

1974 - 2019

No. 60
SRK Consulting's
International
Newsletter



Over 45 years, we've grown into an independent, international consultancy with 45 offices, 1,400 staff, and more than 20,000 earth and water resource projects under our belt. This newsletter features key services provided for some of these projects.

Our business activities continue to be guided by a spirit of entrepreneurialism and discovery. "Whether our clients are facing new mining challenges or seeking more efficient and cost-effective solutions to old ones, we have always aspired to be the consultancy of choice," said SRK Group Chairman and Corporate Consultant Jeff Parshley. "Many of our people have become world-class experts in their fields and strive to add significant value to clients' projects by meeting their unique needs."

Recognising the importance of accountability to our stakeholders, we support development that can be sustained environmentally, socially, and economically. We help clients assess their technical, financial, and social risks and devise cost-effective, technically sound solutions that respect local communities, comply with

international regulations, and facilitate project advancement.

Our guiding principles are largely owed to our "spiritual leader," Dr Oskar Steffen, who sadly passed away in 2018. Not only was Oskar a first-rate engineer, but his personal values greatly influenced the evolution of SRK's culture of belonging and responsibility, and reputation as a premium industry brand.

We added to our service offerings by combining with subsurface ventilation experts Mine Ventilation Services and dynamic process simulation specialists Labrecque Technologies Inc. Our multidisciplinary expertise, global knowledge, and operational experience are illustrated on the following pages.

Africa

Mandena mineral sands mine, Madagascar

SRK initiated an investigation to evaluate the geotechnical properties of the orebody sands, aimed at defining the distribution and geotechnical properties of cemented strata within the orebody, to generate a site-specific geotechnical model for the deposit. The final outcomes of the investigation included a 3D geotechnical model showing the distribution and extent of the cemented strata and the geotechnical parameter ranges associated with defined geotechnical units. The model was incorporated into the mine and production planning to optimise operational planning and control.



International airport

Cape Town International airport, one of three international airports in South Africa, currently comprises two active runways. Airports Company South Africa appointed SRK to manage the Environmental Impact Assessment for the re-alignment of the primary runway and construction of associated infrastructure. Re-alignment of the runway, built to international specifications, will allow larger aircraft to land, enable airport expansion and increase airport capacity. Impacts on surrounding communities included increased emissions and aircraft noise, potentially affecting property values, future land use planning and community health and wellbeing.



Marula tailings dam 2

Marula Platinum Mine is in the process of constructing a new tailings dam abutting their existing tailings dam. SRK completed the detail design of the new tailings dam and assisted with the Water Use Licence Application (WULA) process for the project, during 2017 and 2018. SRK is currently undertaking the construction monitoring and project management of the construction phase. Construction completion is expected by mid-2020.

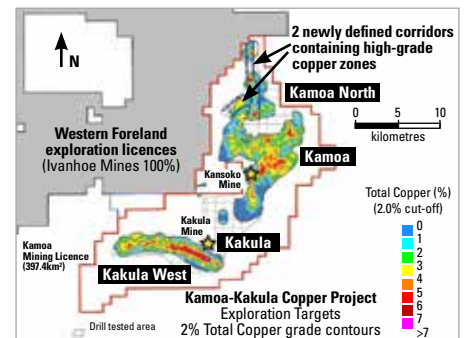


Kipushi mine

Kipushi is a past-producing, high-grade underground zinc-copper mine located in the Central African Copperbelt. In 2016, Ivanhoe mines appointed SRK to complete a pre-feasibility level mining geotechnical investigation and design. The project is currently focused on two high-grade zinc orebodies, which will be mined by longhole stoping with post-filling. Using geotechnical and structural borehole logs, scanline mapping, and ATV data, SRK produced a geotechnical block model and a structural model. Geotechnical design parameters, based on risk management strategies, were derived and include backfill strength and support requirements. SRK is now carrying out the feasibility level work.

Chris Hani District Municipality

This Municipality in the Eastern Cape has a Water Service Authority responsible for the provision of water and sanitation services. SRK was appointed to assist with emergency drought intervention programmes in 2016 and 2019. This included the drilling and testing of boreholes for rural water supply. In 2016, 36 villages formed part of the programme. Forty two boreholes were constructed for abstraction purposes at a combined yield of up to 53.55 L/s (4,626 m³/day). Thirteen villages formed part of the 2019 programme and 10 production boreholes were established to deliver a combined yield of 12 L/s (1,036 m³/day).



Environmental compliance

South Africa has a comprehensive governance framework informing environmental management compliance in the mining sector. Legislation requires mines to acquire relevant environmental authorisations for projects. Over the past two decades, SRK environmental practitioners have provided independent technical assistance to major and minor mining groups and undertaken numerous environmental, waste and water authorisations, including specialist studies and reviews for their South African operations.

Platreef 4 Mtpa feasibility study

In 2015, Ivanplats (Pty) Ltd investigated the feasibility to develop a new 4 Mtpa underground PGM mine known as the Platreef project, located on the Northern Limb of South Africa's Bushveld Complex. The orebody would be mined by longhole stoping with post-filling. SRK undertook the feasibility level mining geotechnical investigation and design. The geotechnical investigation was based on rock mass characterisation and a detailed structural analysis, to create a geotechnical block model. Geotechnical parameters were outlined for the mine design and include backfill requirements, support requirements and strategies to manage potential geotechnical risks the mine may face.

Kakula mine

The Kamo-Kakula Copper project has been independently ranked as the world's largest, undeveloped, high-grade copper discovery and comprises a near-surface, relatively flat-lying copper deposit located within the Central African Copperbelt. SRK has assisted Kamo since 2016 with the geotechnical work required to develop Kakula mine, which will be extracted by the drift and fill mining method. SRK's involvement with the project includes geotechnical investigations at the scoping and pre-feasibility levels, whereby rock mass characterisation has been undertaken and geotechnical mine design parameters and support requirements provided. SRK is currently carrying out the feasibility geotechnical investigation and design for this project.

... Africa



Stakeholder mapping

A mine's ability to maintain good stakeholder relations has become essential in managing community expectations and proactively addressing legacy issues. In 2015, SRK was appointed by a major mining company to conduct stakeholder mapping of three of its mines in South Africa. The purpose of the assignment was to identify key external and internal stakeholders, ascertain their perceptions and behaviours, and identify measures to strengthen relationships - with the findings informing responsive stakeholder engagement plans. Understanding stakeholder dynamics is key to maintaining a mine's social license to operate.



National Resettlement Framework

The expansion of projects in Guinea is encroaching on communities, necessitating resettlement. Careful management is required to guide these processes and ensure positive and sustainable outcomes for affected peoples. Suitable legislation or a clearly defined and enforced framework is not in place, so resettlement happens in an ad hoc fashion. In 2018, SRK was commissioned to develop a National Resettlement Framework. It is intended that a government decree be developed and signed into law, making the framework legally binding and enforceable.



Hydropower plant

In 2016, SRK was appointed to act as the Environmental, Health and Safety Manager for a 9 megawatt hydropower plant. The plant is located on the Nkusi River on the border of Hoima and Kibaale Districts, Western Uganda. The key project structures are comprised of a concrete gravity weir, intake structure leading to a penstock (pipeline) and, subsequently, the power station. The penstock is located in a 905 m long tunnel constructed through an escarpment adjacent to Lake Albert. SRK was responsible to ensure that the project ran in accordance to the International Finance Corporation Performance Standards, and to uplift local HSE team skills.



South African Power Pool (SAPP)

SAPP coordinates power utilities to support development and identify priority power projects. Many of these projects are not currently bankable because they have not adequately identified and assessed environmental and social issues. SRK developed an Environmental and Social Management Framework which the World Bank approved in 2018. It includes a set of tools to assist personnel, including checklists; management plan examples; and lists of accepted environmental and social requirements to guide utilities and independents to screen key power projects that meet lenders' requirements to ensure bankability and support implementation.



Bisha mine

Bisha is a polymetal operating mine in Eritrea, in the Horn of Africa. SRK's team participated in multiple projects and provided operational assistance to this mine from 2014 to 2019. The work included annual reserve updates, strategic mine planning studies, pit optimisation, production schedules, equipment selection, detailed mine design, targeted short training modules for local National Mining Engineers, Geologists and Metallurgists, structural geology studies, mineral processing reviews and assistance for a highly complex mineralogy. SRK's team assisted Bisha to overcome challenging technical issues over this period.



Sasol South Africa Limited

Sasol appointed SRK as the independent Environmental Assessment Practitioner (EAP) to facilitate the environmental authorisation processes associated with the construction and operation of the Sasol Secunda Fine Ash Dam (FAD) 6 project. The FAD 6 project plays a crucial part in the life extension of the Sasol Secunda operations facilities until 2050. Sasol Secunda Synfuels Operations awarded the 2017 Excellence Award for stakeholder/customer focus team of the year to the Project Phase 1 project team. The award recognises the contributions made by the multi-disciplinary project team which enabled the construction of the FAD 6 to proceed.



Solar energy development

In the last decade, the South African government recognised that a stable electrical grid would require sustainable energy generation and made the decision to promote the renewable energy sector. In 2011, SRK was appointed by Sato Energy Holdings to undertake the environmental authorisation process of a large-scale 500MW solar energy development in the Northern Cape province of South Africa, covering approximately 900 hectares. Through careful alignment of the photovoltaic array and detailed project management measures, impacts on sensitive ecological habitats were either avoided or minimised. This project has since been developed.



Maputo harbour

An engineering geological study of the entire seafront of the Maputo harbour, in Mozambique was conducted between 2013 and 2014. The investigation consisted of 132 rotary core boreholes to average depths of about 25 m; 8 piezo cone penetrometer tests (CPTu) were also conducted and 104 boreholes were drilled in 4 parallel transects on land and over water at existing berths while 28 boreholes and CPTu testing were conducted over water, at potential new berths. In soft material, continuous down-hole standard penetration tests (SPT) were performed. The Maputo Port Authority used the results of the investigation to inform engineering design of new berths and for the upgrade of existing infrastructure.

... Africa



Strategic planning

In Uganda, economic growth has had a negative impact on the environment, to the extent that environmental degradation has resulted in a decline in economic growth. The cause of this degradation is inadequate environmental governance. While Uganda does have strong environmental institutions in place, insufficient funding to implement policies and laws has compromised environmental governance. SRK and a Ugandan partner were appointed by the United Nations Development Programme to compile a Strategic Environmental Plan for the Ugandan government to guide environment management for the next decade.



Panda Hill feasibility study

SRK was retained by Cradle Resources to undertake the mining and geotechnical components of the pre-feasibility and feasibility studies for the Panda Hill Niobium project in south west Tanzania. SRK undertook mine planning, including pit slope design and geotechnical characterisation for open pit and mine infrastructure, open pit optimisation, mine design, production scheduling and cost estimation. Plant site foundation analysis and design were also completed for the feasibility study.



Koumbia mineral resource

SRK prepared Mineral Resource estimates and models for 11 bauxite deposits in Alliance Mining Commodities' Koumbia Mining Concession area in Guinea to support a definitive feasibility study. The study focused on the extraction of export quality bauxite from selected deposits and transportation to a river port facility. Upon completion of the resource modelling study, SRK was commissioned to design and manage an exploration programme aimed at the collection and characterisation of material suitable for the preparation of marketing and metallurgical samples.

Mbombela: development of a Climate Change Response Policy, Strategy and Implementation Plan

In response to the pressures and threats of climate change, it is essential that all levels of government, nationally and globally, develop a policy, strategy and implementation plan. South Africa's climate change policy framework has been in development since the early 2000s. South Africa ranks high among the world's most significant carbon emitters per capita; it is therefore appropriate that the country signed up to the Paris Agreement on climate change and agreed to a peak, plateau and decline trajectory that will see carbon emissions from fossil fuels (mainly coal) continue rising until 2030 – after

which they should level out until 2035 and then start dropping.

In 2015, SRK was appointed by the Mbombela local municipality to assist with the development of these documents to enable and guide the municipality's transition to a green economy and to mitigate and manage climate change risks. The project is comprised of 3 phases, namely a Climate Change Response Policy, Climate Change Mitigation and Adaptation Strategy and an Implementation Plan for the Climate Change Mitigation strategy.

The process involved extensive engagement with sectoral stakeholders in the municipality, province and national ministries.

This approach ensured the identification of key issues that needed to be taken account of and addressed in the Climate Change Policy and Strategy.

The team worked closely with officials from the Mbombela Local Municipality in developing an implementation plan that could be effectively implemented through municipal structures and processes.



Genmin exploration support

Since 2014, SRK has supported Genmin's exploration of iron ore properties in Gabon and the Republic of Congo. SRK's involvement has included structural mapping, geological interpretation of ground and airborne geophysical data, drilling assistance, development of sampling programs and resource estimation assistance. SRK has also provided independent valuations of Genmin's assets to the company and their private equity partners. SRK continues to support Genmin's staff in the field with training, technical assistance and as a French-speaking liaison to the Government and Gabonese stakeholders.



Tasiast coarse beneficiation

SRK has been working with mining companies to assess the potential to upgrade or pre-concentrate feed ahead of the process plant. This can be done through a combination of screening, bulk sorting and particle sorting. At the Kinross Tasiast operation in Mauritania, SRK conducted bulk screening trials to determine the upgrade potential of low to medium-grade stockpiles. The fine fraction would be sent to the plant while the coarse fraction could be heap leached. In addition, SRK has developed lab protocols on drillcore samples to estimate where the valuable metal will report to: coarse, medium or fine fractions.



Port Loko bauxite

SRK has provided technical assistance to SierraMin Bauxite Holdings Ltd for their Port Loko bauxite project in Sierra Leone since 2008. The project has grown from an early-stage exploration project through to trial beneficiation and mining in 2019, with full-scale mining expected to commence in 2020. SRK has provided multi-disciplinary input to technical studies, as well as guiding exploration, undertaking mineral resource estimates and providing training to Company staff.

... Africa

Meya mine, Sierra Leone

SRK has been involved in the project since 2016, assisting in geology development and bulk sampling. The Meya project is a field of significantly diamondiferous, steeply dipping kimberlite dykes and is geologically associated with the Koidu Mine. One of the features of the Meya dyke is the presence of high-quality diamonds, including large, rare Type IIa diamonds. These diamonds are only recovered from three other primary diamond deposits globally. SRK and the Meya team are working to better understand the morphology of the dykes as well as the diamond grade and value for resource estimation and mining.



Letšeng, Lesotho

The Letšeng Diamond Mine is the lowest grade primary diamond deposit presently being mined globally and it contains some of the world's largest and highest value diamonds. Due to the very low grade of the various rock types being mined, resource development is challenging. Traditional evaluation methods are often not feasible. Resource development and extrapolation of grade and value requires an understanding of the volcanic history which is developed through petrography and geological mapping. SRK has been involved in geology development and training at Letšeng for the last 5 years and is presently involved in updating the current 3D geology models and mineral resource in support of mine planning activities.



Rwanda Mines

SRK was contracted by the Rwanda Mines, Petroleum and Gas Board (RMB) to carry out exploration and evaluation of seven selected targets across Rwanda for multiple commodities. SRK led the exploration in Rwanda, shadowed and supported by RMB staff who received training in geochemical sampling, mapping and trenching. Gold, tantalum-tin-lithium and sapphire projects were advanced to the drilling or bulk sampling stage and RMB were supported during marketing events in London.



Lucara's Karowe diamond mine

Lucara is a leading independent producer of large, exceptional quality Type IIa diamonds from its 100% owned Karowe mine in Botswana, the only diamond mine in recorded history to have produced two +1000 carat diamonds. A positive feasibility study for a potential underground operation was completed in Q4 of 2019. SRK was retained to undertake data collection and interpretation for an extensive geotechnical drilling program and to complete further updates to the geological model and mineral resource based on the new drilling.

*Photo caption:
1109 ct Lesedi La Rona, recovered in Nov 2015, on a sample of its kimberlite host: EM/PK(S)*

Asia

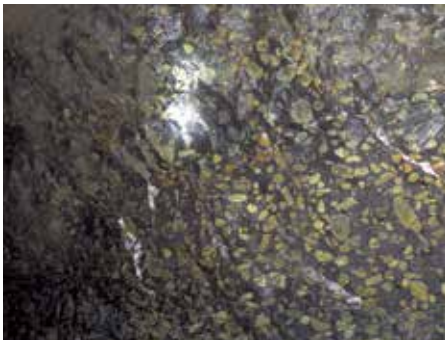
Drone photogrammetry

In 2019, SRK was retained by a limestone mining company in India to review the mine geotechnics, assess opportunities for slope steepening and to develop a slope management programme. The deposit occurs in a structurally complex terrain with varied orientation of strata and joint systems typical of a folded sequence, warranting detailed structural assessment for bench-berm optimisation. A drone-based photogrammetry mapping programme was adopted using predefined flight

and automated imaging at variable camera angles.

The resulting photogrammetry model was used to develop a comprehensive 3D structural model. A kinematic analysis helped to develop an optimal bench-berm configuration to result in improved economics.

A slope management scheme was also proposed to consider the specific structural conditions.



Fuli Peridot Industry Co. Ltd.

In 2017, SRK was retained by Fuli Peridot Industry Co. Ltd. to provide technical services on its Yiqisong peridot project in Yanbian, Jilin province, China, contains more than one billion carats of gem quality peridot, occurring in peridot sand inclusions in basalt. Since 2017, SRK conducted QA/QC on its exploration, estimated JORC Resources, and prepared a technical report. Fuli is now preparing to list the project in the Stock Exchange of Hong Kong Limited.



Red Bull copper project

In 2015, SRK was commissioned by Goldstone Investment Co. Ltd. to review a copper project in Shangri-la, Yunnan province, China as a potential investment. The Hongniu (Red Bull) copper project was under construction at the time. Once commissioned, underground mining methods will be used to supply 4,000 t/day of feed to a processing plant in order to produce copper concentrates bearing silver. SRK reported its Mineral Resources according to JORC code, converted Ore Reserves, and carried out economic analysis. SRK's report supported Goldstone's subsequent acquisition of the project.



Grand T G Gold Holdings

In 2016, SRK was commissioned by Grand T G Gold Holdings Ltd. to provide an independent technical review on the Haochayu-Ganxiewa-Xipo Gold mine. The gold mineralisation consists of a series of quartz-sulphide and sulphide veins, veinlets, stringers, and disseminations in a structurally complex assemblage of Archaean gneisses and amphibolites that have been intruded by granitic bodies. SRK conducted data verification, geological modelling and Mineral Resource/Ore Reserve estimation according to the JORC Code, and prepared a technical report. The report was used by Grand T G in the resumption of trading on the Stock Exchange of Hong Kong Ltd in 2016.

... Asia



Ciemas gold project

From September 2017 to October 2018, SRK led a feasibility study and collaborated with China Nerin Engineering Co. Ltd. on the Indonesian Ciemas Gold Project owned by P.T. Wilton Wahana Indonesia, a company listed on the Singapore Stock Exchange. The project has four mineralised sections. SRK proposed to develop two underground mining systems to mine 300 t/day and 1,200 t/day, respectively. A back-filling mining method was used in the study. The ore will be processed by flotation to produce gold concentrate, which can be exported in initial operating years, and thereafter will be further roasted and milled, and then undergo a carbon-in-leach cyanidation process to produce gold doré.



Hindustan Zinc Ltd.

SRK has provided consulting assistance to Hindustan Zinc Limited for their multiple operating mines and projects located in India since 2005. The commissions initially commenced from a London Stock Exchange Listing Competent Person's Report and since then has comprised the annual auditing of the Mineral Resources and Ore Reserves, providing training and mentoring and undertaking technical studies. Vedanta, the parent company, expanded SRK's role in 2018 to include its global assets in India, South Africa, Zambia and Namibia.



Bunda Kandung

In 2017, Agritrade, a Singapore-based company, appointed SRK to conduct a gap analysis for the Bunda Kandung open pit coal project, located in the jungle areas of Central Kalimantan. SRK assessed the project's available technical data compliance against the JORC Code 2012. A site visit was conducted and a number of gaps were identified. SRK prepared a Gap Analysis Memo including technical measures of infill drilling, topographic survey, etc. and recommended subsequent measures for the company to close those gaps. SRK was also engaged to conduct technical due diligence reviews on several Agritrade projects located in Indonesia and China.

Oman mining strategy

In 2017, SRK was appointed by the Public Authority for Mining as lead consultant of a consortium with Wood Mackenzie Limited and Mayer Brown LLP to deliver a multi-disciplinary review of the Oman mining sector and develop a strategy to support the sector's development over the next decade, laying the foundation for its long-term sustainable growth.

The strategy considered:

- Maximising the economic value of the Oman mining sector
- Managing the sustainable development and utilisation of mineral resources

- Developing national assets and capabilities to ensure long-term sustainability
- Maximising the contribution of the mining sector to the quality of life in Oman

Oman possess a diverse range of geological terranes and therefore the commission needed to consider both metalliferous and industrial mineral opportunities.

Each commodity was assessed in terms of the technical considerations when defining and assessing potential

exploration targets, mineral deposits, development projects, and operations. These were influenced by economic factors, including logistical and downstream constraints/opportunities and the international supply and demand process.

The strategy highlighted the opportunities to create a more attractive commercial environment for developers and operators, whilst also identifying a range of opportunities in a variety of commodity value chains, that would significantly increase the mining sector's contribution to the Oman economy.



Sepon closure planning

SRK assisted with the development of pre-feasibility level closure plans for Sepon, a large open-pit copper mine in central southern Laos. The mine site included more than 40 pits, some backfilled, and 13 waste rock dumps. SRK reviewed the main risks, evaluated closure options and developed recommendations for each area. Conceptual closure designs for waste rock dumps and pits were developed incorporating both passive and active water management infrastructure. The required closure works were described for each mine area, on a catchment by catchment basis.



Caculo Cabaça Hydropower

In June 2016, SRK was appointed to conduct pre-financial close due diligence and a series of regular independent compliance reviews, and thereafter every six months to assess project performance against Equator Principles (EPs) during the construction phases. This is the first major EPs compliance project in Chinese history, with challenges including establishment of the EPs concept for upper management, preparation of environmental and social management systems, and implementation of environmental and social measures and fulfillment of community development. After the most recent audit in July 2019, the project is back on track in compliance with EPs.



Bukit Besi SGX listing

SRK completed a Qualified Person's Report and Independent Valuation of the Bukit Besi iron project in Malaysia. The work was done in support of Fortress Mining's successful listing on the Catalist, the secondary board of the Singapore Stock Exchange (SGX). The Independent Valuation Report was prepared under the Rulebook of the Catalist Board and the guidelines of the 2015 Edition of the VALMIN Code. On 27 March 2019, Fortress Minerals Limited commenced trading on the Catalist of Singapore Exchange Securities Trading Limited under the ticker symbol SGX.OAJ.

Australasia



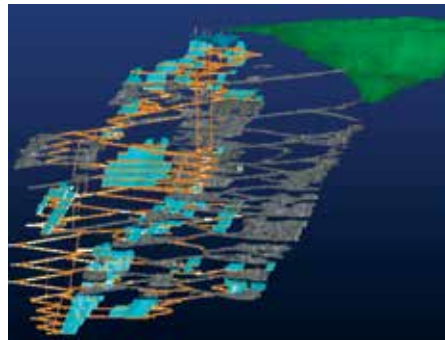
Mount Isa closure designs

SRK developed final landform designs for all Mount Isa Mines' major landforms, including tailings storage facilities, waste rock dumps, major residual stockpiles and infrastructure areas in accordance with the closure goals and availability of rehabilitation materials and water management. SRK developed waste rock dump landform designs by undertaking stability, erosion and cover infiltration modelling and provides on-site support for grade control of the cover at the Handlebar Hill Waste Rock Dump.



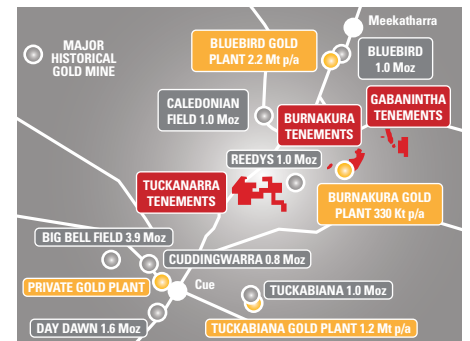
Century Zinc water quality studies

SRK completed a series of technical studies to support closure planning at the Century Zinc mine, a large open cut zinc, lead and silver mine located in North West Queensland. The objectives were to improve the understanding of the water quality that may develop in the pit lake post closure, and to assess potential post closure impacts on the local and regional surface water and groundwater receiving environments.



Woodlawn u/g mining study

SRK completed the underground mining engineering components of a Feasibility Study for Heron Resources' Woodlawn Project. Woodlawn is a volcanogenic massive-sulphide (VMS) copper-zinc deposit comprising two significant resource-based assets, the Woodlawn Underground Project (WUP) and the Woodlawn Tailings Retreatment Project (WRP). SRK prepared mine designs, developed ventilation plans, outlined power demand and water requirements, produced personnel and mining equipment schedules and prepared a Mineral Reserves estimate.



Burnakura

SRK prepared an Independent Technical Report in accordance with Canadian National Instrument 43-101 and an update of the Mineral Resources for Monument Mining's Burnakura project in Western Australia. SRK reviewed all available data over the project's 20-year history and undertook additional geological interpretations to inform the updated Mineral Resource Estimates, which will allow for refined targeting of proposed drilling programs to extend and infill the mineralisation and achieve a higher confidence and enlarged Mineral Resource. The review of the data and its relationship with the mineralisation has allowed for improved targeting of future drilling resources and refining data collection practices.



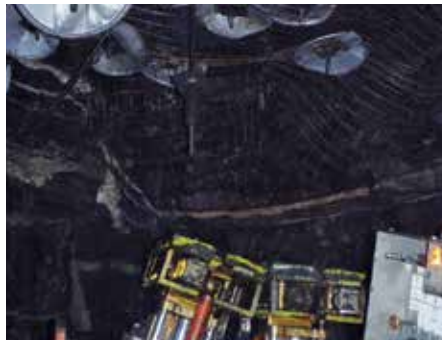
Freida River integrated storage

SRK undertook a multi-disciplinary design of an integrated hydroelectric power, mine waste rock and tailings storage facility. The design features a 190.5 m high asphalt core rockfill dam, two diversion dams, a 35.5 m high cofferdam, two diversion tunnels, and hydropower intake and conveyance system linked to a turbine facility, and a side-hill spillway. Designing for this unique setting presented challenges including the remote location, 8 m of rainfall per annum, high seismicity and steep terrain. SRK undertook complex 3D limnological modelling to characterise the behaviour of the waste rock and tailings planned for sub-aqueous disposal into the reservoir.



Capricorn Copper

SRK provided Capricorn Copper with independent reviews of the development and reporting of resource estimates under guidelines for best practice and the JORC Code for orebodies at its Capricorn Copper Mine in North Queensland. The mine is one of the largest copper development projects in Australia. The reviews cover several groups of technical criteria as Capricorn Copper reaches milestones in the re-development and operation of the mine. This ongoing review process allows any issues to be highlighted early in the process and improved upon rather than at the end of the resource estimation.



Structural modelling

SRK was first engaged in 1999 to review an underground coal mine's structural interpretation, following a series of complex unexpected faulting which had a serious impact on panel development. SRK developed an alternative structural model and has since provided ongoing review and recalibration of the model. The modelling approach has also been extended to other project areas in the Western Coalfield. In recent years, the client is using the structural models, along with on-site geotechnical and surface and groundwater monitoring systems and a customised spatial and temporal data analysis tool to evaluate and better understand the interactions of groundwater behaviour and mine subsidence.



Croydon

SRK prepared an Independent Specialist's Report, consisting of a technical assessment and valuation of Crater Gold Mining's base metal, graphite and gold exploration assets comprising the Croydon Project in Queensland, Australia. The report was prepared under the guidelines of the VALMIN Code (2015), which includes the JORC Code (2012). SRK conducted a high-level review of the available technical information, including historical estimates of quantities and grades. SRK also assessed the project's geology, Mineral Resources, exploration and project risks to determine the validity of such information from a valuation perspective.

Europe

Cukaru Peki, Serbia

SRK was engaged to undertake studies on the Cukaru Peki upper zone. Prior to the PEA in 2017, SRK undertook an access and haulage study followed by a mining method assessment study and was responsible for the geology, geotechnical engineering, mine planning, cost estimation, closure planning, technical economics, risk assessment facilitation, and study management of the 2017 PEA and NI 43-101 report. After the PEA, the mining team undertook optimisation studies and the eventual mine planning and costing in the PFS. SRK was also engaged during the FS mine engineering and geotechnical work until the project was sold in early 2019.



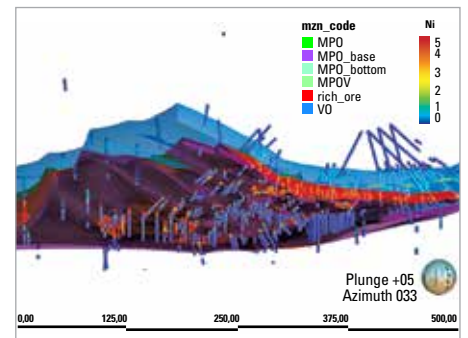
Underground mine, Kazakhstan

SRK completed a trade-off study of ore transport options between an operating mine and an external processing facility (road, rail, overland and aerial conveyor conveying/ropeway) to assess technical feasibility and to estimate capital/operating costs. The objective was to determine the best option to replace the current complex, high-cost logistics system. An economic evaluation showed the road haulage or overland conveyor options would provide significant savings compared to maintaining the existing system for the remaining 14 year mine life.



Almalyk

SRK undertook a maiden JORC compliant MRE and PFS for the Almalyk mining and metallurgical complex in Uzbekistan. This state owned mine is one of the largest copper porphyry deposits in the world, currently processing 35 Mtpa of ore from two open pits. SRK designed and supervised a verification drilling program, and a multidisciplinary PFS that justified a production increase to 100 Mtpa. The MRE presented a resource of 17 billion tonnes containing 44 million tonnes of contained copper and 184 million ounces of gold, making the United Mine one of the largest gold deposits in the world. SRK also undertook an exploration program that identified 25 targets in the vicinity.



Norilsk

Norilsk's Oktyabrskoe and Talnakh deposits are the largest Ni-Cu-PGE deposits in the world. The deposits have been operated by five underground mines for more than 30 years. In that time, a large volume of resource and grade-control data for multiple elements was collected. SRK prepared geological models for all five mines within seven months using Leapfrog software. The task involved creating litho-structural models, reviewing the approach for delineating the higher-grade and lower-grade ores and reassessing the correlation of the principal minerals. The result was a detailed model which can be used for mine planning.

Woodsmith mine

SRK has worked with Sirius Minerals on its polyhalite project in North Yorkshire, UK since 2010. Sirius is currently constructing a deep shaft mine, to around 1500 m below ground level to produce some 10 million tonnes of polyhalite per year in its first phase.

SRK has been involved during exploration, feasibility studies and construction, and most recently providing Competent Persons' Report in support of the company's listing in London and fund raising. SRK developed the geological model and worked with the Company to design the mining method.



DNK mine Phase 2

Since 2011 SRK has been involved with the DNK mine which exploits a world class chromite deposit located in north-west Kazakhstan, operated by the European Resource Group. In 2014, SRK undertook a technical study on implementing the inclined caving method. In 2017, SRK was part of a team to determine growth opportunities at DNK and ERG. Since 2018, SRK has been part of the ERG owner's team, working on the preliminary feasibility study of mechanised caving methods and undertaking hydrogeology studies.



Gold mines of Wales

SRK completed geochemical soil sampling on behalf of Alba Mineral Resources plc (Alba) in the historic Clogau-St David's gold mine located near Dolgellau in North Wales, UK. The mine is in the Dolgellau Gold Belt, which has been mined since Roman times and is famed for producing the gold used in the wedding rings of the British royal family.

SRK has worked with Alba on several studies over the last five years and provided field services during 2018 and 2019. The study included the collection

of regularly spaced soil samples across nine kilometers of strike length and providing targets for further exploration work. Since completing this commission, Alba has also rehabilitated the historical underground workings at Clogau and conducted a preliminary drilling programme investigating near-mine targets, yielding positive results ahead of further exploration work in 2020.

... Europe



Blagodatnoye gold mine

The Blagodatnoye gold mine is a large operation in central Russia operated by Polyus Gold. The deposit is characterised by strong bedding and structural features. Slope stability is further complicated by the presence of a stream and groundwater which creates high pore pressure in the rock mass and weakens some rock types.

Teams from SRK's offices in Russia and Chile jointly collected geotechnical and hydrogeological data and prepared a series of geotechnical block, structural and hydrogeological models

to determine suitable slope designs and water management strategies. SRK also evaluated the impact of blasting on the wall rock strength and then determined the risk of failure for each part of the pit, considering local variability of rock mass properties. We developed a series of slope and water control strategies based on the consequences and probability of failure estimation.

As a result of these studies, the client has been able to achieve more stable, optimised slopes.



Gypsum mine

Gyproc in Ireland, part of the French company Saint-Gobain, extract gypsum from shallow underground room and pillar mines and an open cut located in County Monaghan, Ireland. SRK have been involved in providing underground geotechnical services at the mine since 1998. The work has included geotechnical characterisation and assessment of room and pillar stability, geotechnical hazard and risk assessments, annual regulatory geotechnical audits of mining operations, assessment and analysis of surface subsidence potential and numerical modelling to assess the impact of undermining below 3rd party surface infrastructure.



Curraghinalt mine

The Curraghinalt mine will be the first underground mine permitted in many years in Northern Ireland. The proposed mine will produce gold, silver and copper. It is expected to have a mine life of at least 20 years. SRK have worked on the project for over 8 years, initially on the provision of studies for baseline and scoping work and subsequently on the mineral resource estimation, dewatering assessment and waste management. SRK have also managed the Environmental and Social Impact Assessment and authored the Environmental Statement, involving collaboration with the engineering team, the planning advisors and legal review teams.



SUEK

SRK has, in 2019, once more undertaken Coal Resource and Reserve audits on behalf of SUEK in Russia. This included mobilising teams of experienced coal specialists for visits to SUEK's 40 open pits, underground mines and processing plants. SUEK is a coal, heat and power company and a supplier to the international coal market, producing more than 100 Mtpa, with headquarters in Moscow and operations across Siberia and east Russia. Underground operations, mostly in the Kuzbass Coal Basin, and many open pits supply hard coal for both internal and export markets. Brown coal operations, mostly in the Krasnoyarsk region, supply nearby power plants.

Sakatti project

Significant technological design challenges have been overcome to advance this world-class polymetallic VMS project in an area of protected biodiversity in Finland. SRK technical teams provided pre-feasibility study design solutions for mine access, ore extraction and waste management that won't disturb the overlying Natura 2000 protected wetlands which host wild fauna and flora in an arctic habitat. The mine is designed to have no subsidence. Operations will use electric equipment to limit emissions. To manage waste, cemented paste backfill/waste-rock will be placed in underground voids, and benign tailings will be dry stacked on the surface.



Bystrinskoye

From 2006 to 2008, in cooperation with Russian design institutes in St Petersburg, SRK prepared a Metallurgical/Processing Technical Study for the 10 Mtpa Bystrinskoye copper concentrator in Siberia. This study included laboratory and pilot testing, flowsheeting, equipment definition, layouts and calculation of capital and operating costs. In 2017, SRK reviewed the project status during plant commissioning. The concentrator was very similar to the original SRK study and has since come online successfully, producing gold, copper and magnetite concentrates.



Kazatomprom

On November 13, 2018, Kazatomprom made its stock market debut in London and Astana with an implied valuation of US\$3bn on initial trading. In support of the listing process, SRK authored a Competent Persons' Report on the uranium Mineral Assets of Kazatomprom and authored simultaneous Competent Person's Report in English, Russian and Kazakh languages as part of a detailed multidisciplinary due diligence process. By measure of attributable production from its 26 producing properties, Kazatomprom was the largest producer of natural uranium globally in 2018 as well as being the second lowest cost producer.



Norge Mining

Norway's Bjerkreim-Sokndal layered intrusion is the largest in Europe at 230 km² and hosts important Ti-P-V deposits. It is covered by Norge Mining PLC's exploration licences. Norge Mining engaged SRK ES in 2018 to develop the project. Our exploration has validated and expanded on historical interpretations and discovered extensions of mineralisation and new zones. Geophysical surveys in 2019 suggest a deep sulphide target. We have also completed an ESG review and advised on stakeholder engagement. We will continue our excellent relationship with Norge Mining in 2020, and anticipate an exciting expansion of operations.

North America



Long Canyon mine, Nevada

SRK was selected by Newmont Mining Company to conduct baseline hydrogeologic studies to support dewatering plans and predict impacts from dewatering associated with a planned mine expansion. SRK assisted Newmont with numerous field activities, including the installation of a monitoring network in an adjacent large springs-and-wetland complex, and conducting pumping tests. The hydrogeologic investigations focused on obtaining a better understanding of a carbonate aquifer, the degree of hydrologic connection between the carbonate aquifer and abutting basin-fill aquifer, and the interaction of both aquifers with the wetlands. SRK also developed geochemical and

pit lake models and assisted with the construction of a pilot Rapid Infiltration basin (RIB) to predict RIB performance and to help evaluate candidate locations. The results of the field programs produced a body of work that led to the development of a regional-scale, multi-basin 3D numerical groundwater flow model. Once calibrated, the model provided dewatering estimates during the LoM and estimates of impacts to groundwater which included the wetlands, and a municipal water supply well field. SRK worked with Newmont during technical discussions in meetings with the regulatory agencies which have accepted the groundwater flow and pit lake models as baseline studies to the EIS that is in preparation.

Hermosa

SRK remains heavily involved in the South 32 Hermosa project in southern Arizona. This work focused on developing a robust geological model, scalable to support regional exploration as well as detailed feasibility study work for resource estimation purposes, geometallurgy, and rock mechanics. SRK also played an integral part in developing the complex structural model, which will underpin the current PFS effort. For almost three years, SRK has been an instrumental member of the development team for this Tier 1 base metal project.

Copper Mountain mine

This open pit copper mine near Princeton, British Columbia, resumed production in 2011 after the mine's 1996 suspension.

A permit condition of resumption was the segregation and separate management of waste rock with potential for acid rock drainage even though ARD had not been seen at the site during a century of mining. Any potentially acid-generating (PAG) rock remaining after mining was to be re-handled, used as backfill, and covered with water to prevent oxidisation.

Since the reopening, SRK has annually helped interpret monitoring data collected as part of waste rock and tailings management plans. Samples of non-PAG rock confirmed its non-acid-generating characteristics, and samples of PAG waste rock indicated low ARD potential.

Through a statistically-designed sampling program, SRK confirmed its observation that while bulk rock could be PAG, blast fines were consistently non-PAG. Based on this, our client asked for its permit segregation

requirement to be removed. The government approved this provided an enhanced monitoring program was designed with alert levels specified for segregation resumption.

Increasing waste rock placement options and decreasing re-handling have reduced operation costs.



Gahcho Kué

SRK was the Independent Engineer for the Lenders \$370M debt financing for Mountain Province. Gahcho Kué, located in the Northwest Territories, is a joint venture between Mountain Province Diamonds and De Beers, 49% and 51% respectively. SRK's multi-disciplinary team completed the desktop review and site visit, and identified risks including the logistical access to the site. All construction materials and fuel had to be transported by ice road from Yellowknife, which only operates during February and March. After a successful season the Lenders and Mountain Province closed the deal. At the end of construction monitoring, SRK will conduct completion testing.



Centerra Gold, BC

SRK developed a production simulation of the mine design for the extraction level of the Kemess Underground block cave mine. The model scope included production LHDs, secondary breaking equipment, rockbreakers and crushers. The simulation was used to predict future material handling performance based on various PC-BC production schedules, perform routing sensitivity analysis, predict quarterly fleet requirements, and quantify the effects of design parameters on traffic interactions and fleet efficiency. The model was also used to test and optimise the location of the crushers.



Closure projects

SRK has been involved in the closure and Asset Retirement Obligation (ARO) cost estimation for a client with seven mines located in four different states in Mexico. The ARO costs are currently being updated every two years, involving a continuous collaboration with the client. SRK has identified new opportunities to optimise the closure strategy and decrease closure costs based on site specific information generated by scientific and engineering studies. SRK has also provided training to the project staff, helping them to understand the closure process as a multidisciplinary effort.

... North America



Caving

In the past three decades, modern mechanised cave mining has proven to be a successful mining method for the exploitation of large low-grade deposits that could not otherwise be economically extracted. In this decade, cave mining projects are moving to new frontiers with higher desired production rates, stronger rock masses, high caving lifts and greater depth than in the past.

The increasing speed of computing and the sophistication of numerical modelling codes enable experts to model more complex mining problems.



Robinson copper mine, Nevada

SRK assisted with management of the new tailings storage facility (TSF) in 1996, and has provided a wide variety of engineering, permitting and closure services. From engineer-of-record through the 20-year life of the original cycloned-sand TSF design, to design/permitting and phased annual construction of a 60-foot vertical TSF expansion (with 4 miles of new compacted-alluvium perimeter embankments), to development/implementation of closure plans for leach pads/dumps/seeps, to design/construction of 5 evaporation cells, to pumping/piping designs, reclamation planning/costing, SRK has had two decades of challenging and rewarding work through four mine operators.



Faro mine, Yukon Territory

The Faro mine was once one of the world's largest lead and zinc mines. The mine closed in 1998, when the operator became insolvent, leaving behind a legacy of 320 million tonnes of acid-generating waste rock and 57 million tonnes of acid-generating tailings. At that time, the federal government assumed responsibility for the site, including managing the site to limit off-site impacts until a closure plan can be designed and implemented.

SRK's involvement in closure planning began during the mine operations in the 1980s. Today, SRK leads an expert team that brings together both scientific disciplines (such as geochemistry,

hydrology, and revegetation) and engineering disciplines (such as civil, geotechnical, hydrotechnical, water resources, and water treatment). This expert team must consider the long-term future of the site, including the challenges posed by a changing climate and thawing permafrost. Our primary role is to develop the engineering designs necessary to advance the Faro Mine Remediation Plan through regulatory and early implementation phases and to prepare for the full-scale remedial works necessary to mitigate long-term environmental risks. We also provide expert support to site management in areas of geochemical characterisation, water management, and design of interim remedial works.

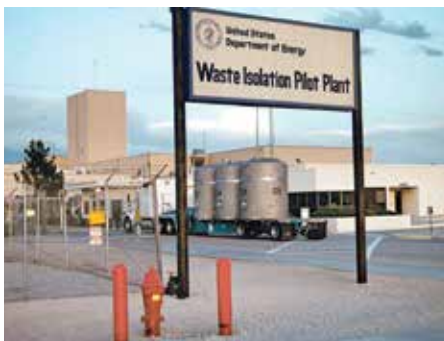
However, sophisticated visualisation is ahead of predictive reliability for many numerical models. The challenge is not only the complexity, but the need for accurate input information, which is typically only available after the cave is operating. The success of predictive models without comprehensive calibration, especially for greenfield projects, is not very high and does not necessarily increase confidence in the design compared to other empirical tools and benchmarking. Basic cave mining principles have been postulated and proven. Moving to a new frontier requires an update of those basic principles in light

of new experience. Dr Dennis Laubscher was instrumental in the development of such techniques. He recently celebrated his 90th birthday and his appetite for news from the cave mining world has not diminished. We would like to wish him all the best for the next decade.

Although cave mining was very successful in the past two decades in safety improvements, the increasing awareness of environmental legacy to future generations will also require reconsiderations for responsible mine decommissioning and closure.



Dr Dennis Laubscher
and Jarek Jakubec



Waste isolation pilot plant

In 2014, a radioactive release occurred at the Waste Isolation Pilot Plant (WIPP), an underground nuclear waste repository near Carlsbad, New Mexico, contaminating parts of the facility. SRK's ventilation engineers were brought in to help with recovery efforts by developing ventilation schemes for operation with limited airflow, strategies for recovery, and the design and modelling of a new interim ventilation system. SRK engineers also designed the long-term ventilation system, specifying the airflow needs for the future of the facility. In 2017, WIPP resumed its mission of nuclear waste emplacement, the primary goal of nearly three years of recovery efforts.



Twin Metals, Minnesota

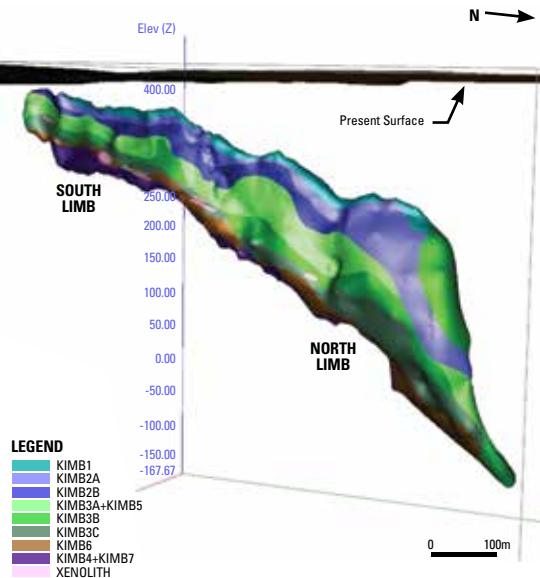
Beginning in 2015, SRK has been providing environmental consulting and permitting expertise to Twin Metals, a subsidiary of Antofagasta plc, for the development of an underground copper, nickel, platinum, palladium, gold and silver mine in northern Minnesota. SRK is also supporting the hydrogeological investigation efforts for the project, and leading development of the site-wide water balance – a critical issue for construction of a sulfide-bearing mineral project near the pristine Boundary Waters Canoe Area Wilderness.



Mount Wright

SRK's open pit teams completed two major projects on ArcelorMittal's biggest iron ore operation in the world, Mount Wright and Fire Lake in eastern Canada, from 2018 to 2019. The initial work included an in-depth review of resource models, mine designs and production schedules. It was followed by strategic mine planning and detailed mine designs for two major pits. SRK conducted pit optimisation for two major deposits, selected the final pit considering the company's strategies, developed detailed mine designs, sequenced mine development and developed a detailed production schedule for the life of mine. SRK also assisted ArcelorMittal in technical reports and long term mine planning.

... North America



Kennady North

SRK has provided geology development, evaluation and resource estimation for the Kennady North project, owned by Kennady Diamonds, a subsidiary of Mountain Province Diamonds. It is located north of the Gahcho Kue diamond mine that is operated by De Beers Canada in a joint venture with Mountain Province Diamonds.

The Kennady North project includes several significantly diamondiferous pipes and dykes. The known pipes display unique external morphology that has not previously been documented.

SRK has worked with Aurora Geosciences and Kennady Diamonds on the geological development and evaluation of these kimberlites since 2013.

Due to the unique shapes displayed by the kimberlites, new exploration and evaluation approaches were implemented to develop the geology and understand the grade distribution.

Resources have been classified for the Kelvin, Faraday 1–3, and Faraday 2 kimberlites. Further exploration and evaluation work is warranted.



Hope Bay, Nunavut

Since 2002, SRK has worked at the Doris North mine on the 80 km Hope Bay Greenstone Belt in Nunavut, and has helped advance this gold project from the initial scoping study, through the detailed engineering and construction quality assurance phases. SRK provided geotechnical (rock and permafrost soil), hydrotechnical, waste management engineering, geochemistry, hydrogeology and overall regulatory guidance. The tailings impoundment area designs include a precedent setting frozen core dam (north), and a frozen foundation dam (south). SRK continues consulting towards developing and constructing more deposits and infrastructure.



Galore Creek mine

SRK hydrogeologists completed field studies in cooperation with the SRK rock mechanics and tailings teams to support design of an expanded mine design for the Galore Creek project, British Columbia. The project area, a remote location in mountainous terrain with proximity to mountain glaciers, presents numerous water management challenges, including the potential for significant inflows to the pit and complex slope stability issues. This work expanded on previous field investigations, slope design inputs considering compartmentalisation, dewatering system definition and mine design trade-offs, including diversion of significant surface flow around or through the pits.



Teck saturated rock fill projects

Since 2008, SRK has worked with Teck to develop technology for using saturated rock fills (SRFs) for treatment of selenium and nitrate in waters at Teck's Elk Valley metallurgical coal operations. In 2017, SRK and other specialists defined design parameters and layouts for a pilot wellfield and technical and regulatory support during a pilot trial. As of December 2019, the SRF has been removing nearly all nitrate and selenium from up to 10,000 m³/d of mine-impacted water. The technology may reduce water treatment costs by millions of dollars. SRK now supports Teck with expansion of the initial system, design and construction of a second, and initial characterisation of a third.

South America

Chuquicamata pit closure

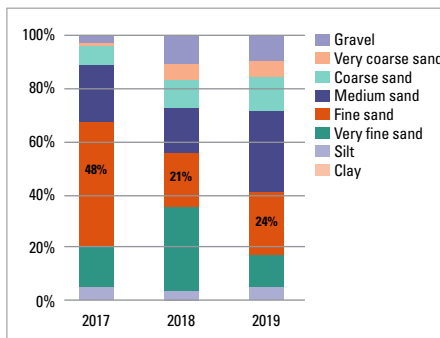
SRK assisted in providing information for decisions on the best slope steepening alternative for closure of the pit. The methodology included three main tasks: Evaluation of the probability of failure (PF) representative of the stability conditions of pit slopes; Evaluation of economic losses derived from impact on production and costs; and generation of risk maps to compare the four closure alternatives. The results provided valuable information for decisions on the closure plan in accordance with the mine's reference criteria for economic risk.

L-F Contreras, E Hormazabal, R Ledezma, M Arellano. (2019). Geotechnical risk analysis for the closure alternatives of the Chuquicamata open pit.



Cerro Moro

This project is located in the region known as Macizo del Deseado, a gold and silver district from low sulfidation epithermal deposits in the province of Santa Cruz, Argentina. In 2017, SRK was contracted by Estelar Resources S.A. for the development of the initial geochemical characterisation, acid rock drainage/metal leaching assessment and a conceptual management plan for waste rock dumps based on the potential for the production of acid drainage and leaching of metals and metalloids. This study was developed by means of static tests, optical mineralogical studies, short-term metal leaching and kinetic testing.



Grainsize distribution monitoring

SRK has been involved in various studies relating to river dynamics for a confidential client to inform decisions on the reclamation of watercourses impacted by mining activities. One study involves the evaluation of riverbed sediment grain size distributions and the change in these with time. The approach is to develop a database of sediment grain size distributions over the years for statistical analyses to identify parameters that could be used as reliable indicators of river stability.



Candelas lithium brine

Candelas is located in the Antofagasta de las Sierras District, Catamarca Province, Argentina. In 2019, SRK's personnel supervised sample logging and contribution to the definition of hydrogeological parameters of the strata, as well as the taking of brine samples, and reviewed and interpreted geophysical studies carried out in the area. SRK continues working on this project, contributing to the construction of the geological model of the deposit as well as providing technical advice for the development of a Quality Assurance Plan in order to update the results in the different stages of exploration.

... South America

Pascua-Lama

Since 2014, SRK has worked on the closure of the Pascua-Lama gold project on the border of Chile and Argentina, owned by Barrick Gold. The pre-feasibility level closure plan was developed for the mine pit, rock dumps, water management system, road infrastructure and cut-off wall considering the geotechnical, geochemical, hydrological and seismic issues. SRK developed the detail design and QA/QC plan of key infrastructure components of the mine closure, such as the design of the plug in the bi-national tunnel connecting Argentina and Chile.



Subfluvial tunnel and risers

SRK assisted the client in the construction of a tunnel and risers on the Matanza-Riachuelo project. The project consists of a tunnel that is 4.9 m in diameter and 12 km in length that will flush treated water into the River La Plata. The excavation works are located 40 m in the bed of the river using double-shielded TBM. This tunnel will be one of the longest of its kind in the world. Since January 2018, several numerical analyses have been completed to check the geotechnical designs, complemented with analysis of monitoring data and CPTu campaigns to advise the client in the early construction stages.



San Rafael geomechanical model

Additional resources have been found 1400 m below the surface at San Rafael mine, but deepening underground operations has become challenging. Engineers will have to work with high levels of rock mass stresses in unfavourable geomechanical conditions. The project undertaken by SRK considered the structural geological understanding, the rock mass characterisation and measurements of in-situ stresses to obtain modelling input parameters and calibration. The results include the stope design, rib, sill and crown pillars, the assessment of the mining sequence and recommended support systems for maintaining a safe and profitable operation during the LOM.



TecPlata

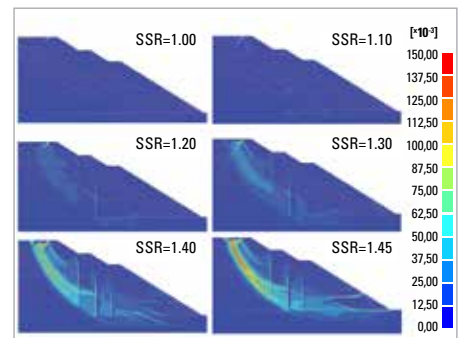
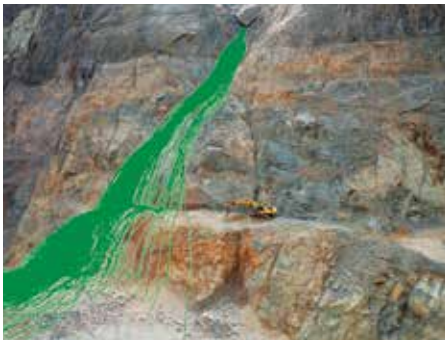
In 2013, SRK designed the excavation sequence for the placement of rockfill protection under the dock at La Plata, Argentina. Numerical models and analytical verifications of the background stability and the stability of the sheet piling of the lateral closing coffer were carried out. The anchoring system was designed and the displacements of the containment wall were calculated. SRK staff made periodic visits to the site over two years to observe the progress of the work. Modifications and adjustments were made to the designs as the project proceeded.

Cerro Vanguardia

SRK worked for the Cerro Vanguardia mine, located in Santa Cruz, Argentina, from 2012-2018, validating and optimising the design of several open pits. The project team analysed the geological, structural and geotechnical data, determined the main geotechnical domains and characterised them for their resistance, weathering and fracturing. Stability assessments at bench-berm, inter-ramp and global scales were undertaken for the designs proposed by Cerro Vanguardia.

SRK completed a feasibility-level design on the TSF expansion, including the bases

of design, storage capacity assessment, review of geotechnical and stability assessment, water balance, tentative construction procedure, operational aspects, closure recommendations, material take-offs and cost estimates. SRK has undertaken the detailed design engineering of the embankment and arcillary elements, including the development of a tailings deposition plan, the QMS manual, and construction procedure to allow ongoing production to be deposited into the TSF while the embankment raise is undertaken.



Orosur Mining

A deep open pit that was flooded for eleven years in Uruguay, was dewatered in 2015 to carry out underground mining. The exposed pit walls showed a large wedge failure, leaving a 25-ton block hanging high above a projected mine portal. SRK was called in to assess the risk of leaving the block in place and concluded that the chances of a fall could not be overlooked. The most probable landing zone was located some 30 m away from the portal with a +50% chance of being hit. At the portal, the probability of impact was estimated as 0.35%, a low and tolerable value.

Salar del Rincon

During 2015-18, SRK worked on the Rincon project in Salta, undertaking a geotechnical investigation for the process plant and spent brine disposal ponds, and developed the feasibility and detailed engineering studies for the spent brine disposal facility (SBDF). The geotechnical investigation included a site geotechnical campaign, laboratory testing and geotechnical interpretation. The feasibility level study included the definitive location of the SBDF, capacity assessment, water balance, embankment design, surface water management and material take-offs and cost estimate. The detailed engineering updated the analyses from the feasibility level study.

Computational geomechanics

SRK has positioned itself as a regional leader in the application of numerical methods for geotechnical design and analysis. This is the result of more than 10 years of practice in several challenging projects throughout Argentina and other Latin American countries. The numerical team also has been involved in projects located in Central and North America, Australia, West Asia and South Africa. One of the key experiences of the last 5 years is the analysis of tailings. SRK uses commercial and advanced material models and in-house development to predict realistic pore pressures under static and cyclic loading conditions and evaluate how these impact the safety and performance of the dams.

... South America

Chinchillas

Chinchillas is a high-altitude silver, lead, and zinc deposit in northern Argentina. SRK worked on this project from 2015 to 2019 encompassing different levels of studies including preliminary economic assessments, pre-feasibility and feasibility. SRK provided mine operating cost estimates, detailed monthly plans, dilution models, waste dump designs, stockpile designs and access roads, site layout, cut-off grade, and pit optimisation. In summary, SRK engaged in detailed mine design and production planning suitable for construction and development that led to a positive construction decision for the open pit mine by 2018.



Salar de Uyuni brine deposit

In 2017, the Government of Bolivia appointed SRK to prepare a resource estimate of the Salar de Uyuni brine deposit. Uyuni is known as the largest lithium resource in the world, though no official estimate has been published. The team then conducted hydrogeological exploration to validate pumping scenarios and the geological model. The team then developed a complex numerical hydrogeological model for both the resource estimate and the mine plan. SRK also provided training to the project staff to run their own simulation scenarios throughout the life of the mine.



Geomechanical design

The Chuquicamata underground mine in the Atacama Desert in northern Chile is one of the largest planned mining projects in the world to use the method of block caving with a macro-blocks option to mine copper ore. CODELCO is currently finishing the detail engineering stage and the construction of the main infrastructure for the project. The underground mine is expected to begin operations in 2019, with a 7-year ramp-up period and a nominal production of 140,000 tonnes per day. The rock mechanics team of SRK has been providing technical support to the project during the last 8 years, including the prefeasibility, value, feasibility, liaison and detailed engineering stages.



Doce River, Brazil

SRK has created a hydrological and hydraulic model that simulates extreme hydrological events that could cause a significant impact due to rising water levels within the river channel. This was used to provide more accurate information regarding the population impacted with the unexpected/unnatural rise in water river level caused by the Fundão dam failure. This approach used a conservative scenario to simulate the potential river flood. The model will be updated when more accurate surveying topobathymetry along the river is available.



Cerro Lindo, Peru

SRK was commissioned by Minera Milpo S.A.A. (Nexa Resources) to prepare an environmental study for the expansion of the processing plant to 22.5 Ktpd. The study included technical improvements of processing systems and ancillary facilities, and modifications to the desalination plant. The impacts associated with the proposed activities were identified and assessed. Occupation of new areas and dust emission due to ore transport were determined as the critical impacts. Two irrigation systems were recommended as an environmental mitigation measure; 90% of the water use would be recirculated.



Santander feasibility

Trevali operates the Santander Mining Unit in the province of Huaral, department of Lima, Peru. SRK developed a study of location alternatives and tailings disposal methods for the project. Based on this study, the engineering design was established at feasibility level for the most favourable alternative, corresponding to the growth of the Santander tailings dam pond at the elevations for Stage 1 and Stage 2 of the facility.



Inmaculada mine

Hochschild Mining operates the Inmaculada Mining Mine Unit, a gold and silver operation in the province of Páucar del Sara Sara, Peru. SRK's work consisted of establishing exploratory drilling plans to increase the level of confidence in their economic viability to categorise the resources as indicated, allowing possible consideration as reserves for further mining exploitation. In addition, the study considered developing new veins for mining engineering at conceptual level.



San Rafael mine, Peru

This mine is a deep and narrow hard rock mine with frequent rock bursts problems due to large, open stopes left without backfill. SRK provided a geotechnical rock mechanics study consisting of logging, mapping of underground workings, classifying rock mass quality to input parameters for stopes design, mining sequence and control strategies for over-excavation. By applying numerical 3D modelling of rock masses, strategies for mitigation of rock bursts were developed. One approach was to change the mining method to bench and fill or to transverse stopes in specific orebodies, optimise the mine sequence, evaluate of the paste backfill strength and design support to dynamic loading in burst-prone areas.

... South America

MEIA expansion

Atacocha Mining Company proposed the expansion of the Glory Hole open pit in Pasco, Peru and the development of new components. These involved the development of three pits, Glory Hole, GH West Satellite, and GH East Satellite; the development of the Atacocha waste dumps and two internal low grade pit fields. The objective was to identify and evaluate the environmental and social impacts that could occur due to the activities proposed during the construction, operation and closure stages; and establish environmental management strategies.



Veladero mine

The Veladero mine is located in Argentina, in the west of the San Juan Province, 5 km from the Chilean border. The current mine plan includes mining operations continuing through 2024 with residual gold leaching continuing through 2029. In 2018/19, SRK updated the closure plan at the pre-feasibility level, evaluating the geochemical, geotechnical, seismic and hydrological aspects. The facilities included three open pits, the heap leach valley, the process plant, three waste rock dumps and the camp and hotel facilities.



Tucush

The Tucush tailings deposit detailed engineering consisted of pulp and filtered tailings for the Contonga mine located in Peru. Studies and designs were developed at a detailed engineering level to raise capacity, beginning with a pulp arrangement and a filtering process for the final stage. The designs considered the harsh topographic conditions and geological, geotechnical and hydrological aspects for technical and environmental viability.



Buenos Aires Metro

In 2015, SRK developed the conceptual-to-construction design for extending Line H, of the Buenos Aires Metro. SRK assumed full responsibility, leading the geological, geotechnical, structural, waterproofing and procedural aspects of constructing five underground caverns, one cut-and-cover station, 1.2 km of warehouses and underground parking and 3.2 km of inter-station tunnels. One landmark achievement was the first head-bench excavation of an underground cavern. SRK's underground expertise in Argentina spans 20 years.

