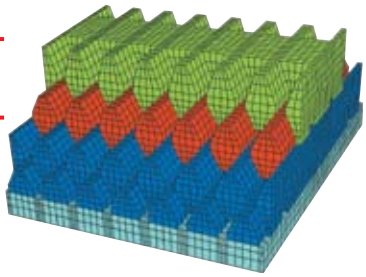
"Sublevel caving methods are more risky with regard to mudrushes," Richard states, "because any mud in the waste capping is closer to the extraction location than it is for block, panel or front caving. The latter methods maintain the mud at a greater distance."

The second aspect (Drain) encapsulates a series of measures aimed at preventing water (ground or rainwater) from fluidising mud-forming materials. It is important that mines must have correctly designed surface and underground drainage systems to prevent groundwater and rainwater from entering muckpiles, filled stopes and open cuts.

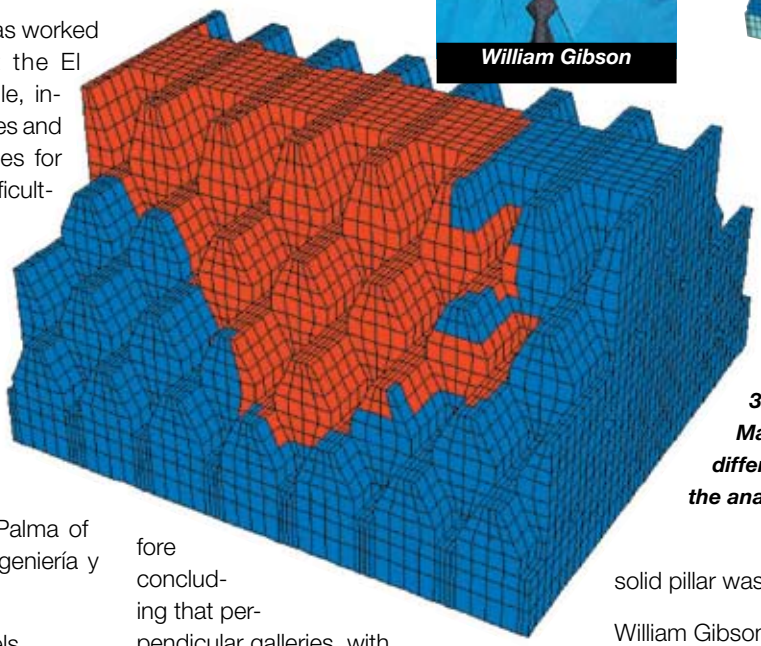
"Overdrawing and isolated draw conditions are trigger mechanisms for mudrushes," Richard continues. "It is important, regarding the third aspect (Draw), to correlate the percentage extraction with the possible occurrence of mud. As a general guideline for mudrush prone mines, only 120% of the allocated drawpoint reserve should be extracted, despite the economic viability of waste cap mining."

Caving projects at El Teniente

William Gibson



▲ *3D FLAC model of the Macrozanja showing the different levels of exploitation*



◀ *3D FLAC model of the Macrozanja showing the different rock types included in the analysis*

Over the past few years, SRK has worked on several caving projects at the El Teniente division of Codelco-Chile, including analyses of pillar instabilities and conceptual geomechanical studies for developing some of the more difficult-to-mine reserves.

The largest study was the geomechanics part of the development of a new Macro-Zanja method of panel caving, based on an idea by Dr Dennis Laubscher. SRK completed this work over a period of two years, as part of a larger conceptual design under the lead of Ricardo Palma of SRK's partner company, NCL Ingeniería y Construcción SA.

The resulting design has four levels, 15 m apart, with a global slope angle of 45°. The draw points are laid out on a 15 x 20 m staggered grid, and are 4.5 x 4.5 m in cross-section. The SRK team studied a number of variations before concluding that perpendicular galleries, with sub-level caving for the mineral inside the trenches and traditional caving for the pillars above the apex, were the most convenient method. To strengthen the pillar above the apex, the height of the solid pillar was raised to 20 m.

William Gibson was responsible for the FLAC modelling. Other SRK contributors to the El Teniente work during this time included Dermot Ross-Brown and Chris Page.

Updating the mining rock mass rating classification

The in situ rock mass rating system (IRMR) – leading to the mining rock mass rating (MRMR) – for jointed rock masses has been used (and abused) in mining operations around the world for the past 27 years. Despite the recent development of elaborate design procedures and computer-aided design packages, MRMR remains one of the most versatile and practical empirical mine design systems available.

Jarek Jakubec

It is important to realise that the rock mass classification system should not be replaced, but rather complemented, by more sophisticated and detailed design procedures. The classification system is not only a 'crude' method used for initial assessment (as described in some geotechnical literature), but also in many respects a very effective and practical engineering tool. MRMR could, and should be used during the entire mine life as an integral part of the design process.

"The MRMR system is one of the best methods used to characterise the rock mass competency," says Jarek Jakubec of SRK Vancouver, who has worked with Dr Dennis Laubscher in further developing the MRMR classification for the International Caving Study.

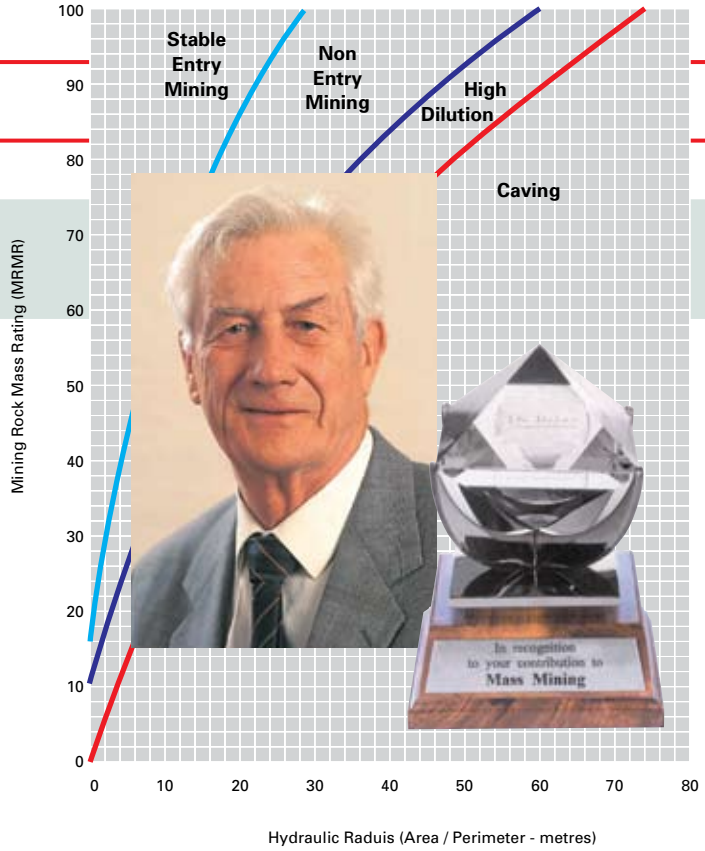
"All the critical parameters influencing the rock mass behaviour should be catered for, if rock mass classification is to reflect reality. Ignoring strength reduction due to micro-fractures, or ignoring the presence of cemented joints could have serious safety and/or economic consequences." This was recognised by the caving community, which called for further updates to the MRMR system.

"Although some of the techniques used by the classification system need further refinement and calibration, it is better to use a simplistic method than to ignore the issues. In other words, it is better to be roughly right than precisely wrong!"

Dr Dennis Laubscher

SRK congratulates Dr. Dennis Laubscher; recipient of the MassMin 2000 De Beer's award.

The MassMin conferences concentrate on "bulk" mining, or low cost, methods that account for a majority of the economic material moved in underground "hard rock" mines. It has an additional emphasis in promoting caving methods. It is only held every ten years or so and is therefore a very important gathering for the underground mining fraternity. At this last year's conference the new De Beers award for the person who has made the most important impact on bulk mining over the last ten years was awarded to Dr Dennis Laubscher for his contributions to the understanding and optimization of block caving.



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