srk news
Mining Project Evaluation

Overview

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Project evaluation: serving both the mining and finance communities

The term project evaluation has very broad applicability within the mining industry. However, the fundamental concept—generating information to support decision making regarding a project—is the same for all projects or stakeholders.

The evaluation may take any form from an independent expert's report in international arbitration to a due diligence report for a financial client, or the National Instrument 43-101 feasibility study the retail investor relies on. Most critically, to be able to undertake the most effective and efficient project evaluation, the purpose and strategy behind that evaluation must be understood: what will the project evaluation be used for and who will rely on it? Is the purpose to set a valuation in an acquisition or sale, to determine the viability of a project for a board's development decision, to undertake a technical and risk analysis to support project financiers, to support a short-term public investment strategy or a long-term private investment strategy? Each interested party's expectations differ and it is critical to be able to answer questions related to risk, opportunity, present value and future value, providing the best information possible within the scope of the review.

The mining industry has had more than its fair share of poor decision making in a number of high profile cases, where assets purchased just a few years ago have been sold for cents on the dollar, investments have been lost within a few years or months of being made, and share prices for some companies have reached all-time lows.

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NEAL RIGBY

Dr Neal Rigby has 40 years' experience in the international mining industry. For the past 20 years, as a Corporate Mining Consultant and senior participant, his consulting work has focused on major due diligence audits, competent person's reports and other reports supporting the merger, disposal and acquisitions of international mining companies and mining finance institutions. In this role Neal certifies "bankability" i.e. fundamental value and risks and opportunities of mining projects to shareholders, stock exchanges and financial institutions. Most recently, he has consulted on the restructuring and sale of mining assets and the scoping and implementation of business improvement strategies.

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JOHN PFAHL

John Pfahl is a Mining Engineer with over 15 years of global experience in the mining industry. He is a Corporate Advisory Consultant with SRK. John has expertise in investment analysis, strategic planning, risk analysis, capital markets and project valuation in the mining field. His background activities include technical and commercial due diligence, technical studies, project management, financial modelling, structuring and negotiating terms in mergers and acquisitions. John has taken on strategic planning and project finance for projects ranging from exploration through production and across a broad spectrum of commodities.

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Each situation is unique and most result from a cascade of events, with falling commodity prices often the straw that breaks the camel's back.

Commodity prices are out of the control of most mining companies, investors and other stakeholders unless they are the dominant global producer or in a niche market where they can be price setters. However, other challenges are more under the companies' and management teams' control. These include cost overruns on development projects, underperformance of assets, improper assessment/valuation of qualitative risks (e.g. social, permitting) and technical errors, say, in resource and reserve estimates. Understanding past mistakes and incorporating these learnings into current evaluations is necessary to prevent making the same mistakes over and over. At SRK we never assume anything and strive to verify everything that could influence value.

SRK has always been good at understanding client goals and matching its product to client strategy. However, SRK is more explicitly expanding its strategic role by developing a Corporate Advisory group. This group is supporting companies, investors and others in setting strategy to meet long-term goals and helping to implement those strategies so they are executed as envisioned.

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Project financing of the Kwale heavy mineral sands project, Kenya

Process plant under construction

In early 2011 SRK was engaged by the potential lenders as the Independent Engineer for the Project Financing of the Kwale Heavy Mineral Sands project in Kenya owned by Base Resources (Base).

SRK put together a multi-disciplined team of engineers and scientists to review all technical, environmental, social and economic aspects of the Feasibility Study (FS) that Base had completed. Most of the review disciplines undertook a site visit in May 2011, and SRK concluded its initial review in June 2011 by issuing a full due diligence audit report to the potential lenders, including an assessment of the project against the Equator Principles.

Kwale is located approximately 50km south of Mombasa and some 10km inland. The FS envisaged a project mine life of some 13 years, mining a paleo-aeolian dune deposit using a dozer mining trap unit and processing the ore through a 'wet' plant to produce a heavy mineral concentrate. Further processing in a 'dry' plant would separate out the final products of ilmenite, rutile and zircon. Final products would then be transported by road to a newly constructed storage and ship loading facility for bulk shipments of ilmenite and rutile, while zircon product would be bagged or containerised for export through the Port of Mombasa.

During SRK's review of the FS, risks were identified and recommendations made for further work to be undertaken to mitigate these, prior to finalisation of the loan facility being agreed and before construction started. SRK also recommended adjustments to certain assumptions in the financial model the lenders used in assessing the project for the loan facility. Following interaction between SRK, the lender group and Base, an initial loan facility of USD170M was agreed and formally signed at the end of November 2011.

Detailed design and construction of the project commenced in late 2011 and production commenced in Q4 2013. The lender group retained SRK to monitor the project through its construction and ramp-up of production and to assess the project against Completion Test criteria. This has involved regular quarterly site visits by a technical team and review of monthly construction and operations reports produced by Base.

Undertaking the role of Independent Engineer can be difficult and challenging but has its rewards. SRK is pleased to have worked on what has become the first large-scale mining project in Kenya.

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NICK FOX

Nick Fox, MSc, ACA, is a Principal Consultant (Geology/ Mineral Economics) with 15 years post-graduate international experience in resource geology, mineral economics, financial modelling and due diligence. Nick's technical expertise includes authoring and reviewing mineral resource estimates and financial models for various commodities globally, in particular Africa and Russia and CIS countries, and including gold, iron ore, nickel, heavy mineral sands, potash, tantalum-niobium and china clay. Nick manages multidisciplinary commissions including stock exchange Competent Persons Reports on behalf of mining and exploration companies and also audits and due diligence studies on behalf of investment institutions or in support of mergers and acquisitions.

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Gahcho Kué diamond project

Ice road

JAREK JAKUBEC

Jarek Jakubec, C.Eng. has over 30 years of operating and consulting experience in mining, geology and rock mechanics, including technical and managerial positions in operating mines in Canada, Botswana and the Czech Republic. As an SRK Engineer based in Vancouver, Jarek has worked on over 70 projects on all continents, completing technical operational audits, and due diligence studies, publishing technical papers and speaking at conferences. Jarek is also a Qualified Person for 43-101 reporting.

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SRK was mandated to act as the Independent Engineer on behalf of the consortium of Lenders supporting a potential debt financing of the Gahcho Kué diamond project. Gahcho Kué is located in the Canadian North, approximately 300km northeast of Yellowknife.

The Gahcho Kué project is a joint venture between Mountain Province Diamonds and De Beers, who own 49% and 51% of the project, respectively. The debt facility was to help fund Mountain Province's share of the estimated C$1,019M capital cost.

SRK assembled a multi-disciplinary team, sourced from various offices in Canada, as well as outside organisations. The initial desktop review and site visit were completed in September 2014, and SRK identified a number of risks associated with the project. A key risk for the project was logistical access to the site.

At the time of engagement construction had begun at the project site, but was still in the early stages (~5% complete). All major construction materials and fuel were to be transported to the site over an ice road from Yellowknife, which is only operational for roughly two months of the year, typically February and March. The life of each winter road season and maximum load weight depend on ice thickness, which is directly correlated with cold temperatures. As a result, a poor ice road season could have a significant negative impact on the procurement, cost, and schedule of the project. SRK provided advice to the Lenders on how this, and other risks, might affect the project.

After completing the initial review, a number of additional Lenders became involved in the potential financing. This increase prompted the need for a second site visit, additional review by SRK, and further interaction between the Lenders and SRK. This work was undertaken during the first quarter of 2015, during which time cold weather permitted the ice to become sufficiently thick for the ice road to open ahead of schedule, mitigating one of the major risks to the construction project. The additional review was completed and updated findings were delivered to the Lenders in March 2015.

Following interaction with SRK and the successful ice road season, the Lending group and Mountain Province agreed to and signed the US$370M facility, closing the deal on 2 April 2015. SRK continues to act on behalf of the Lenders by conducting ongoing construction monitoring and will ultimately conduct completion testing at the end of construction. SRK is pleased to be involved in what will become one of Canada's next generation of diamond mines.

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STUART SMITH

Stuart Smith is a Project Manager with a Master's in International Business. He has over 10 years' experience in the mining industry. Prior to joining SRK, Stuart was involved in managing data and samples for geological investigations into diamond deposits. Since joining SRK in 2014, he has focused on managing multidisciplinary projects, with a particular emphasis on due diligence reviews. Additionally, Stuart is a member of the 11th International Kimberlite Conference Executive Committee.

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Winter airstrip

Goderich and Cote Blanche salt mines

Compass Minerals commissioned SRK to investigate various alternatives in salt mining extraction and material handling for their underground room and pillar Goderich and Cote Blanche Mines (in Ontario and Louisiana respectively). The goal was to identify a mining option that would reduce mine cost by improving operational performance and improve safety. At that time both mines were using conventional drill, blast and bench mining technology, extracting salt seams as thick as 18 metres at the Goderich Mine, and 23 metres thick at the Cote Blanche Mine.

SRK worked closely with Compass Minerals along with various continuous mining equipment manufacturers to explore a wide range of options with a view toward practicality, strong system performance, innovation and 'out of the box' thinking. Many of the options investigated had never been used in an underground salt environment. The benefits of an integrated tele-remote system were also investigated during this study.

In approaching this work, SRK collected data on-site to create a cost and performance baseline as well as data from other operations using other technologies and methods. This information was fed into SRK's dynamic mine cost and performance model to compare over six different alternatives to their current mining process. The model incorporated daily shift cycles, labour rates, equipment performance (including operating availability and delays), equipment and infrastructure capital costs, mine operating costs, salt sales and revenue.

The results, in the form of comparative discounted cash flow, demonstrated that a continuous mining and conveyance system could significantly benefit the company through cost reductions, increased productivity and reduced diesel emissions.

SRK further refined the continuous mining option to achieve maximum panel extraction by optimising mining conditions as a function of panel configurations while improving pillar and roof stability. SRK has now been asked to incorporate mine simulation modelling to help choose the best panel mining pattern for extraction, cycle and sequence.

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GARY POXLEITNER

Gary Poxleitner, P Eng, PMP is a Principal Consultant with 24 years of operational, engineering, management, and consulting experience. He specialises in underground mine design and economics, due diligence, and operational improvement. Gary has worked at near-surface and ultra-deep mines worldwide, including gold mining near Yellowknife, a room, pillar and bulk mining operation on Vancouver Island, caving and VCR methods at DeBeers in South Africa. He has produced audits, due diligence reviews, and technical studies.

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Goderich Mine, largest rock salt mine in the world

Andes Iron's Dominga Norte and Sur project

3D view of stock pile for the Dominga Norte y Sur Project

From December 2011 to July 2013, SRK carried out a prefeasibility engineering study for Andes Iron's Dominga Norte and Sur project. The study included resource estimation, geotechnics, mine design and production schedule, Iron (Fe)-Copper (Cu) mineral processing, power and water supply, a reverse osmosis plant and slurry pipeline for pellet feed, a filter plant, copper concentrate production, tailings dam and port facilities. SRK also provided a NI 43-101.

The project, located 75km north of La Serena, Chile, in the Coquimbo Region, will pursue Fe and Cu through two open-pit mines. The combined proven and probable reserves for Dominga Norte and Sur are: 733 Mt at 25.6% FeT, 0.08%CuT and 0.01 ppm gold (Au). The 23 year mine life is estimated with 34 Mt/y ore and 95 Mt/y waste.

The project will be divided into six main areas: mine pits and waste dumps; process plant; power supply; slurry and water pipelines; main port infrastructure, and tailings dam.

The north and south mine pits will produce 95 Ktonnes/day (34.4 Mt/year); the plant will produce 11.5 Mt/year of Fe concentrate and 120 Kt/year of Cu concentrate containing approximately 15 Koz/year of Au.

The plant area includes the primary crusher, stockpile, grinding plant, iron wet magnetic separation plant, copper concentration and filtration plant and infrastructure for thickeners, ponds and slurry transport. It contains Andes Iron´s administrative offices, construction camp, storage, laboratories, center for solid waste management, and a gas and diesel station. Power will be supplied by the Punta Colorada power substation.

In the piping area iron concentrate, water and tailings will be pumped into the process plant area, port area and tailings dam.

The port facilities consist of an iron concentrate filter plant, water dissipater stations, thickeners and pond conditioners, reverse osmosis plant and building, sea water ponds, treated water, brine and emergency ponds and general support facilities.

In the process plant area for example, the overburden was removed to construct the crushing area followed by assembling and filling the mechanically stabilised earth wall to its maximum elevation.

The iron magnetic concentration area was designed to bring together the particles of iron ore through low intensity magnetic concentration and reverse silica flotation. The copper flotation area was designed similarly to treat the tailings from the iron plant.

Key tasks included a pipeline to transport iron concentrate from the plant to the port, a pipeline to transport desalted water from the reverse osmosis plant, and a third to transport recovered water from the port to the plant.

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EDUARDO BASTÍAS

Eduardo Bastías is a Mining Engineer with 29 years of professional experience in the mining industry. He specialises in engineering and operations for underground and open pit mines, including mine design, mine schedule, mine equipment, mine OPEX and mine CAPEX. During the last ten years, Eduardo has worked as a mining consultant, conducting open pit and underground projects in Chile, Peru, Brazil, Mexico, Ecuador and Cuba. He has been project manager in several scoping studies and due diligence projects. Eduardo conducted the prefeasibility study for Dominga project, located in Chile during 2012-2013.

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Osborne copper gold project

ANNE-MARIE EBBELS

Anne-Marie is a Mining Engineer with over 20 years' experience in mining operations and consultancy in Australia and overseas. Her expertise includes mine design open stoping, narrow vein mining, scheduling, drill and blast, supervision and contract management. Anne-Marie's consulting experience includes scoping, prefeasibility and feasibility studies, technical reviews, due diligence, economic modelling and site support; she is a competent person for JORC and NI 43-101 reporting and has completed numerous Ore Reserve reports for lead-zinc, copper and gold deposits.

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CHRIS BRAY

Christopher Bray, BEng, Principal Mining Engineer, has 18 years of international experience, with 10 years in operations. With SRK, Chris contributes in a project management and technical capacity, covering activities such as open pit and underground optimisation, mining method selection and mine design. This includes scheduling, ventilation, equipment selection, cost estimation, materials handling options, mining contractors, financial modelling and valuation. Over the past 8 years with SRK, Chris has worked on a large number of projects and commodities in Central Asia, Russia, India, Europe, Africa, Central and South America.

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Osborne underground headframe and winder

Ivanhoe Australia Limited's Osborne Copper Gold Project (Ivanhoe) is located in northwest Queensland, approximately 50 km south of Ivanhoe's existing Merlin (Cu/Mo) and Mt Elliot (Cu) deposits.

Ivanhoe acquired the Osborne Copper Gold Project in September 2010 from Barrick Gold Corporation. Subsequently, Ivanhoe was renamed Inova Resources in 2012, and Inova was acquired by Shanxi Donghui Coal Coking and Chemicals Group Co. Ltd to form Chinova Resources in 2013.

The project has been in operation since 1995, having originally started with Placer's Osborne mine, and now includes the nearby Selwyn operations. The project area consists of several copper-gold deposits at various stages of development and a processing plant.

The mineralisation is characterised as belonging to the iron-oxide-copper-gold (IOCG) class of deposits.

In 2011, Ivanhoe commissioned SRK to complete a review of the Osborne Copper Gold Project Study, which demonstrated the economic viability of the project. First production from the Osborne underground deposit was achieved in February 2012 and the first copper shipment made in June 2012.

Following the successful completion of the review, Ivanhoe requested that SRK complete a Mineral Reserve Estimate and NI 43-101 Technical Report for three of the deposits within the Osborne Copper Gold Project. The project was split into two areas—Osborne/Kulthor and Starra 276—with two separate NI 43-101 Technical Reports commissioned.

Ivanhoe commissioned geological consultants who were familiar with the orebodies to complete the geology reports, and SRK incorporated these reports into the Technical Reports. The geology consultants conferred with SRK to ensure that the reports remained technically unchanged, and they were satisfied to sign off as the Qualified Person for the relevant sections.

SRK personnel made site visits in both 2011 and 2012, which proved invaluable in terms of understanding the interactions between the deposits and what had been mined to date. A site visit undertaken partway through the development of the Mineral Reserve provided the opportunity to discuss the designs with the site personnel, allowing us to collect feedback pertaining to any significant issues with the designs. This interaction resulted in some changes to the designs, a better understanding of the deposits, and information about the progress that had been achieved in mining the deposits. These updates ultimately resulted in a design that the site engineers could use as a basis for the detailed designs.

Once the Technical Reports were completed, and during the 45-day period from the announcement to filing of the Technical Reports, Ivanhoe and Ivanhoe's legal advisors conducted a series of reviews. These reviews resulted in updates to the reports and final liaison with the Qualified Persons for sign-off prior to filing the Technical Reports.

SRK thanks Ivanhoe for permission to publish this article and for supplying the accompanying pictures.

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An overview of benchmarking capabilities

Sourcing benchmark data can be a time consuming task, and time is a valuable commodity in consulting. Benchmarking is essential for defining early stage limitations for estimating Mineral Resources and for informing clients of key areas for improving operations. Every deposit and operation has its own unique characteristics, so the challenge is to identify enough comparable data for a meaningful analysis. The greater the level of detail required and number of constraints placed on the benchmark data, the more challenging it becomes to generate a sufficiently large and reliable data population quickly.

SRK subscribes to database sources that provide a continually up to date and informed position for benchmarking; they complement our extensive in house experience and systems. For commodity price assumptions, this process extends to regularly updating the market consensus on metal price forecasts, for internal guidance and professional dialogue with clients.

It is important to understand the limitations of database sources, which is why SRK subscribes to a range of the best and most recognised products. In many instances these database subscriptions are not comprehensive enough to complete the full benchmark task the client requires so additional investigations and enquiries are needed.

Recent examples of benchmarking exercises completed by SRK include the following:

- Review of open pit iron ore and chromite mine technical and cost operational parameters such as design, equipment, labour, maintenance and energy consumption to provide an operator in India targets for future expansion.
- Operational improvement exercise for a client with multiple underground lead-zinc mines in the USA. The project covered due diligence, data collection and value tree analysis to determine key drivers for establishing improvement targets.
- Market research for a major distributor of mining equipment in Russia and a number of African countries to determine the future sales forecasts of open pit and underground equipment.
- On-going monitoring of a decline cover drilling and grouting program to prevent water inflow in Europe and comparison with the key performance indicators of similar projects to facilitate efficiency and reduced costs.
- Benchmark capital and operating cost breakdown analysis of underground copper-gold mines utilising sublevel caving and open stoping methods to assist with determining reasonable cost estimates for a developing project in Eastern Europe.
- Review of technical and cost parameters for mines utilising underground shrinkage methods to use as means of comparison on a due diligence commission for a potential investor.

SRK has a large global multi-disciplinary base of experienced mining professionals and associates who can typically cover all reasonable benchmarking requests.

When undertaking benchmarking assignments, SRK focuses on what needs to be achieved to develop an efficient approach and regularly communicate throughout our global network to access additional knowledge and support to complete the task.

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Boa Esperança feasibility study

Mineração Caraiba S.A. (MCSA) commissioned SRK to prepare a feasibility study for the Boa Esperança Project in Para, Brazil. The copper deposit is located in the municipality of Tucumã, Pará State, Brazil. The Project design plans to process 12,000 tonnes per day, using standard copper flotation, producing 762 Mlbs of copper with a concentrate grade of 28.4% Cu. The average mine grade is 0.72% Cu/t (diluted) with a stripping ratio of 3.73:1 (waste to ore), delivering 53.5 Mt of ore to the plant. The reserves are defined by a final pit with dimensions of 800m x 1,075m x 500m and a volume of 92 Mm3. The mine plan was divided into five phases using variable inter-ramp slope angles and 16m-wide ramps with a maximum grade of 10%.

SRK was chosen as the lead consultant responsible for coordinating a multi-disciplinary team of SRK staff and Brazilian consultants, using standard CIM reporting practices under the NI 43-101 national instrument framework. As part of the project scope, SRK was directly responsible for geology and resources, mining and reserves, geotechnical evaluation, metallurgy and economic modelling. Brazilian companies were responsible for all other study items, with review by SRK.

SRK worked closely with MCSA staff and Brazilian consultants to help guide the critical path work plans required for the successful completion of the study and defense under due diligence conditions for possible project financing.

SRK was able to leverage its deep understanding of Brazilian mining conditions, where specialised mine haulage equipment is frequently substituted for highway trucks using rock beds in the 40t range. The economies of scale, given labour costs, maintenance, selective mining, capital intensity and import duties, make this option not only viable but desirable. Combined with advanced stockpiling and production schedule strategies aimed at maximising copper content early in the project, SRK estimated significant improvements to the project financials.

The success of the working relationship between MSCA and SRK was based on open and transparent dialogue among all contributing parties so the project could support robust third party due diligence, internal review, peer challenge and potential project financing.

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FERNANDO RODRIGUES

Fernando Rodrigues, BS Mining, is a Mining Engineer with 15 years of global mining experience. He has contributed to multiple feasibility, prefeasibility, preliminary assessments, due diligence and Competent Person reports, with SRK and Maptek, Denver. Previously, he worked on design and implementation: short-term mine design, dump design, haulage studies, blast design, ore control, grade estimation, database management, and CAES Systems for Phelps Dodge Morenci Mine, Arizona. Fernando also used Vulcan Software and MineSuite Production Statistics in sales and support roles, gaining exposure to mining operations and projects around the world.

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Don't forget environmental issues

Historic workings near the Mineral Ridge Mine, Esmeralda County, Nevada

With mine project evaluations, the tendency is to focus on the potential resources and reserves followed by the mining and processing costs. But environmental issues related to project permitting, operations and closure can have a material influence on the overall valuation of a mining asset. Proper identification of environmental liabilities and risks, as well as the cost of ongoing environmental expenditures, need to be included in the overall cash flow model. Likewise, mine closure costs need to be included to determine the closure fund contributions from cash flow.

Before new mining can be initiated, properties with pre-existing, mining-related liabilities need to be assessed and included in the project valuation. The mine's expansion, redevelopment, or reuse may be complicated by the potential presence of environmental issues, usually a hazardous substance or pollutant. Assigning responsibility to historical liabilities can be critical during early negotiations, as the full assumption of existing liabilities could lead to long-term remedial programs.

Permitting mine projects has become increasingly challenging in some western jurisdictions. Prolonged permitting processes affect the investor return period. For this reason, most mine developers try to expedite the initial permitting process to ensure the project has obtained, or is close to obtaining, permits prior to market presentation. While initial permitting costs are usually borne by the development company, maintaining the permits, as well as the environmental and social management programs, should be considered in the overall project valuation. Environmental requirements associated with mineral rights, surface land uses, and water rights/appropriations also need to be considered during the evaluation.

Environmental capital costs provide for constructing or upgrading pollution control measures, such as stormwater diversions, settling ponds, water treatment plants, or air pollution control measures. Capital costs could also include provision for further investigations or for compensation payment to affected parties. In some cases, this extends to the purchase of neighboring properties, where land capability has been or could be affected by the mine. While generally not associated with "greenfield" projects, litigation resulting from environmental, labor, and health & safety claims need to be considered for operational or "brownfield" projects.

For years the mine evaluation process has ignored or given only cursory consideration to final reclamation planning and closure costs, as these issues can occur years into the future. At best, a Greenfield project may develop a conceptual closure plan espousing the virtuous nature of corporate reclamation and sustainability programs, with little detail to evaluate the true extent of necessary activities and associated costs. Experienced closure specialists draw on a breadth of site experience, facility and process design knowledge, known closure pitfalls, and post-closure commitments to guide the mine evaluation to realistic final closure cost.

The closure specialist can assist in identifying opportunities for alternative closure strategies, cost savings approaches, or closure scheduling to improve the overall cash flow model.

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MARK WILLOW

Mark Willow, Principal Environmental Scientist with SRK for over 20 years, is a Practice Leader in the U.S., with degrees in fisheries and wildlife management, and environmental science and engineering. He is certified by the State of Nevada to manage hazardous materials, investigate the potential release of hazardous substances, and respond to requests for the cleanup and remediation of contaminated soil or water. Mark focuses primarily on federal and state permitting and environmental impact assessment, and analysis of mining-related risks and liabilities for due diligence and competent person evaluations.

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Due diligence review of a mineral sands project in Victoria, Australia

Test pit full of water due to the heavy rain experienced immediately before the site visit

YONGLIAN SUN

Dr Yonglian Sun, PhD, is a Corporate Consultant with over 25 years' experience in geotechnical and mining engineering in five countries across four continents. His expertise covers site investigation, analysis, and modelling of geotechnical issues in open pits, underground mines, and tunnels, as well as project evaluations. In recent years, Yonglian has coordinated and led dozens of due diligence projects, mainly for listing on the Hong Kong Stock Exchange. Yonglian is a Fellow with the Australasia Institute of Mining and Metallurgy.

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The client, based in Melbourne, Australia, commissioned SRK to review the mineral sands project following the previously prepared final "Definitive Feasibility Study" and available engineering studies, to then prepare a technical report, and to present our opinion and findings. The company develops and mines mineral sands deposits and produces a range of zirconium and titanium based products from mining interests in Australia and Africa. In China, the company finishes, sells and markets zirconium and titanium products; abroad, the client is a world leader in advanced zirconia materials for the refractory and ceramic industries.

In our scope of work, SRK reviewed the prepared mineral resource and ore reserve estimates; assessed mine planning and the proposed mining; technically reviewed the ore concentration and separation processes; and reviewed the project infrastructure in Australia; the project's environmental, legal, and social aspects; and the project costs and financial model.

The mineral sands deposit is located north-west of Melbourne. The total Measured and Indicated Mineral Resource of the Australia deposit is estimated to exceed 800 Million tonnes (Mt) based on a cut-off grade of 1.0% heavy minerals. Proved and Probable Ore Reserves of about 460 Mt are presently estimated for mining zircon, rutile, leucoxene and ilmenite.

The open pit mine, operated by shovels and trucks, follows a model identifying optimised operating blocks with a semi-mobile screening unit located near the mining front to prepare the ore for pipeline transport. The mineral sands concentrate would then be shipped to south China for further processing to achieve marketable products.

It is planned to develop the mine in two stages. At the first stage, the mine should produce 9.0 Million tonnes of ore per year (Mtpa) increasing ore production to 17.9 Mtpa in the second stage. At full production during the first stage, about 18 Million bank cubic meters of overburden has to be stripped per year to expose the ore. The heavy mineral concentration plant will accommodate the mined ore and will use de-sliming cyclones and spiral separators for concentrating.

After full production during stage one, 660,000 tpa of heavy mineral concentrate will be shipped to China for processing in wet magnetic separators and spiral separators to achieve 90% heavy minerals. Further treatment in an electrostatic mineral separation circuit will complete the recovery process.

During the second stage, shipment of heavy mineral concentrate should increase to 1.32 Mtpa.

Overall, the project poses some engineering challenges due to the complex mineral preparation process proposed for the relatively fine-grained mineral sands. With the proposed and proven technology available, it is considered possible to achieve a workable and satisfactory process solution.

A decision on implementing the project is expected early in 2016 after detailed design is complete and financing has been secured.

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Bruno Strasser, Dipl.-Ing. (M.Sc), MAusIMM, is a Principal Consultant (Mining) with more than 30 years of professional experience in mining, project management, and plant construction. He has working experience in several countries in Europe and Asia, including Germany and Indonesia, Austria and the Philippines, and in Hong Kong. He worked for many years as a self-employed consultant in Hong Kong and Austria, where he gained experience in a wider field of industries and also as a business and management consultant.

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SRK due diligence team during the site visit

Complexities in mineral project evaluation

Preparing a cash flow model to be used in project evaluation is not just an exercise in manipulating numbers in Microsoft Excel. There are numerous complexities in compiling such a model which require a thorough understanding of the project and the commodity, from geology to mining to processing to logistics to marketing the finished product. There are technical matters specific to product and commodity to be considered. Further, the terms of any off-take / marketing agreement or toll-treating agreement need to be used accurately and properly modelled.

In most projects, month zero (marking the start of the project) is not the same for the mining and the processing components. The mining ramp-up to steady state invariably takes much longer than that of the processing plant (see diagram). The time when the first ore can be fed into the plant needs to be carefully assessed, so the size of the run-of-mine (RoM) stockpile during construction does not get too large, compared to a plant that is brought on stream too early -- only to be starved of RoM ore (reducing revenue and increasing unit costs).

This requires carefully modelling the movements of tonnages and contained metal into and out of the stockpile.

A simple error is the incorrect use of terminology with respect to processing plants: with coal, industrial minerals and dimension stone, apply yield to RoM tonnage to describe the percentage of saleable product to be derived; with precious and base metals, apply recovery as a percentage of contained metal in the plant feed. With projects such as platinum group metals (PGMs), relationships exist between the head grade of the plant feed and the applicable recovery – the higher the grade, the higher the recovery. A further complication is that the distribution of the PGMs in the plant feed, or the prill split, varies from project to project, and the recoveries that apply to the various elements are different. Applying an average recovery tends to understate the recovery of the main revenue drivers, platinum and palladium, and overstate the Au (gold) recovered, with a general reduction in revenue.

This discussion introduces a few of the many important distinctions in calculating elements that can impact cost estimates and make the difference between success and failure.

For instance: were capital cost estimates phased independently for each component? How were costs determined? Who has considered the effects of changing foreign exchange rates? Does the mining licence grant ownership of the surface? How about funding for the environmental closure costs? Are the evaluation models calculated in real or nominal terms? And what about inflationary effects?

The SRK study team looks closely at all of these eventualities, critically reviewing and validating them against historical operating statistics.

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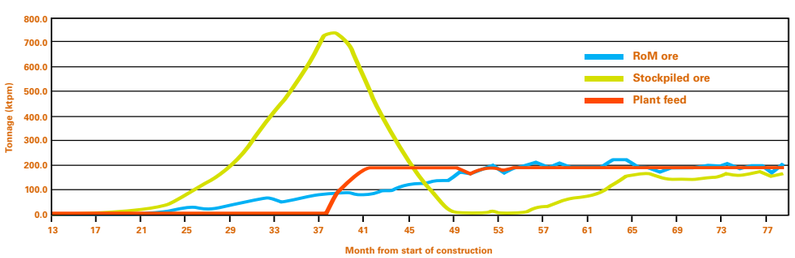

Sustainable value creation


Visit to Renukoot, India with Minister Motaze

To better manage project complexity, processes are needed to guide the development of estimates and identify and mitigate related risks. The process should identify the various approvals required to renew an exploration permit or receive a mining permit. However, recent changes in public perception and sentiment have added a level of uncertainty. Simple compliance with legislation is not always adequate to ensure that a company retains its operating licence.

The expectations of communities and governments have changed, and these changes must be captured in the host country's permitting requirements. Previous operations or governments may have left a legacy that adversely affects the current project. Former owners may have made commitments that cannot be met. Companies might be tempted to continually focus on the best outcome to attract investors without considering that negotiations for fiscal incentives are not yet finalised.

The larger the footprint of the operation, the more complicated this process becomes. This is as a result of combining the numbers of communities impacted by the operation, each with their own needs and desires, and the likely national strategic significance of the associated infrastructure.

Companies need to reconsider Net Present Value and Internal Rate of Return as primary measures of value in most projects, particularly "greenfields" projects. These measures can lead to unsustainable operations by favouring short-term returns over long-term sustained cash generation that would promote the ongoing development of the mine and the community. They can ignore the value of flexibility by rewarding lower capital costs and lower operating costs in the base case without considering the range of likely conditions over the life of the operation.

Companies should communicate frequently with all stakeholders to increase trust and facilitate effective engagement. They should be wary of closing a quick deal that does not provide for returns to the government until several years after commissioning. Governments need to hire skilled staff and consultants to complete the regulatory review of complex projects on time – areas such as customs, environmental, social monitoring and engagement come to mind.

Governments must ensure their negotiating teams include members and decision makers who can adequately cover all issues and are supported by skilled advisors who can ensure that technical, legal and financial risks are addressed. Companies may need to provide financial support to the government to retain such a team. It is essential to remember that in any bureaucracy, uncertainty leads to delay.

Governments can facilitate more sustainable operations by working to reduce the uncertainty investors face, effectively lowering the discount rate and increasing the value of later returns. Companies should avoid trying to 'beat' the government or the community in a negotiation. Collaboration and trust with all stakeholders and adaptable, cash generating operations are essential to create sustainable value.

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Andrew van Zyl, Partner and Principal Consultant, B Eng, M Com (Financial Economics), worked in production and project roles before 2006, when his focus shifted to strategy, business development and valuation. Recently, he was technical advisor to the government of Cameroon, negotiating the Sundance Iron Ore Convention and Concessions. Andrew has extensive experience in valuing metals and minerals. He lectures on exchange rate theory and corporate valuation at the University of Johannesburg, and has presented conference papers in economics, mining valuation and health economics, in particular on the economic impact of HIV/AIDS and Antiretroviral Therapy in mining.

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MATTHEW GREENTREE

Matthew Greentree, PhD (Geology), MAIG, MGSA, is a Principal Consultant at SRK with over 13 years of experience in mineral exploration geology He has international experience working on numerous deposit styles, including lode gold, IOCG, sediment-hosted Cu–Co and base metal deposits, magmatic nickel, and BIF-hosted iron ores. Matthew has industry experience as a gold exploration geologist for Sons of Gwalia, and various grass-roots and advanced nickel exploration projects in China and Central Australia, while in the employ of Anglo American Exploration. His consultancy expertise is in the management and interpretation of geological and exploration data within geological and GIS computer packages.

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ROGER DIXON

Roger Dixon, Pr. Eng, BSc (Hons) Mining, Hon Life FSAIMM is a Mining Engineer with over 44 years' experience in the industry. He spent his early career managing deep level gold mines in the Witwatersrand Basin. He was a founder member and Chairperson of the South African Mineral Resource Committee (SAMREC) which developed and published the original SAMREC Code in 2000 and the revised version in 2007. Roger is currently one of two South African representatives on the Committee for Mineral Reserves International Reporting Standards (CRIRSCO) an organisation which he chaired in 2009-2010. He is currently a Corporate Consultant with SRK Consulting SA.

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Valuing exploration properties and the public reporting requirements

A site visit is a key aspect of understanding the context of the information

The valuation of exploration assets is required as a basis for the commercial terms of corporate transactions, but can also support a company's exploration strategy when every exploration dollar must be carefully considered. In exploration it is generally recognised that while the investment risks are high, the financial returns of discovery are significant. Many parts of the globe, both mature and relatively under-explored, continue to deliver new finds.

Any valuation approach needs to take into account both the technical merits of a project and the market conditions, and will usually incorporate several different valuation methods. All statements by the company regarding discovery potential and possible outcomes for future exploration campaigns must be made on a reasonable basis. The valuer should communicate the project merits while satisfying the market regulators who are very cautious about forward-looking statements.

The guiding principles for any valuation should revolve around the materiality of the data, the competence of the valuer and the transparency of information. Materiality guides what data should be considered for the valuation. For example, if a historical or foreign estimate of mineralisation is known on the property, this is clearly material information, even though it may not be readily released in accordance with public reporting guidelines. A site visit is a key aspect of understanding the context of the information. Competence refers to the relevant previous experience of the individual who is conducting the valuation. Commonly, a number of technical specialists will need to take responsibility for their respective areas of reporting, rather than a single expert. Reports should be transparent with sufficient information, so that the reader can understand the approach and assumptions made in clear and unambiguous terms.

In Australasia, the release of the JORC Code (2012) and the update of the VALMIN Code, which is currently in progress, provide increased guidance to the industry in disclosing information in public reports. Both these committees have worked with international bodies in attempting to harmonise the requirements of a number of jurisdictions. In addition to the professional codes, each jurisdiction will have their own regulatory and reporting requirements that need to be considered. Adhering to these guidelines provides transparent and defendable valuations, offers comfort to the investment community and helps protect the reputation of the resources industry.

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More questions than answers in expanded reporting codes

Protecting the environment and communities in and around exploration and mining projects is now a major issue in valuing mineral assets, with the media and society at large elevating the need for a 'social license' to mine into daily conversations and even protests.

The major reporting codes have recently recognised the importance of these issues, by adding 'infrastructure' and 'social' as additional modifying factors to be considered when converting a mineral resource to a mineral reserve (Figure 1).

The question posed recently – and the question for the project valuator – is how to measure the impact or cost of obtaining a social licence to mine on the financial feasibility of a project.

Previously, if applying for an exploration or mining permit, a reasonable expectation that the relevant government departments would issue it would be sufficient (community engagement and social and labour plans are required before applying).

However, in today's world, government is not the only constituent to be considered. All interested and affected parties have to be engaged and they have to issue the social licence. To further complicate matters, this is not a one-off exercise; the social licence has to be obtained and maintained throughout all the phases of a mining project from early exploration to mine closure.

My first response to the question was that a comprehensive and multi-disciplinary risk assessment should be undertaken in all phases of a project – which recognises all the risks to the project and attaches some quantitative judgment to them.

While mitigating actions to ameliorate the risk profile should be managed on an ongoing basis, the valuator has to value the project at a particular point in time. There are levels of risk in all aspects of a project which can be estimated and a risk factor built into financial calculations.

However, the risks associated with environmental and social matters do not lend themselves to a mechanistic calculation; rather, they tend to be more qualitative in nature. The risk continuum ranges from project termination at the one end, to a sustainable mining operation where all stakeholders realise value from the project, at the other. This does not mean that the risks are any less serious. For instance, it would be interesting to know what risk was attached to social aspects in the case of the Pascua-Lama project on the border of Chile and Argentina – which has been stopped indefinitely under a court order on a matter concerning the water supply to local communities.

To consider all risks associated with a mining project, there is a need to apply a multi-disciplined team approach to mineral asset valuation; this is what SRK supports with its broad spectrum of skills and disciplines across the world.

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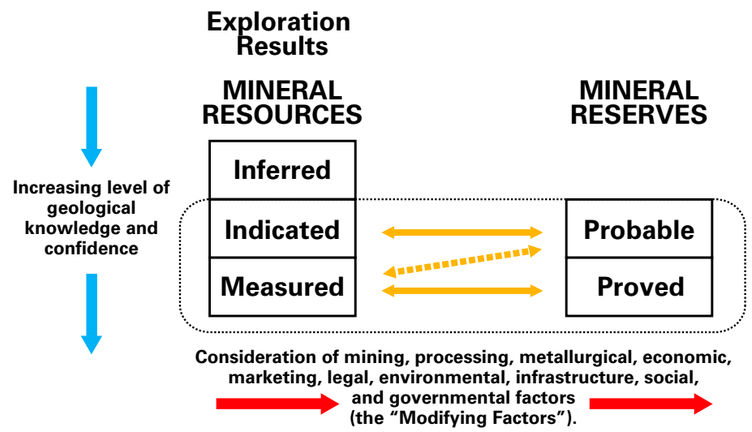

Nui Phao project review

SRK was commissioned by Masan Group Corporation, in Vietnam to provide an independent oversight of Masan Resources, Nui Phao project during construction and production ramp up. This work took place over a period of 18 months.

The Nui Phao project is a polymetallic deposit, located some 80km north west of Hanoi. A Reserve of 53Mt has been defined containing tungsten, fluorite, bismuth and copper mineralisation. Mining is designed to produce 3.5 Mtpa of ore for a multistream processing plant.

The project was designed to an international standard and was ably led by a multinational leadership team.

SIMON HANRAHAN

Simon Hanrahan is a Mining Engineer and Chairman of SRK Australasia, based in Perth. He has 30 years of experience in the mining industry. Before joining SRK in 2010, Simon was involved in the full value chain of projects: studies, construction, commissioning and operations in South Africa, Australia and USA. In particular, he has extensive knowledge of block caving and with that, the transition of open pit to underground production. As an SRK engineer, Simon now works globally on project due diligence, reviews and studies.

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In late 2011, construction commenced on site with the processing plant earthworks, Tailings Storage Facility (TSF) earthworks and waste pre-stripping for the mine. The project delivery method selected was for an owners' team to provide construction management, supported by an EP design contractor for the processing plant, design engineer for the TSF and a mining contractor. The owners' team was responsible for sourcing and awarding all construction contracts for site works.

SRK's initial role was to review the construction preparations and reserve. Following from that, SRK conducted monthly report reviews and quarterly site visits to review site progress and provide independent feedback to the Masan Group on project progress and ongoing updated project risks.

SRK has provided review coverage for geology/resource, mining, processing, tailings and environmental areas.

During the review period, SRK has also provided support for the Masan Group in terms of seeking ongoing finance for the project by preparing specific independent reviews for financial institutions on the project progress.

This scope of work has demonstrated the value of carrying out an ongoing independent project review to satisfy both the parent owner's and other stakeholders governance requirements. That, in turn, has allowed these entities to have a level of external oversight over the internal project team.

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Nui Phao processing plant

Harmonisation of mining projects according to Russian and international standards

Russian documentation	International documentation	Comments
Preliminary assessment of mineral deposits at early exploration stages (TES, TED, TEO, TEP)	Conceptual study/ Scoping study	Study of the deposit aimed at identifying key issues and the potential for deposit development. Determination of the efficient development options, feasibility and economic viability of the deposit.
TEO Konditsii	Pre-feasibility study	Studies aimed at working out the uniform technical-economic parameters (options) for the deposit exploitation which determines the optimum and cost-effective methods of project development.
OVOS	ESIA	Similar studies but each has its own requirements.
Detailed project and project documentation	Feasibility study	Development of a project design consistent with the preferred deposit development option.
Project of construction organisation	EPCM	Construction of the mine.

One of the sought-after services SRK Russia provides is harmonising mining projects to meet both Russian and international standards. SRK's comprehensive approach to implementing mining projects has become essential as the recent acute deficit of investment in Russia's mining industry necessitates the attraction of foreign capital. At the same time, foreign investors from Asia, Europe and America have been looking for mining projects at the initial stage of development. However, foreign investors do not have a clear understanding of Russian legislative requirements for preparing and developing mining projects, while mining companies do not always understand investor's requirements and expectations.

SRK Russia has worked on several projects that demonstrate the necessity for attracting international investment, while knowing that a project implemented in Russia must fully comply with Russian legislative requirements.

For the past few years, SRK Russia has applied a comprehensive approach to mining projects with a development strategy that satisfies both Russian and international requirements. This includes the completion of comprehensive studies that present parallel resource and reserve estimates and classifications that meet Russian and international requirements.

Similar projects have been undertaken before, by SRK and other consulting companies, but with the current approach, SRK Russia takes the lead, supporting geological exploration and supervising the work of design organisations/institutes. SRK Russia assumes the intellectually-challenging responsibility for the business development strategy and the appropriate level of engineering, while the design institutes perform their work following the previously developed technical-economic solutions. Implementing the project successfully requires the joint efforts of all disciplines.

Within the framework of comprehensive studies, SRK Russia has developed an approach that includes the interaction of all stakeholders. A comprehensive approach to both Russian and international requirements require compliance with standards, such as these:

- Preparing input data at the earliest stages to avoid potentially faulty decision making;
- Conducting project studies: geology; hydrogeology; geomechanics; opencast operations; underground or open pit mining; production complex; infrastructure; environmental baselines; project execution schedule; capital cost estimate; operational cost estimate; economic assessment; risk and environmental impact assessments;
- Preparing reserves and resources estimates following GKZ and international Code requirements (JORC/CIM 43-101 etc.); and
- Preparing two packages of project documentation that do not contradict each other, based on a single set of technical-economic parameters and solutions.

Common elements of main project documents that meet Russian and international requirements are provided in the Table above. SRK specialists worked in close collaboration with other experts to define methods and practical approaches for single technical-economic solutions to meet Russian and International requirements.

SRK Russia has gained significant experience in project development and engineering, at, for example Udokan copper deposit and Agaskyr copper-molybdenum ore deposit.

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Svetlana Polutornaya, Mineral Economist, is Head of Project Development and Principal Business Evaluation Consultant with SRK Russia. With a Ph.D from Moscow State Mining University, she has over 10 years' experience in mining production and project management. With SRK, Svetlana participated in and managed projects on mining coal, iron ore, uranium, gold, platinum, bauxite, copper, and molybdenum within CIS and elsewhere. She prepares technical assessments following the JORC Code, NI 43-101, registrations of enterprises for the stock exchange, and Scoping, Pre-feasibility and Feasibility Study reports. Svetlana is currently implementing mining projects with Russian design organisations following international standards.

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STEPHEN TAYLOR

Stephen, B Eng, M Sc., P Eng, Principal Mining Engineer, has over 23 years of experience in mine engineering. Before joining SRK, he worked at major mining operations in Canada, where he was involved in all aspects of underground mine engineering and gained valuable operational and capital project experience. His areas of expertise include project and construction management, underground mine design, planning, optimisation and scheduling, infrastructure, narrow vein mining methods, track and trackless development and estimating mineral reserve using Studio 5DP, Mine 2-4D and Vulcan.

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SUBRATO GHOSH

Subrato Ghosh is a Mining Geologist and the Managing Director of SRK's office in India. He is a graduate of the Indian School of Mines-Dhanbad, with some 22 years' experience in mineral property evaluation. Subrato specialises in mining project assessment; feasibility studies; due diligence reviews and CPR studies; contract review and project management. He has considerable experience in high-level project review, and competent persons reporting for project financing and stock exchange listings. Subrato has worked on multiple international projects spanning a range of commodities, including coal and lignite, copper, chromite, limestone, and iron.

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Preliminary economic assessment for Alexco's EKHSD project

Aerial view of Keno District Mill, Yukon Territory

In 2012, Alexco Resource Corp. (Alexco) commissioned SRK to assist in completing an updated NI 43-101-compliant Preliminary Economic Assessment for their Eastern Keno Hill Silver District project. Located in a historic silver mining district in the Yukon Territory, Canada, there are approximately 30 known polymetallic silver-lead-zinc deposits in the area, many of which have been subject to-small scale mining operations over the last century.

In order to realise Alexco's objective of unlocking the value of the silver-rich district, SRK undertook complete economic assessments for the operating Bellekeno mine and three of Alexco's advanced exploration projects, all located within 10km of the Keno District Mill. Each assessment included a complete life of mine plan, schedule, operating and capital cost estimates.

This allowed the team to explore many scenarios to optimise the strategic business plan for the district, and focus on growth by advancing Alexco's promising district properties to development decisions. The final result of these strategic planning exercises was used to create the combined Life of Mine plan for the Preliminary Economic Evaluation.

A number of challenges and opportunities were explored through the course of the assignment:

- The Keno Hill Silver District is well known for the challenging conditions experienced underground – many of the deposits feature graphitic and sericite schist packages at or near the contacts. Historically, the deposits were mined using square set stoping, shrinkage mining, or cut and fill mining methods. In the last two years the Bellekeno mine has successfully implemented small-scale longhole mining and started moving away from the mechanised cut and fill methods. The small size, challenging ground conditions and the tendency for veins to be saturated when new levels are exposed, limits the productive capacity of individual deposits, thereby requiring several deposits to be operational in order to ensure the district mill is operating at capacity;
- Consideration was also given to the drop in the spot price for silver during the course of the assignment and the tight capital markets, making it difficult for junior mining companies such as Alexco to raise the funds to put a new mine into production; and,
- With Alexco temporarily suspending production at the Bellekeno mine, a number of opportunities to restructure the operating costs, including shifting from contractor to a company mining workforce and establishing an owner operated equipment fleet, were incorporated into the PEA.

The completed Technical Report entitled "Updated Preliminary Economic Assessment for the Eastern Keno Hill Silver District Project – Phase 2, Yukon, Canada" is now available on Sedar.

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Feasibility studies are only as good as the attention paid to data collection

SRK has been involved with multiple projects in India that involved feasibility studies. These projects included advising on requirements, preparing studies and reviewing earlier studies.

SRK has recently completed a feasibility study for Balasore Alloys' underground chromite mine in Orissa that will sit below its existing Kaliapani open pit operation. SRK has added multiple dimensions to the feasibility study of their underground plan. For example, understanding the structural complexity due to multi-phase tectonic deformations, SRK advised generating subsurface rock mass data from oriented cores. With this, SRK could capture and visualise rock defects to develop more precise models. Also, groundwater investigation characterised different aquifers intersecting open pit and underground areas.

SRK has been involved with multiple opencast coal projects that required engineering analysis or review of feasibility studies done by other organisations. With the easy blocks already targeted and exploited, most new blocks are either deep or structurally complex. Some mines face the lack of available space for waste dumps. Another confronted a river flowing through the lease that was simply diverted without appropriate study of hydrology and geotechnical considerations. SRK recommended generating robust geotechnical data to support a large open pit and backfilling option, and a study design on hydraulics, hydrogeology and geotechnics to divert a significant river flowing across the block.

In general, SRK's experience shows that such studies were conducted mainly at the desktop level for permitting purposes, whereas significant engineering study and design efforts are required for implementation. While some commissions have been challenging, a few projects are encouraging for the Indian mining industry, especially start-ups. With regards to OPGC's Manoharpur opencast coal block planned for Orissa, OPGC is reviewing multiple business models suitable for the coal blocks. While this takes time, OPGC wants its mine to meet international standards for safety, environment, productivity and quality.

There are no precise practising guidelines in India governing how a company should develop a feasibility study. Instead, many companies rush through the steps to quickly secure statutory permits and hand over the project to the contractor, but this potentially has negative consequences and also sometimes means missing opportunities. Mining companies need to approach feasibility studies in a deliberate linear fashion. The weakest link remains the quality and quantity of data. Often, there is no clear understanding of where to obtain data, how to use it, and how to include it in reports.

SRK recommends careful design of data collection to ensure that the results can be defended. The temptation to take shortcuts can have exactly the opposite effect: producing a dataset that cannot provide scientifically defensible conclusions. Skipping steps can ultimately delay projects and increase costs. Beyond the actual monetary cost, what is lost is the opportunity to allocate resources to more worthwhile projects.

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Cerro Lindo mine, Peru

Cerro Lindo, owned and operated by Compania Minera Milpo S.A., is the largest underground mine in Peru, currently mining more than 20,000 tonnes per day. The mine profitably develops seven volcanogenic massive sulphide (VMS) ore bodies.

To begin mining the secondary stopes in Ore Body 5, and realise the optimal dimension and stope support design while tackling excessive dilution from the walls and roof, SRK conducted a series of field and laboratory investigations to establish a reliable geomechanical model. This included installing 46 geomechanical monitoring stations, three detailed geomechanical transects and re-logging four strategically selected diamond drill holes, comprising a total of 410m.

The frequency of the discontinuities was carefully recorded to estimate the RQD values, and the body's RMR was also estimated. A total of 104 samples were taken from all lithologies and various mine levels and assigned for laboratory tests to determine the physical and mechanical properties of the intact rock.

Structural mapping and logging allowed for the creation of a new model of the in-situ stress field and for the calculation of the principal stresses using kinematic analysis of faults as well as in-situ stress measurements.

Following dilution reconciliation across different stages of mining, using the equivalent linear overbreak slough (ELOS) criteria, SRK conducted a back analysis of these stopes to establish the optimum stope geometry as well as the key dilution controls.

Using the results of those analyses, SRK developed a mine extraction sequence and a numerical model to ensure that optimum mine stability was attained.

Further back analysis of past fill strengths allowed for the identification of a series of alternate strategies and opportunities.

Finally, SRK oversaw the installation of blast monitoring instrumentation to assess on-going effects and allow for the control of the rock mass behaviour.

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Dr Antonio Samaniego, founder of SVS Ingenieros S.A. (now SRK Peru), is a Corporate Mining Consultant and an experienced specialist in Rock Mechanics. He focuses on mineral appraisal and feasibility studies, underground mine design and mine planning, slope and underground geomechanics and mine waste management. He is responsible for all geotechnical studies related to rock mechanics in mining and civil engineering projects in Peru.

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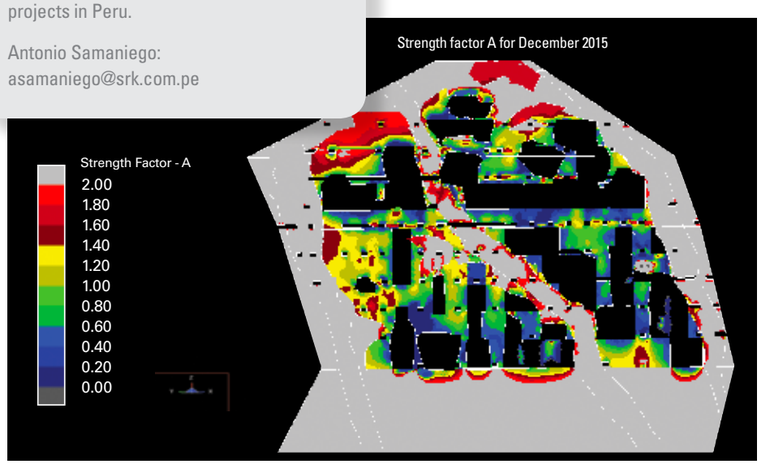


Yaramoko feasibility study

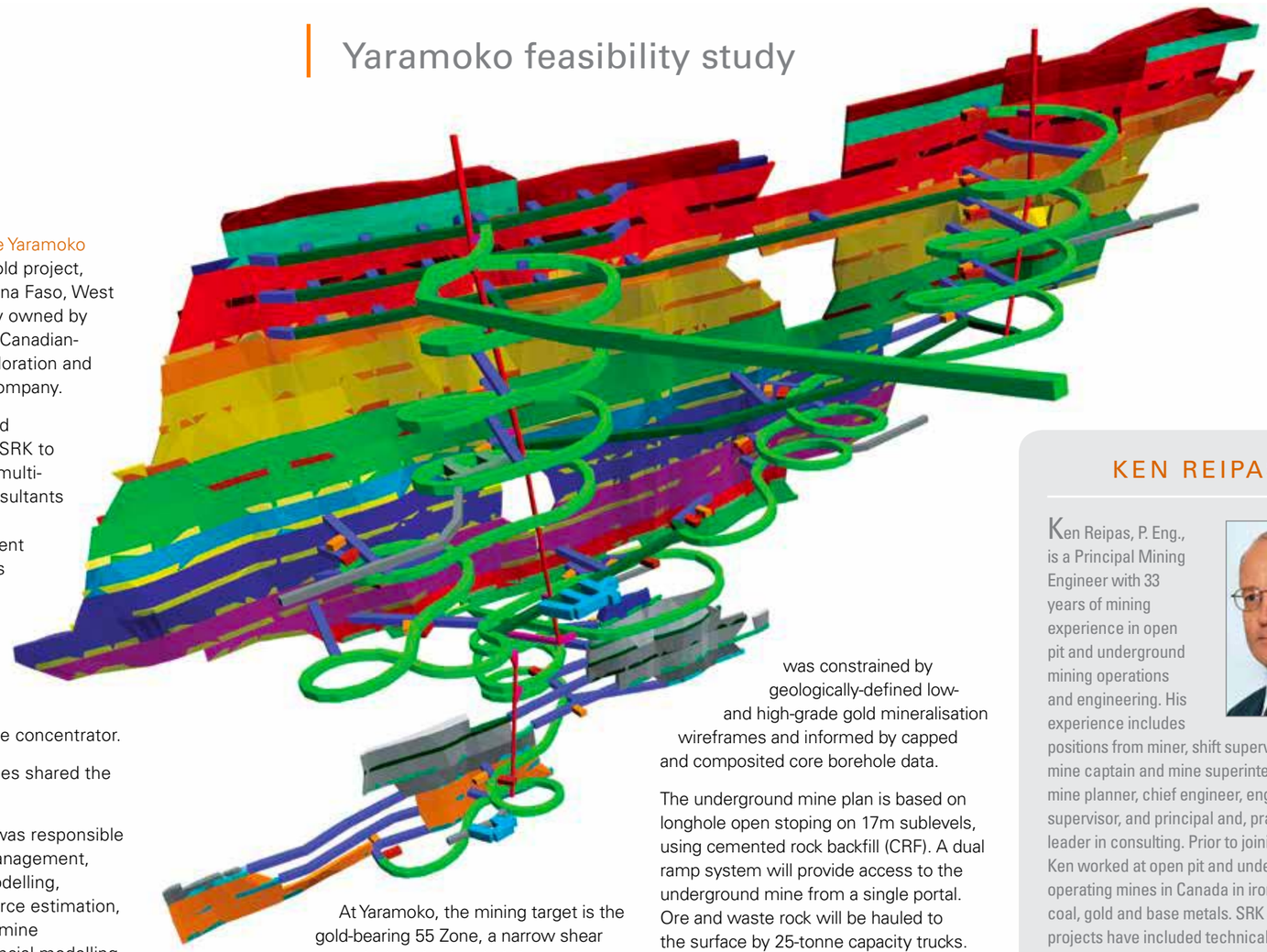
The high-grade Yaramoko underground gold project, located in Burkina Faso, West Africa, is wholly owned by Roxgold Inc., a Canadian-based gold exploration and development company.

In 2013, Roxgold commissioned SRK to lead a team of multi-disciplinary consultants from SRK and other independent consulting firms in preparing a bankable feasibility study for a proposed underground mine and on-site concentrator.

Three SRK offices shared the scope of work:

- SRK Toronto was responsible for project management, geological modelling, mineral resource estimation, underground mine planning, financial modelling and compiling the 43-101 technical report.
- SRK Vancouver undertook the rock geotechnical design of the underground mine.
- SRK Cardiff's scope included hydrogeology and water management, social and environmental management, geochemistry, and mine closure.

This article focuses on the geological modelling, mineral resource evaluation and mine planning aspects of the feasibility study.



At Yaramoko, the mining target is the gold-bearing 55 Zone, a narrow shear zone, which varies in width from a few centimetres to more than four metres. Based on detailed on-site structural geology investigations, the reverse shear zone, which defines a low-grade resource domain, was modelled geologically. Within the shear zone, most of the high-grade gold mineralisation is associated with low-sulphide quartz veins developed within dilational zones. High-grade gold resource domains were modelled with a shallow west plunge, consistent with the structural geology interpretation.

Using a geostatistical block modelling approach, SRK estimated the mineral resources for the 55 Zone. This approach was constrained by geologically-defined low- and high-grade gold mineralisation wireframes and informed by capped and composited core borehole data.

The underground mine plan is based on longhole open stoping on 17m sublevels, using cemented rock backfill (CRF). A dual ramp system will provide access to the underground mine from a single portal. Ore and waste rock will be hauled to the surface by 25-tonne capacity trucks. Probable ore reserves of 2.0 Mt at 11.8 gpt Au will be mined at 750 tpd over a 7.3 year mine life.

Key features of the mine include:

- High-grade gold veins with regular geometry and excellent grade continuity;
- Fast development access planned from the portal to the upper vein area that hosts some of the highest gold grades;
- Full up-hole retreat recovery of planned sill pillars to be located below high-strength CRF; and
- Contractor-operated mine startup with mid-life transition to owner mining.

SRK's feasibility study report, dated June 4, 2014, is entitled "Technical Report for the Yaramoko Gold Project, Burkina Faso".

Roxgold expects to begin production in Q2 2016.

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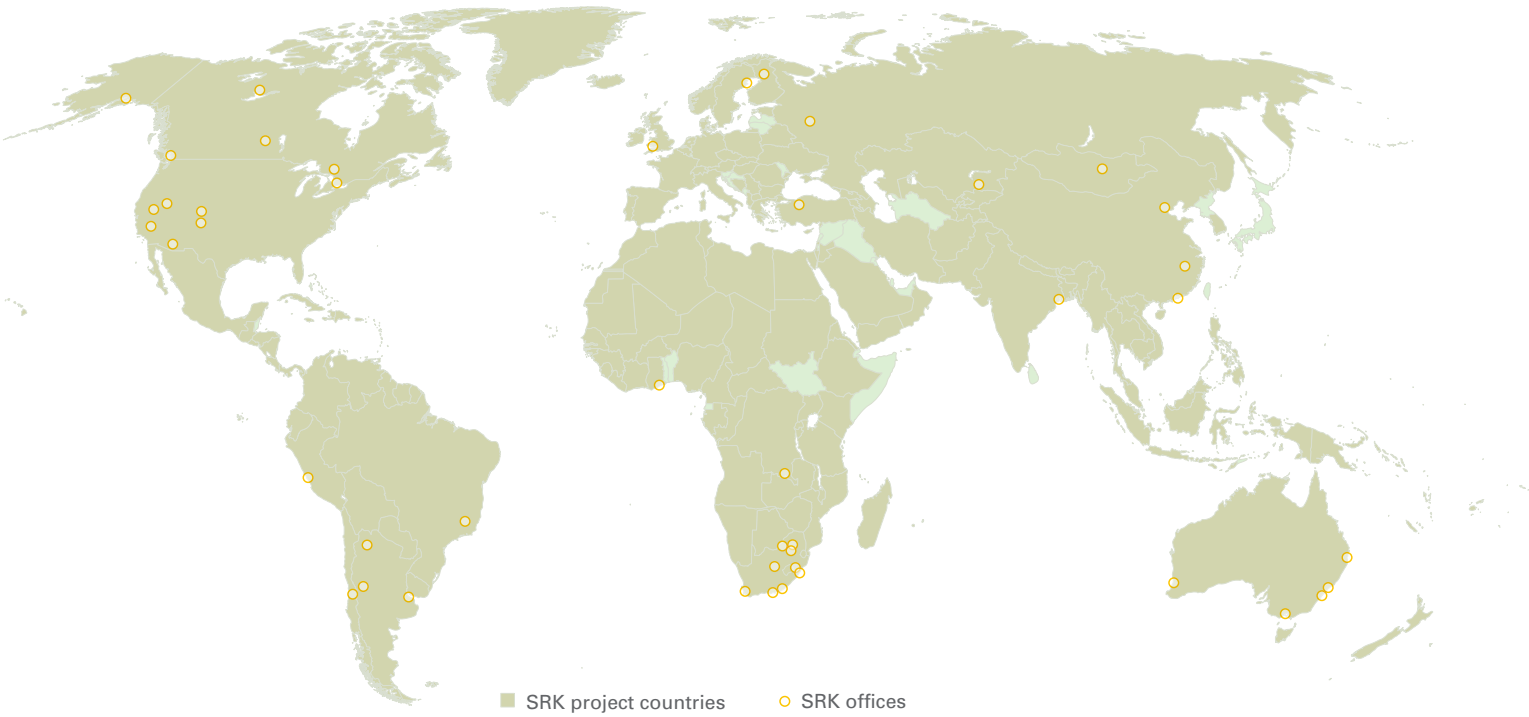

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