srk news
Geological Modelling and Mineral Resources

Uncertainty management in mineral resources

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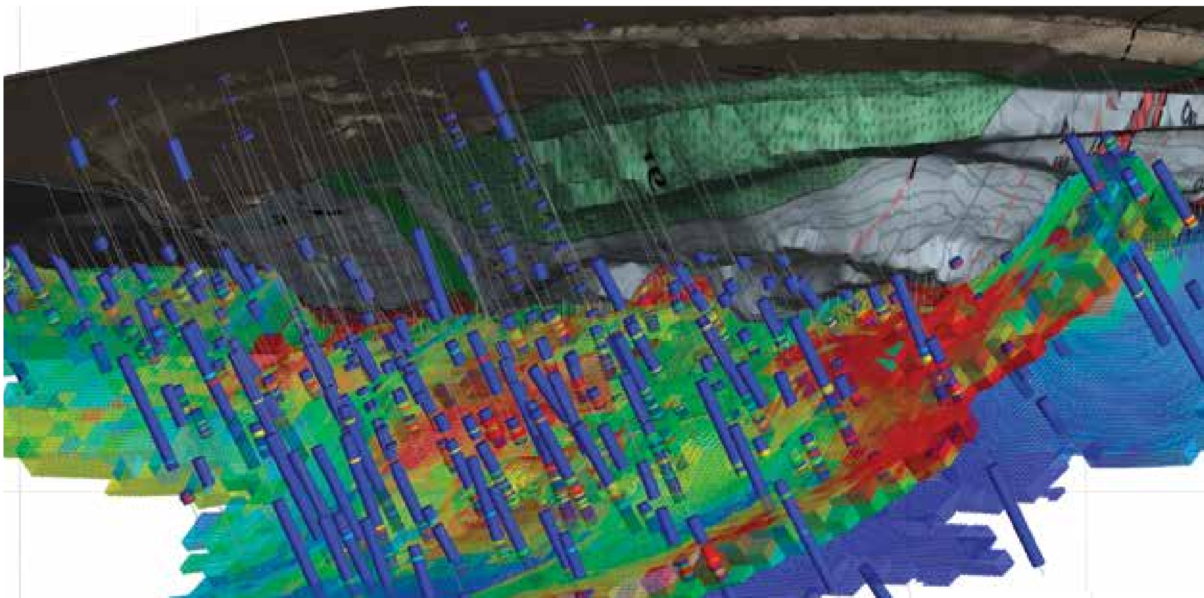
Newsletter



Example of geological mapping, drilling, and a block model. All common tools utilized to understand and quantify mineral resource risk. Not shown: a multitude of other data or inputs to the MRE risk assessment process.

We begin where all mining geoscience-focused newsletters should, with obscure American Civil War naval history. It is 1864, and a flotilla of Union ships sail towards the Confederate port of Mobile Bay, Alabama.

One Union warship has already been sunk by a Confederate line of underwater mines (called torpedoes in the 1860s) when Union Rear Admiral David G. Farragut gave his ships the now-famous order of: 'Damn the torpedoes! Four bells. Captain Drayton, go ahead! Jouett, full speed!'.

Miraculously, the rest of Farragut's fleet sail unharmed through the minefield, enabling them to get beyond the range of the shore-based guns and ultimately take control of Mobile Bay. The capture of the Bay severed Confederate supply lines at one of their last major ports and served as a major factor in ending the war.

The idiom 'Damn the torpedoes!' stands now as a famous reference to advancing to success despite the apparent risk.

What Farragut didn't know was that most of the mines at the entrance to the bay had become waterlogged since the first Union ship was destroyed and simply failed to detonate as his ships pushed them out of the way. Had the mines been operational, it would have spelled disaster for his ships, for the Union war effort, and potentially changed the course of history. Of course, Farragut's well-known quote would be famous for a very different reason.

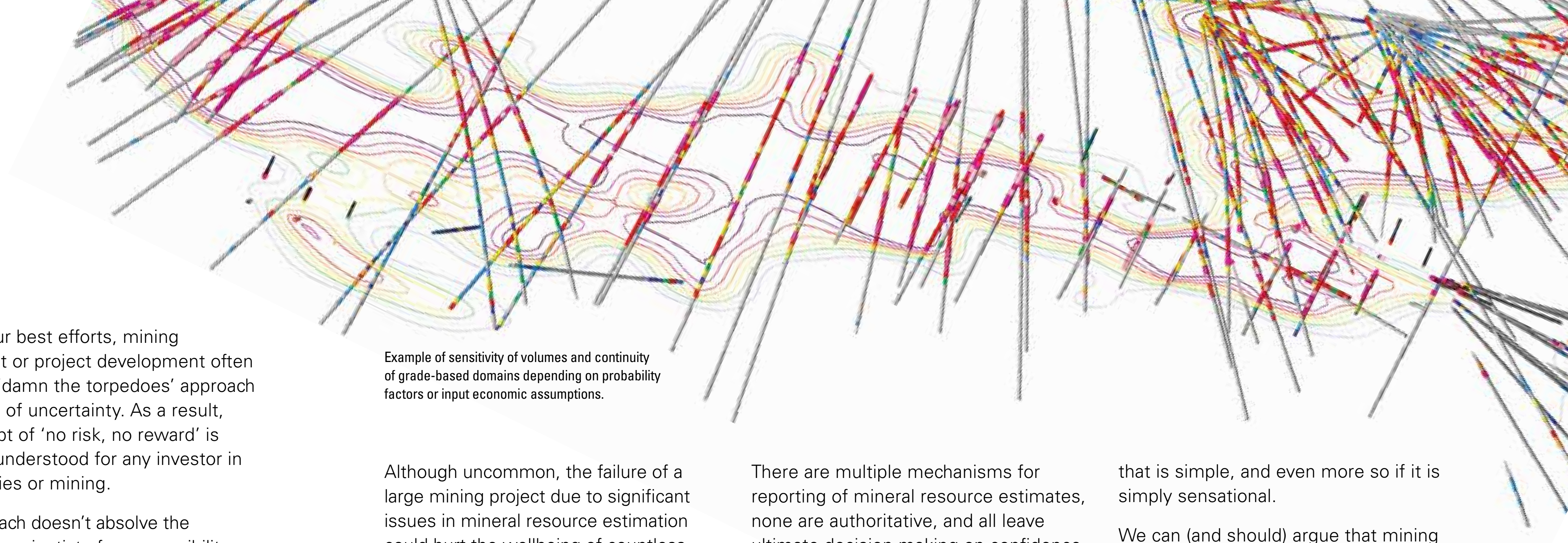
…continued

Uncertainty management in mineral resources *(continued)*

The relationship between an obscure history reference and mineral resource estimation may not be immediately obvious. Like Admiral Farragut, mining companies face numerous and substantial risks to achieve success throughout their project development cycle, often beginning with the mineral resource estimate. Estimation implies inherent risk in the certainty of the result, yet this is often glossed over to provide assurance to investors or internal stakeholders of a stable foundation on which to base a myriad of expensive downstream decisions. Risks are also understood only in the context of conditions or assumptions as we understand them, and those commonly change with time. Like the changing conditions in the Battle of Mobile Bay, our perspective on risk in a geological model or mineral resource estimate may fluctuate as new information is generated or as market conditions change. It is often understood by geoscientists that we sample a very small part of the thing we are trying to characterise, and what happens between points of observation is uncertain on a sliding scale of geological complexity.

Despite our best efforts, mining investment or project development often takes the 'damn the torpedoes' approach regardless of uncertainty. As a result, the concept of 'no risk, no reward' is generally understood for any investor in commodities or mining.

This approach doesn't absolve the modern geoscientist of a responsibility to do good work, assign relative confidence in the result, and be able to relay these concepts to stakeholders at all levels. Significant investment decisions get made on the basis of resource estimations, and bad decisions can quickly (and publicly) turn into significant losses. When the estimate shifts or changes due to new information, interpretation, economics, constraints, or dozens of other factors, it is not uncommon for reactions to be surprise, disappointment, or even anger.



Example of sensitivity of volumes and continuity of grade-based domains depending on probability factors or input economic assumptions.

Although uncommon, the failure of a large mining project due to significant issues in mineral resource estimation could hurt the wellbeing of countless stakeholders – from company executives and institutional investors to rank-and-file employees, mom-and-pop shareholders and local communities that supported the project. Therefore, it is critical that the risks associated with these estimations be clearly communicated to decision-makers and stakeholders beforehand.

There are multiple factors which inhibit this communication. Every ore deposit is different, and each features challenges or uncertainties which may be unique or difficult to model or quantify effectively.

There are multiple mechanisms for reporting of mineral resource estimates, none are authoritative, and all leave ultimate decision making on confidence and risk to the subjective opinion of a person. In many cases, this person is designated as qualified or competent, although the definitions of this are highly variable. Internal and external governance of resource (and reserve) estimation process is inconsistent in terms of rigour, timing, or impacts to public statements. Technical reports are generally the final source of information for investors to understand the project, but are commonly too long and complex for the layman to interpret efficiently. Mistakes or omissions are common in technical reports as well, with a very small percentage of these types of disclosure reviewed by regulatory agents. They are often pulled together immediately before filing deadlines, in many cases from multiple sources.

Given the complexity of these documents and murkiness of the language, it is no surprise that modern investors often skip through ponderous technical reports and go straight to a table showing tonnes and grade, net present values, or rates of return. The absence of a concise summation of the risks in mineral resource estimation also makes investors more susceptible to the sorts of language that can appear in press releases, such as 'bonanza', 'world-class' and 'open in all directions'. People naturally gravitate to information that is simple, and even more so if it is simply sensational.

We can (and should) argue that mining projects are complicated and require appropriate governance, review and documentation to support business decisions. But it is up to geoscientists in the modern mining industry to adapt and do all of this better and more efficiently by applying the lessons of the past to the concepts and tools of the future. Whether we like it or not, we find ourselves in a world where complex situations or major events are often delivered in real time, with very little background, in fewer than 280 characters. The technical report isn't going away, but the approach to any form of disclosure or documentation should recognise the audience and present *relevant* information in a concise and clear fashion. Risks and opportunities should be front and centre and worded with as little equivocation as possible. Governance should be rigorous, but streamlined to best fit the project. Modern geoscientists should also look beyond the written report and develop other innovative ways to convey information or concepts to stakeholders.

It is my hope that the contributions in this edition of SRK News will touch on a variety of ways for consultants and their clients to evaluate and communicate risks (and opportunities) in mineral resource estimation.

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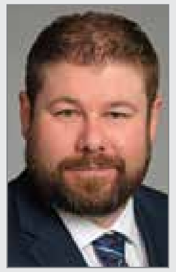
MATTHEW HASTINGS



Matthew has more than 15 years of experience working in exploration and mineral resource definition. Matthew's commodity experience includes precious metals, base metals, iron ore, industrial minerals, and rare earth element deposits. Matthew has worked on site and remotely with projects from initial field evaluation to resource definition, development, and mining. Matthew has extensive experience working on multi-disciplinary teams and is familiar with many aspects of the mining industry including mine design, planning, scheduling, process, environmental, permitting, and economics.

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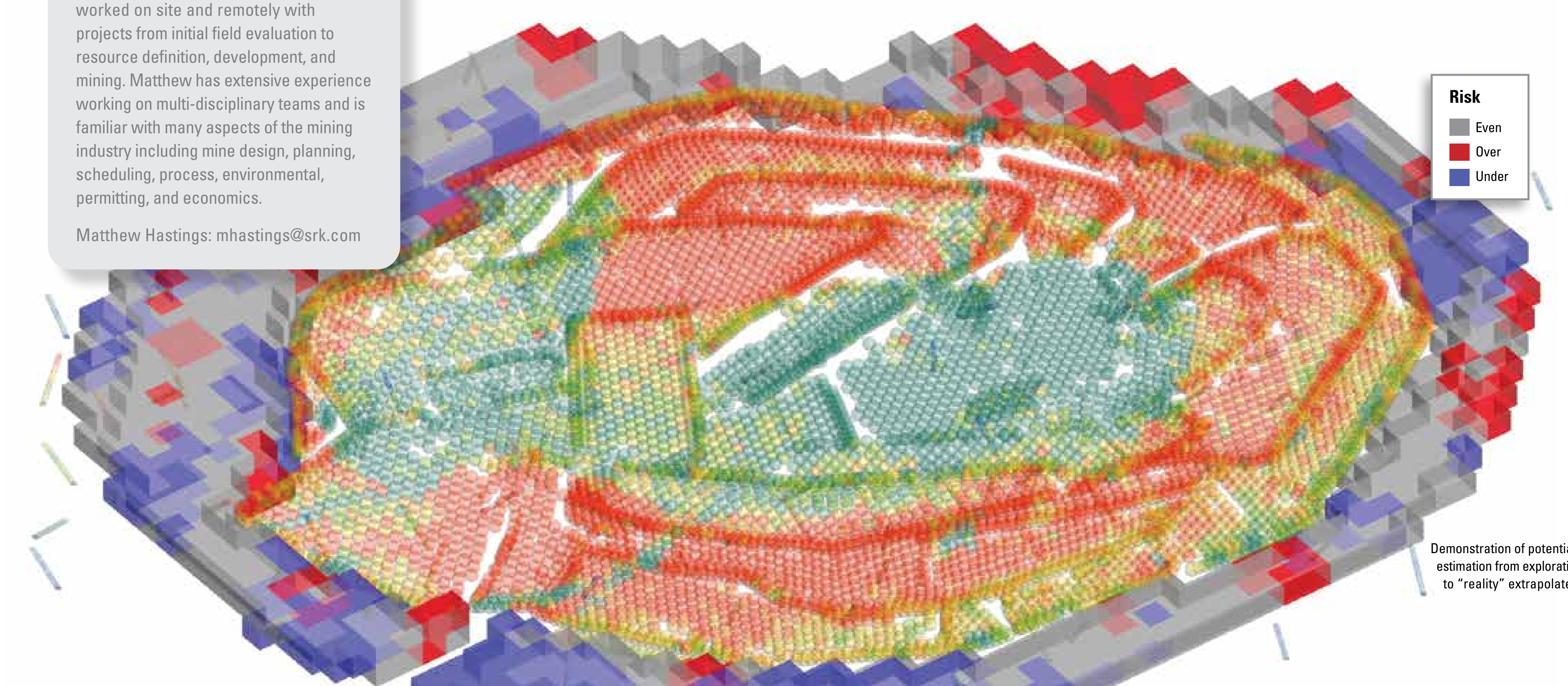
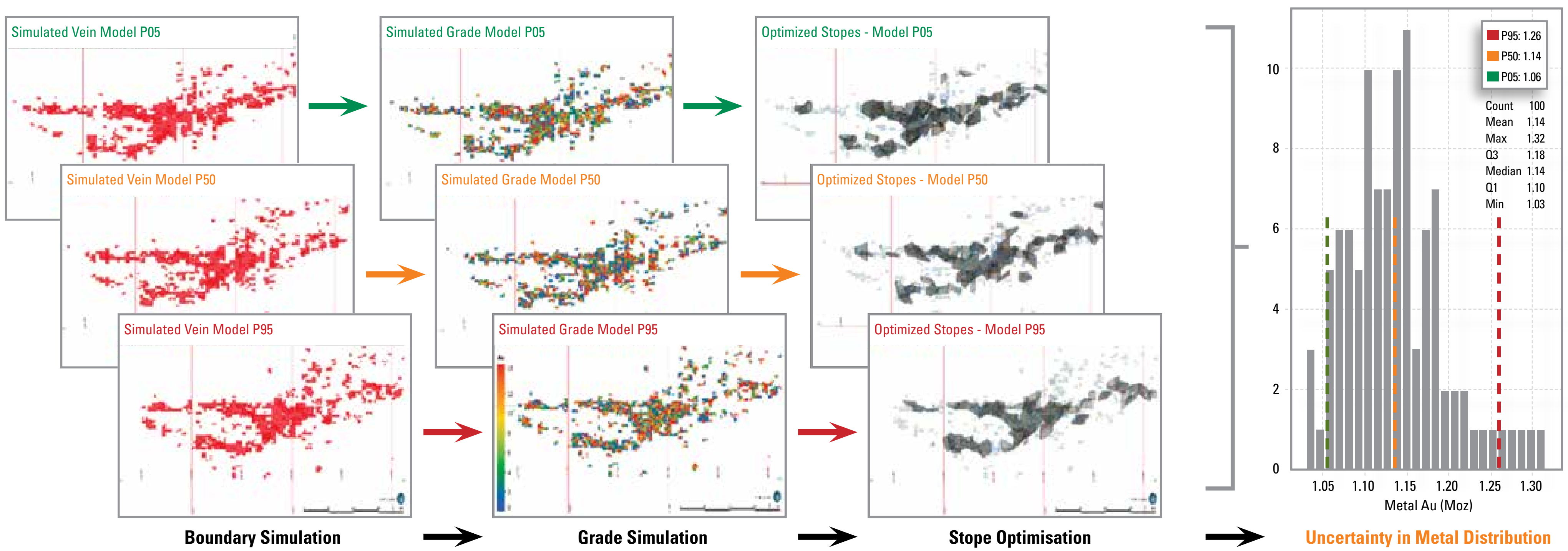


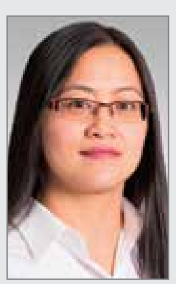
Demonstration of potential over or under-estimation from exploration data compared to "reality" extrapolated from mine data.

The future of mineral resource modelling

Uncertainty transfer from geology through to underground metal content



OY LEUANGTHONG



Oy has over 20 years of experience with geostatistics and 3D modelling of mineral and petroleum resources. Oy's areas of expertise are in resource estimation, simulation, and classification using geostatistics, with particular interest in multiple variables and trend modelling. Oy has been involved with estimation and simulation studies in multiple commodities including gold, copper, zinc, nickel, phosphate, and uranium in North America, South America, Africa and Australia.

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The tools and methods used for mineral resource modelling in the mining industry have been tried and tested over many years, with many projects and in a multitude of commodities around the world.

Among the tools in use today, we can date the kriging methods back to the Witwatersrand deposits in South Africa and the early days of Danie Krige, Herbert Sichel and Georges Matheron in the 1950s and 1960s. Even more impressive, inverse distance methods can be dated as far back as the 14th century!

More recently, the discovery and exploitation of world-class deposits gives rise to the search for the next big find. Shallow, easy to access deposits appear to have all been discovered. The remaining ones present significant challenges: they may be marginal deposits, occur at great depths and/or present other access constraints. Some would say that most challenges can be solved if you throw enough money at the problem, but how much is too much? What is the risk of getting it wrong? If wrong, how far off the mark are we?

These questions are not new to the resources sector. We have always known that the mineral resource models that are built are a snapshot in time, reflecting our best assessment of the deposit. We have also known that there is uncertainty in this model, uncertainty in the geology interpretation, uncertainty in the sample data, uncertainty in the predicted grades, and ultimately, uncertainty in the 'optimal' pit or stopes that may form the basis for a mine design and schedule.

The idea of quantifying this uncertainty and using it to manage risk is also not new. Conditional simulation was posed as a potential solution to this problem in the early 1990s. Over the last three decades, we have seen the rise of geological simulations, grade simulations, and the merging of these sources of uncertainty. In the last 15 years, the focus subtly shifted to the use of these simulated models to determine the optimal pit or for underground stope optimisation. Some have even gone so far as to build schedules and cash flow models based on these uncertainty models, to assess the uncertainty in the cash flow over the life of a mine. This is the present state of innovation in mineral resource modelling.

Today's mineral resource models often rely on technology that can be traced back 70 years, or even 700 years. Tomorrow's models are going to be based on technologies that took seed over 30 years ago. The future of mineral resource estimation requires us to acknowledge that uncertainty exists. It demands for us address it, quantify it, and to use it to make more responsible risk management decisions.

Figure provided by Ilkay Cevik, Consultant (Resource Geology)

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Thirty not out

As I write this article I am coming towards the end of 30 years of resource estimation and reporting with SRK. When I joined the available software was 2D based and the interpolation process took a long, long time and was mainly done overnight so as not to tie up a machine all day. Many estimates were still being done using graph paper, colouring pencils and transparency. Hard copy sections and plans were the basis of almost all geological models. While most exploration programmes and new mines were computerised, most mines still operated a paper system and while geostatistics had been "invented" most estimates were still being done using classical methods. 2D inverse distance interpolation and polygonal analyses were the norm and no commercial software system was up to do anything more than simple statistical and geostatistical analysis. For my PhD a few years earlier I wrote the semivariogram and kriging algorithms into Lotus 123 and used a spreadsheet to produce 2D semivariograms and block models. Try and tell that to the young geologists of today, they wont believe you!

Not only was computerised resource estimation in its infancy, resource reporting was poorly regulated 30 years ago. The first JORC Code had been published a couple of years earlier and was starting to gain traction but there were big differences between the various codes in use. Some used the same terms as others but where they did the definitions were different. Fortunately this did not matter too much because most readers did not understand the codes anyway and most reports did not state what code was being used.

Since 1991, the software capability has improved, more elaborate geostatistical approaches are now open to everyone and modelled orebodies now tend to look more like mineral deposits and less like Klingon warships. Mineral resource reporting is much more standardised and continually being refined and improved.

It still remains critical that the estimators understand the orebody geology and the theory behind, and limitations of, the methods they are using, and these are strong themes throughout this newsletter, but notwithstanding this it is clear that we are in a better position now to produce better estimates and to convey the confidence we have in these compared to 1990. I can only wonder what changes the next 30 years will bring.

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MIKE ARMITAGE

Mike has been involved in resource estimation for over 30 years, has written several papers on the subject and spent several years as joint course co-ordinator of an MSc in Mineral resource at Cardiff University, and then as external examiner for the MSc in Metals and Energy Finance at Imperial College, University of London. At SRK he is now mainly responsible for managing feasibility studies, Competent Persons Reports, due diligence studies and project valuations on behalf of investment institutions and mining companies.

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Improved assurance for mineral resource and mineral reserve estimates and reporting

Effective mineral resource and reserve assurance ensures reliable reporting

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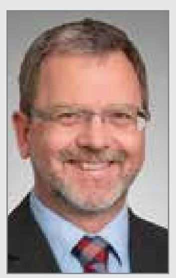

Mark has over 30 years of experience and provides advice in all aspects of orebody knowledge for developing projects and operating mines. As a leading consultant in geosciences and the mining industry, Mark provides advice, training, and mentoring in exploration reporting, data assessment, resource definition and reporting, mine geology and grade control through to inputs to reserving. Mark's clients include the technical leads, management and boards of resource project owners, as well as the investors, lenders and legal advisors to these projects.

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Risk governance is an integral part of corporate assurance and decision making. Assurance regarding the processes applied to data collection, estimation and reporting of Mineral resource and Mineral Reserves is required to mitigate the risk of inaccurate results and must therefore be included in a minerals company's risk management and control framework.

While some companies recognise the importance of peer review in their standard procedures, there may be no practical or effective assurance process in place. Adequate and effective processes and systems will improve the reliability of estimates.

An effective assurance process for the governance of mineral resource and mineral reserves consists of three layers: self-validation and peer review where and when the work is performed, oversight and targeted internal review, and an independent review or audit mandated by management and/or board risk or audit committees.

Reviews and audits improve the level of reliability of estimated and reported mineral resource and mineral reserves. They not only contribute to governance processes, but also identify improvement opportunities and provide mentoring and professional development guidance.

A recent technical audit of a client's operations was conducted because a weakness within its existing mineral resource and mineral reserve processes for one project had been identified and the company wished to review the entire process across all operations to evaluate if the processes were adequately designed and personnel sufficiently skilled to support the accurate generation and reporting of the estimates.

The audit process included:

- Interviews with key stakeholders
- Reviewing systems and process documentation
- Learning the estimation processes and assigned responsibilities and competencies
- Identifying and evaluating compliance with internal and industry standards and the risk management controls within the estimation and reporting
- Testing and validating key procedural controls
- Presenting and documenting findings, recommendations and management actions required to address any risks found to be inadequately managed.

Some findings were common across all operations, and therefore the company stood to benefit from an integrated solution to manage these risks. The audit also provided an opportunity to share knowledge across the local technical and management teams and between the operations of the importance of the results they generate, and the effort required to produce the results.

Some companies conduct audits and reviews to proactively ensure their processes are robust, their systems appropriate and their staff adequately experienced to accurately generate and report on mineral resource and mineral reserve estimates. If a company does not at least have a system of internal peer review, it may have poor assurance of the estimates generated and reported. Senior management and/or the board should disclose to their stakeholders how adequate assurance on the effectiveness of the company's governance, risk management and control structure is provided.

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The importance of a good geological model

A robust geological dataset and a well understood and constructed geological model are the foundation of a reliable mineral resource estimate that will guide financial and operational decisions through a project's value chain.

Geological models should include all lithological, structural, alteration and weathering aspects that control the mineralisation in a deposit, but also aspects that could impact geotechnical stability, geometallurgical recovery and waste characterisation.

There are many projects that SRK has been asked to review where the client's geology team usually has a reasonable understanding of the local geology and mineralisation controls, but time and budget constraints have resulted in geological models that only consist of simple grade shells interpreted above a cut-off with limited geological context. Without this context, the shape, size and orientation of the interpreted mineralisation may be incorrect, which then affects the mineral resource estimate and any subsequent ore reserve estimation. Realistically, these models should be treated as low confidence or high uncertainty models and classified accordingly.

Advances in geological modelling, notably implicit modelling, have allowed geoscientists to visualise and model geology in 3D rather than using the classical 2D sectional approach, as well as rapidly incorporate more extensive datasets into a model. While implicit modelling is a vast improvement, practitioners should still take time to first understand all the geological aspects of their deposit before modelling. It's very easy and quick to produce 'a model' using implicit modelling software, but it takes time and patience to produce robust geological models that reflect all the available geological information.

Geological models are an important asset for exploration and mining companies that should not be overlooked, or their preparation rushed. Investing time and effort in geological modelling early on reduces the geological uncertainty for a project and can lead to savings for infill and grade control drilling and reduce the time to update future geological models as more data become available.

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MICHAEL LOWRY

Michael has over 25 year's experience in the mining industry working primarily as a mine geologist and resource geologist in various gold, nickel and iron ore operations in Western Australia. Michael specialises in geological modelling, mineral resource estimation, mine geology and reconciliation and governance reviews. He has experience with a number of geological modelling and resource estimation software including Vulcan, Datamine, Isatis, Supervisor and Leapfrog.

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Examples of overly simplistic vs more robust geological models

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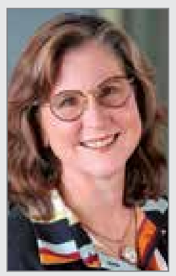

Fiona has nearly 30 years' experience in the management of environmental, social and governance (ESG) issues. Fiona has worked as both a regulator at the UK's Environment Agency (8 years) and as a consultant in SRK's South African and UK practices (>20 years). Fiona's E&S experience spans preparation and management of ESIAs, input to project engineering studies, management planning, closure planning, risk management, audit and due diligence, technical advice on water and waste issues, and environmental reporting.

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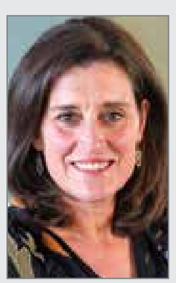

Jane has 28 years' experience providing environmental, social and governance (ESG) consulting services to the mining industry. Extensive experience undertaking permitting and auditing of mines, coupled with a thorough understanding of ESG concepts and standards, enables Jane to provide clients with pragmatic and forward-thinking ESG advisory services. Jane has a high level of interest in legislation pertinent to ESG and mining, supporting achievement of compliance with legal obligations and assisting clients to maintain and gain social licence to operate.

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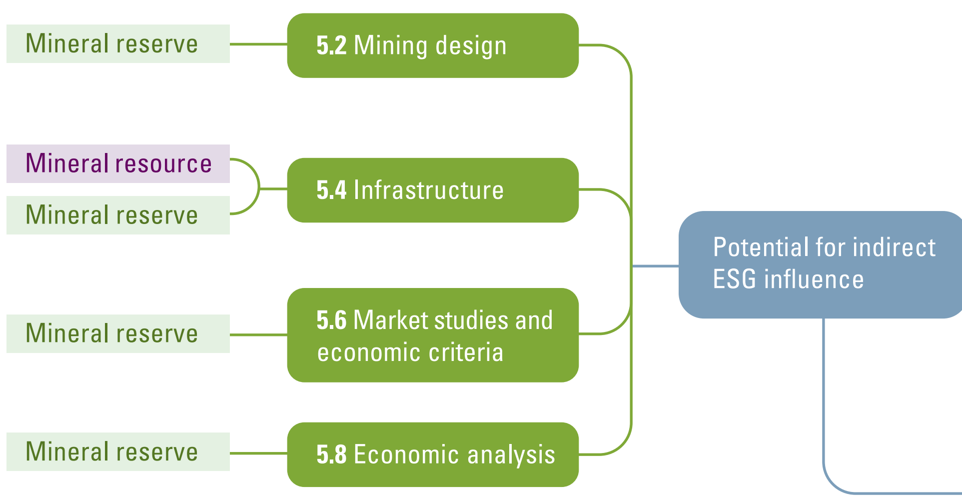
ESG requirement for resource and reserve reporting

ESG influences in CRIRSCO



'We are not aware of any factors (environmental, permitting, legal, title, taxation, socio-economic, marketing, political, or other relevant factors) that have materially affected the mineral resource estimate.'

How many mineral resource statements have similar wording? With increasing global recognition of the importance of environmental, social and governance (ESG), such statements are no longer sufficient. A recent roundtable of Committee for Mineral Reserves International Reporting Standards members and advisors concluded that historical disclosure of ESG factors has been weak. Several reporting code committees are looking to revise their codes and/or provide further guidance on how ESG factors should be reported to improve public confidence and address investor expectations. This will build on the stronger ESG requirements contained in the latest CRIRSCO guidance (2019).

CRIRSCO 2019 includes a clear recognition of the trend towards stronger corporate governance, tighter government regulation, and increased demands from investors and supply chain for transparency and disclosure on potentially material ESG risks. CRIRSCO's Table 1's Section 5.5 entitled 'Environment and Social' is new and many other sections include reporting requirements related directly or indirectly to ESG. Items like land access, property description and permitting clearly contain an ESG component. However, ESG considerations also arise when mine design needs to incorporate closure requirements, where ESG factors constrain infrastructure location, and when the establishment of carbon taxes may influence economic analysis of the project.

Currently, Table 1 treats the level of disclosure for reporting ESG aspects for mineral resource and mineral reserves the same, though Chapter 12 indicates the assessment of impacts and associated mitigation measures should only be done for mineral reserves.

SRK recognises that ESG materiality for defining a mineral resource with 'reasonable prospects for eventual economic extraction' will be different to reporting a mineral reserve that is 'economically mineable'. Assessing ESG factors in a mineral reserve estimation is easier than for mineral resource reporting, as information to identify ESG risks for mineral reserve reporting (at a prefeasibility study or feasibility study level) is more readily available. There is an expectation that ESG studies have commenced, permitting requirements are understood and engagement with local communities and other stakeholders is well underway. When reporting mineral resource, the ESG studies may only just be starting; however, ESG constraints still need to be highlighted and a statement made on how these will be addressed in the project development.

Mineral resource reporting is no longer solely the province of geologists. ESG professionals are needed early in the project development process to contextualise the ESG setting, identify potential modifying factors, ensure fair disclosure and advise on implications for future reporting of mineral reserves.

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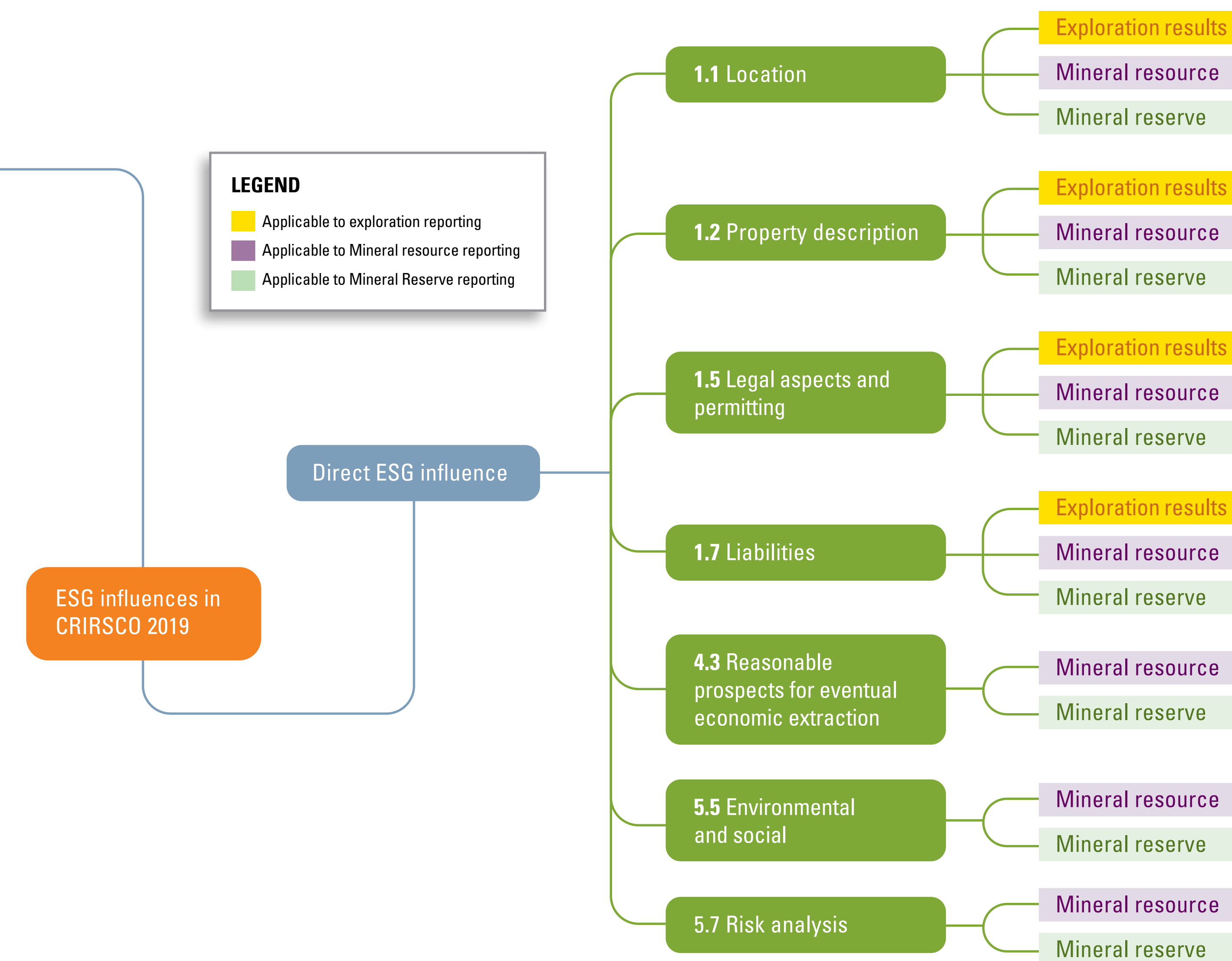

Geology is geometry and geometry is geology

We tend to think of geometry as being all about triangles and squares and angles, circles and mathematics. However, the origins of the word from Latin and Greek, 'geo' and 'metria' literally mean earth measuring or earth craft. The 'geo' was probably related to both its use in astronomy and also its use in surveying plots of land (usually for taxation purposes).

Geometry is also a fundamental element of all that we do when modelling geology and estimating mineral resource.

The vast majority of deposits contain direct or underlying structurally controls, either as fluid pathways and traps or as hard boundaries. At the regional and deposit scale, these structures are often highly linear or planar in their geometry, or at least made up of numerous linear and planar features. However, we often don't or can't, collect and/or process sufficient structural data to define these features in the detail required for mineral resource estimation.

We almost always have vastly more, and more closely spaced, grade information in the form of multi-element assays than geological information. We can use the grade to understand the geometry, then use the geology to refine the geometry and use both geometry and geology to guide the grade estimates. Grades approximate structural geometry – geometry approximates geology – geology provides the key understanding.

The thickness and shape of our domains is also a major driver of the estimation methodology we choose and also impacts the estimation (and apparent estimation quality) that results.

The relationships between the drill spacing, block size, domain shape and variography are all about the relative geometries.

Most modelling and estimation software now allows us to use some sort of automated trend modelling features for both creation of surfaces and solids and for block estimation search orientations and variogram model orientations. These tools not only allow us to build more realistic models but they can also aid us in the initial interpretation and understanding of the controls on a deposit, particularly when the mineralisation is not aligned with the stratigraphy or lithology.

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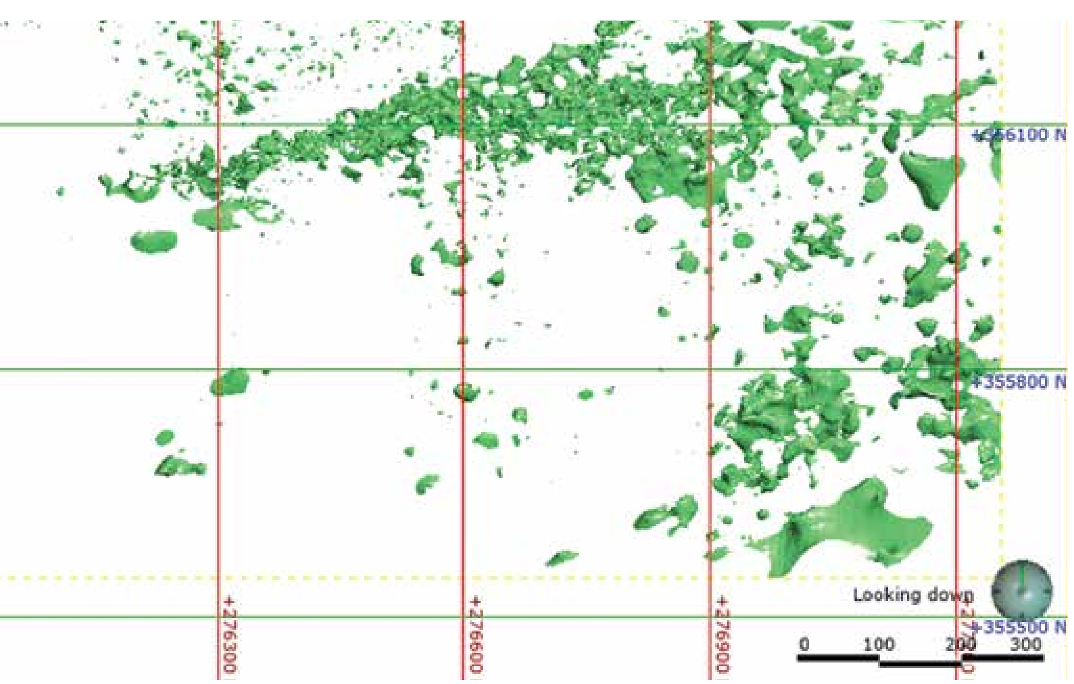
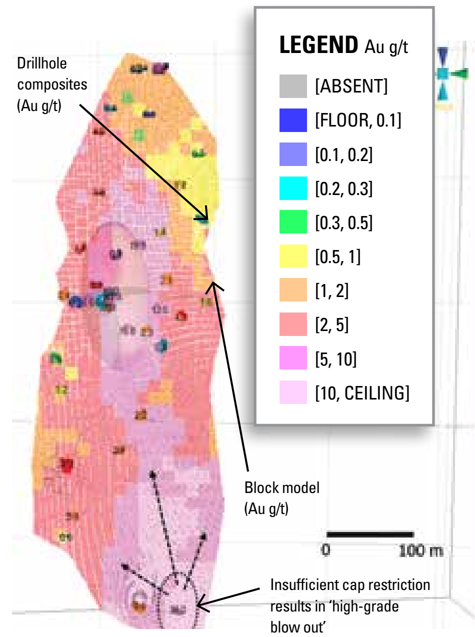


Structural trends highlighted by Al2O3 isotopic grade shells from drilling

Myths and legends

Figure 1: Underground Gold Prospect Block Model



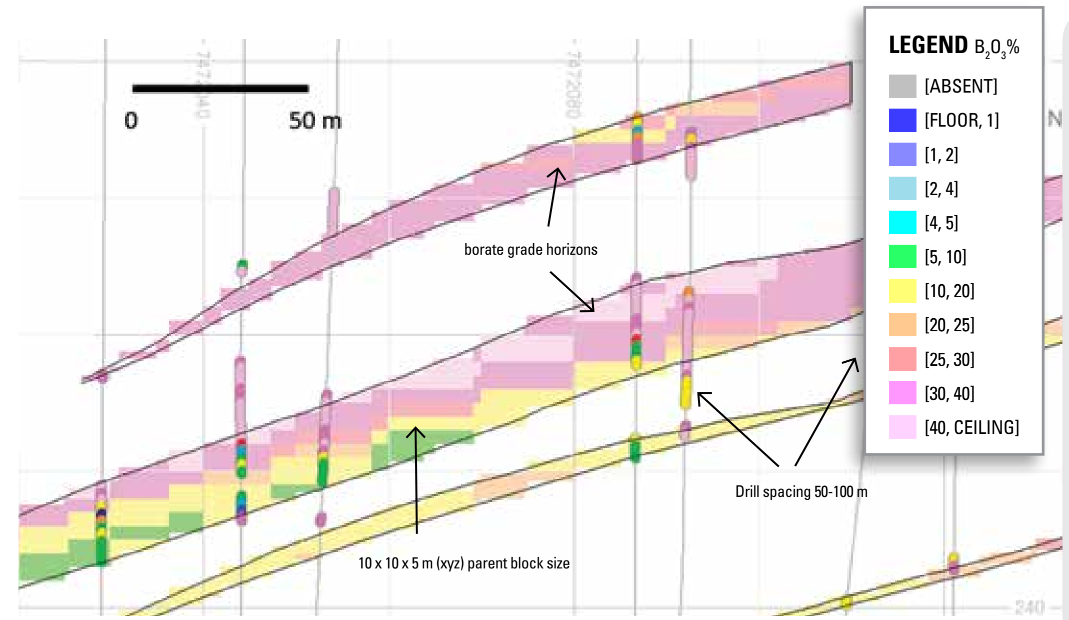


Figure 2: Black Model Cross Section

Myths and legends in resource modelling have merit in some circumstances but are not always the most appropriate approach to problem solving. In this article, we consider legends, myths or 'rules of thumb' associated with top capping, block size and grade interpolation.

Myths and Legends: Case examples

A) High-grade capping above the 97.5th percentile. While this potentially has limited significance in well-sampled deposits with homogenous grade distributions, high-grade 'outliers' may also occur at values less than the 97.5th percentile in other deposits where grade variability is significant, for example nuggety gold, and particularly those at a relatively early stage of drilling. These values, if left uncapped and otherwise not restricted or sub-domained, may result in high-grade 'blow outs'. This could lead to upward bias in the resulting grade estimate and risk of overstating the metal content. This is illustrated in Figure 1, an example from SRK's review of a third-party estimate for an underground gold prospect.

B) Block size at half the average drill spacing. In general, this is a good rule of thumb to help avoid the estimation of overly small blocks, which can result in grade distributions that are poorly supported by the input sample data. However, block size selection should also consider the interpreted mineralisation style. For example, where there is a predictable grade trend observed in drilling from top to bottom contact within a mineralised orebody, use of a smaller block size (less than half drill spacing) may be justified to appropriately reflect the interpreted distributions of high and low grades. This was the case at a sediment-hosted borate project where SRK recently estimated the mineral resource (Figure 2).

C) Search neighbourhood ellipse dimension set to two-thirds of the variogram range. In general, this is a reasonable rule of thumb where variograms are well informed by sample data and their range exceeds multiple drill fences. However, in early-stage exploration projects where the variogram range is based on limited data and is similar to the drill spacing, a search dimension at two-thirds of this distance could result in poorly informed block estimates based on single drill holes. A larger ellipse dimension (less than two-thirds of the variogram range) is likely to be more appropriate in this scenario.

Conclusions

The resource modelling myths and legends considered in this article often form a reasonable starting point or rule of thumb for analysis; however, as highlighted in the cases above, every dataset and geological model should be assessed individually, with project-specific parameters to avoid sub-optimal mineral resource estimates.

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Mark has 15 years of international experience in mineral exploration, resource estimation, and project development. Mark specialises in the authoring and auditing of resource estimates in accordance and compliance with International Reporting Codes, for independent assessments and as part of multi-disciplinary technical studies, auditing mining operations as part of Competent Person's Reports and stock exchange listings and technical reviews.

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ROBERT GODDARD

Rob has 10 years' experience, specialising in estimating and auditing mineral resource in accordance with international reporting standards. He has an in-depth knowledge of mineral resource estimation, with emphasis on geological modelling, geostatistics, interpolation, and classification. Rob has managed and acted as the technical lead on numerous mineral resource-related assignments, on mineral projects ranging from exploration properties to established operating mines, undertaking all aspects of data review, QA/QC, 3D geological modelling, and mineral resource estimation.

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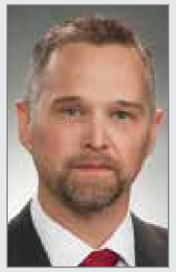
Geological characterisation: a prerequisite to mineral resource evaluation

CLIFF REVERING



Cliff has over 25 years of diverse experience in exploration, project evaluation and due diligence, mine operations and technical consulting. Cliff's experience spans the full project life cycle from early to advanced exploration, project economic and engineering studies including scoping level, pre-feasibility and feasibility studies, to mine start-up and full operations. Areas of expertise include geological modelling, mineral resource and reserve estimation, production reconciliation, grade control, strategic mine planning, and project evaluations and due diligence studies. Cliff has worked on a variety of deposit types throughout North and South America, Australia and Africa.

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ERIK RONALD

Erik is a geologist with over 20 years of experience, specialising in resource geology, exploration and evaluation, resource estimation and geostatistics, mine and production geology, auditing, due diligence, and reporting of mineral resource. Erik has worked across North America, South America and Australia, from greenfields projects through open pit and underground operations. He is a Qualified Person for the purposes of NI 43-101, JORC, and SEC's S-K 1300 in several deposit types and commodities for exploration, geology and mineral resource.

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An example of complex cross-cutting quartz veining relationships associated with gold mineralization

Mineral resource estimation can go wrong for a variety of reasons, but often it can be traced back to one source: a lack of geological knowledge, or more specifically the geological model not reflecting the controls on mineralisation.

Mineralisation controls refer to the lithology, alteration and structural features that control the distribution of mineralisation. There are often multiple controls on mineralisation within a single deposit, each having unique characteristics (e.g., orientation, grade variability, mineralogy) that, if not properly defined or modelled, could lead to the over- or under-estimation of quality and quantity of metal or mineralisation within a deposit. This is especially critical in precious metals projects, where grade distribution is often highly variable, and a disproportionate amount of total metal relies on a small subset of drill intercepts. There have been countless examples of projects progressed to development on the basis of an assumption of continuous grade distribution, only to be discovered after production has commenced that the predicted metal content falls well short of the estimate. Inadequate characterisation of the deposit geology and mineralisation controls may lead to incorrect assumptions regarding metallurgical recovery, geotechnical stability, mining dilution, deleterious materials, and overall production cost assumptions with mining and milling.

Junior exploration, mid-tier and large international producers are all repeat offenders. There is a long list of global projects that have progressed to advanced engineering studies or into operations, only to discover at that stage that the lack of robust geological characterisation has resulted in cost overruns or unknown complexity and that the project is in fact, not economically viable.

To use a common analogy, if a home is built on a crooked or weak foundation, then it doesn't matter how well engineered the walls and floors are because it will only be a matter of time before the cracks start to form. The same principle applies to mining projects, except that the eventual write-down or remediation costs could amount to hundreds of millions of dollars or more.

Adequate drilling, drill spacing and quality of the fundamental data are the first steps to properly characterise the geology and mineralisation controls. The interpretation of data and robust modelling by experienced and qualified geologists is key to bringing the understanding of key economic controls on the project to light and only then can risk be assessed.

Developing a robust interpretation of the geology and mineralisation controls requires the involvement of a well-experienced geologist or team with appropriate technical expertise and the ability to spend but is commonly where companies drop the ball. Spending just 1-2% of an exploration and evaluation budget on people is often all that is required. Engaging technical experts typically costs well under a hundred thousand dollars but this cost pales in comparison to the millions of dollars required to complete a robust drilling campaign – and constitutes the best insurance policy for understanding a billion-dollar deposit.

Despite the relatively low costs involved, there are countless instances where companies have spent millions of dollars on drilling programs only to neglect to properly analyse and interpret the data and develop a robust geology and mineralisation model. Back to the house analogy, no one would ever purchase a million-dollar home then insure it for a hundred bucks.

Initial robust characterisation of an orebody's geology and mineralisation controls is essential to developing a confident mineral resource estimate, understanding the geological risks of a project and ultimately to the successful advancement of a project. By understanding your rocks from the beginning using experienced and qualified geologists, it becomes a more straightforward and less risky engineering exercise to develop the mine. But fail to adequately characterise and interpret the mineralisation controls and the project may end up being doomed before the first tonne is mined.

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Sulphide mineralization preferentially associated with one generation of quartz veining

Empirical geostatistics

With the advances in software speed and capability, many of us now are running multiple scenarios on entire models rather than just small areas or a few blocks. In SRK's experience, both the geological and geostatistical academic theory and our rules of thumb often prove unuseable or incorrect in the real world. The only way to validate and finetune our models is to complete the entire model. If it lacks some property we were expecting, or contains some property we were not expecting, then we need to find out why and/or run different scenarios to see what changes. As we run several scenarios on models more often, we have come to understand that every deposit is different and requires its own parameters to obtain valid and useful results. We've been calling this process empirical geostatistics.

For example, the graph below shows how the grade estimate and the kriging slope of regression estimate change, for a group of ten blocks, when different maximum sample numbers are used in the search neighbourhood. Grade and estimation quality are not independent, as the estimation quality changes so does the estimated grade.

SRK is planning a series of articles and papers on the theme of empirical geostatistics focusing on what happens in reality with changes in different sets of parameters rather than what happens in theory.

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DANNY KENTWELL

Danny has some 30 years' experience in geostatistics, geological modelling, mine planning and surveying. He has extensive international experience with varied commodities including gold, copper, mineral sands, iron ore, nickel laterites, nickel sulphides, bauxite and phosphate. In over 20 years of consulting Danny has had exposure to more than 300 different projects. Danny's skills cover 3D geological modelling, resource estimation and technical reviews.

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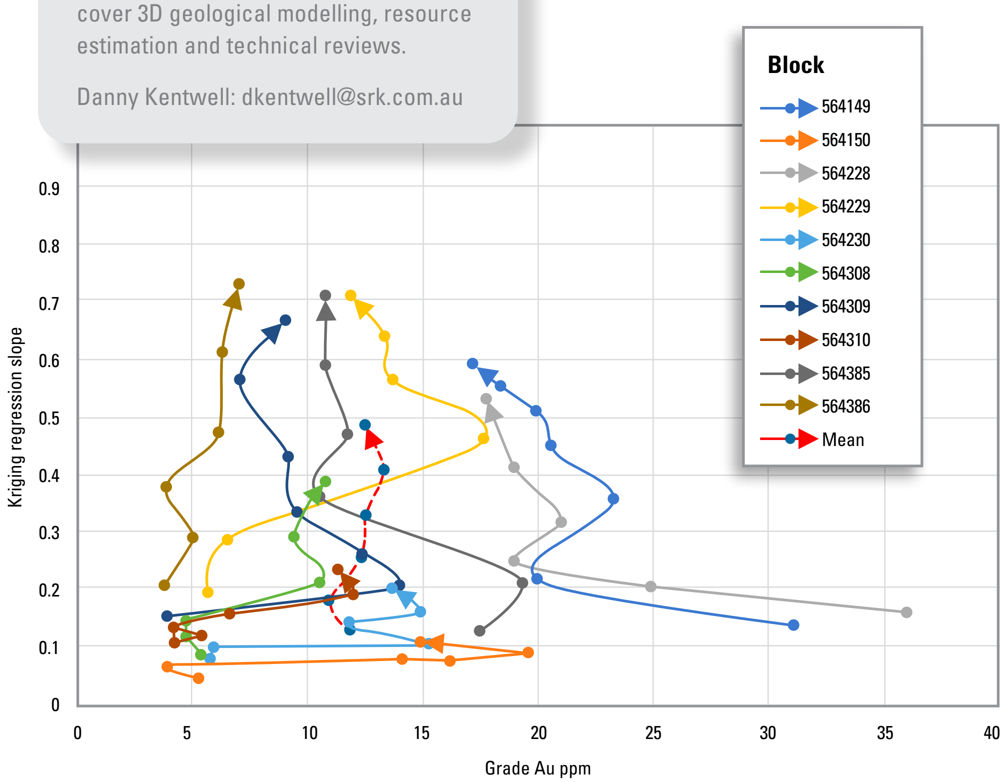
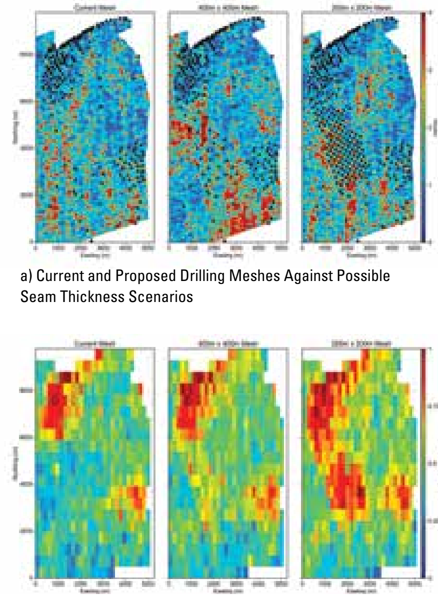


Grades vs Regression slope with increasing samples -10 blocks

Harnessing the power of uncertainty

Figure 1: Multiple simulated scenarios and confidence levels



a) Current and Proposed Drilling Meshes Against Possible Seam Thickness Scenarios

b) Confidence Level Around +-15% of the Expected Seam Thickness for Quarterly Production Volume

Figure 2: Probabilistic metal content curve

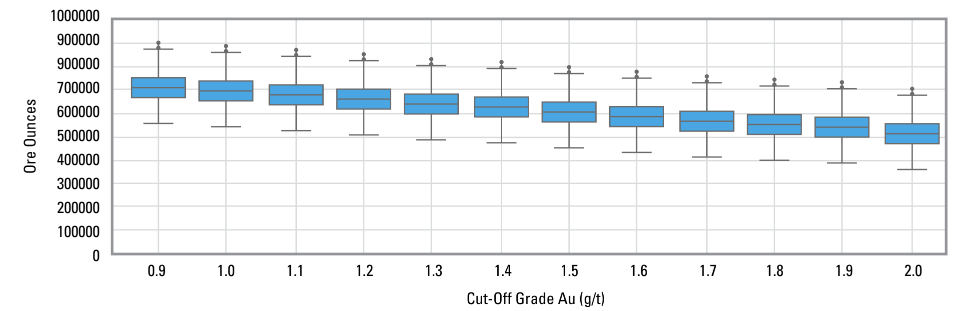
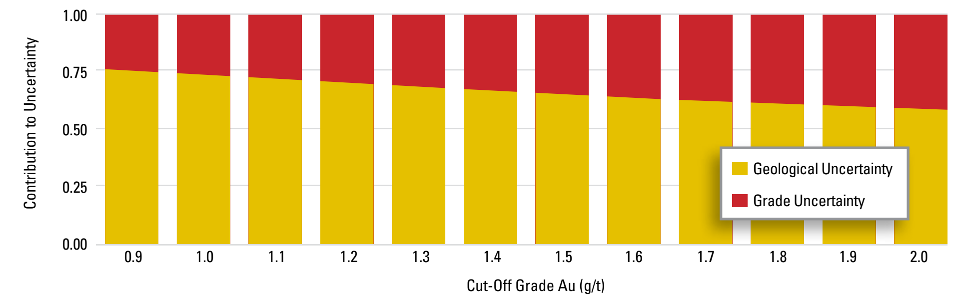


Figure 3: Quantification of the source of uncertainty



The inherent uncertainty in mineral resource evaluation is perceived as negative. However, similar to skilled sailors negotiating contrary winds to advance their sailboats, we can harness this uncertainty to improve our decision making. Two examples of how SRK applies geostatistical analysis of geological and grade uncertainty are drill hole spacing studies and validation of mineral resource estimates.

1. Drill hole spacing studies

Drill hole spacing studies aim to maximise the confidence on grades and tonnages while minimising drilling costs. These are two divergent objectives, as mineral resource confidence can only be increased by acquiring new costly information. To be effective, these studies must consider practical constraints such as new access road costs, topographical relief, and inaccessible areas, while prioritising areas of the deposit where increased confidence may be most beneficial. Different drilling meshes at increasingly closer spacings are designed with the aid of an optimisation algorithm that incorporates these constraints and targets. The resulting drilling meshes are used to 'interrogate' reference mineralisation models that reproduce the spatial variability and other geological and statistical properties informed by the currently available data. These simulated data are amalgamated to the real data to generate multiple possible scenarios that are used to assess the grade and tonnage confidence of production volumes (Figure 1). The retained drilling plan is the one that achieves the grade and tonnage confidence target within an acceptable drilling budget.

2. Mineral resource uncertainty and validation

Mineral resource estimates provide a single, or deterministic, forecast of the tonnage and grades above cut-off. By generating multiple simulated scenarios that respect the informing data and their spatial properties, we can access the full range of possible outcomes of our mineral resource estimates. The metal content at various cut-offs is, therefore, expressed as ranges of possible outcomes (Figure 2). While mineral resource uncertainty has geological, or tonnage, and grade uncertainty components, geological uncertainty can be the primary source of uncertainty (Figure 3), particularly at lower cut-off grades.

Geostatistical simulation techniques are also applied by SRK to assess the amount of internal and external dilution at different block sizes, and as a validation tool for estimated mineral resource models. The capability of simulation techniques to reproduce complex multivariate relationships is key when dealing with multiple metals and contaminants to produce comprehensive assessments.

Drill hole spacing and uncertainty assessment studies require huge amounts of computational effort. To reduce the computer processing time from days to hours, SRK takes advantage of parallel computing algorithms that run on powerful virtual machines in the cloud.

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David has over 15 years' experience in resource modelling, evaluation, reporting and auditing for various types of mineral deposits and energy resources, and five years conducting advanced research on geostatistics. His areas of expertise include the estimation, simulation, validation and classification of mineral resource using standard and advanced geostatistical methods. David's experience also includes the application of conditional simulations for mineral resource classification, drill hole spacing optimisation and the characterisation of geological and multivariate grade uncertainty and risk.

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Glen has over 30 years' diverse and holistic experience in exploration, open pit and underground production, and technical consulting. Glen has held senior technical positions for major mining companies. He has authored numerous independent technical reports for international precious, base metal and uranium exploration, and mining projects. Areas of expertise include operations geology, grade control, reconciliation, mineral resource modelling, and mining due diligence studies.

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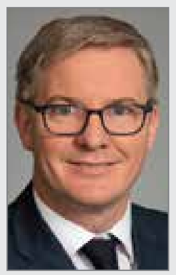
Standardising mineral resource reporting

BEN PARSONS



Ben has over 18 years of broad geological experience, including precious metals, base metals, and more recently niobium and phosphate mining. Ben's expertise includes the production of independent mineral resource estimates, geological modelling, due diligence and auditing of exploration/mining projects, review of operation performance, technical reviews, and assistance in project evaluation as part of Competent Person's/Mineral Expert Reports and stock exchange listings. Ben has project management experience in technical studies such as exploration programs, Mineral resource and ore reserve studies, scoping/conceptual studies, pre/definitive feasibility study projects, working with junior exploration companies at grassroots exploration level through to the listing of large multi-national operating companies with multiple assets.

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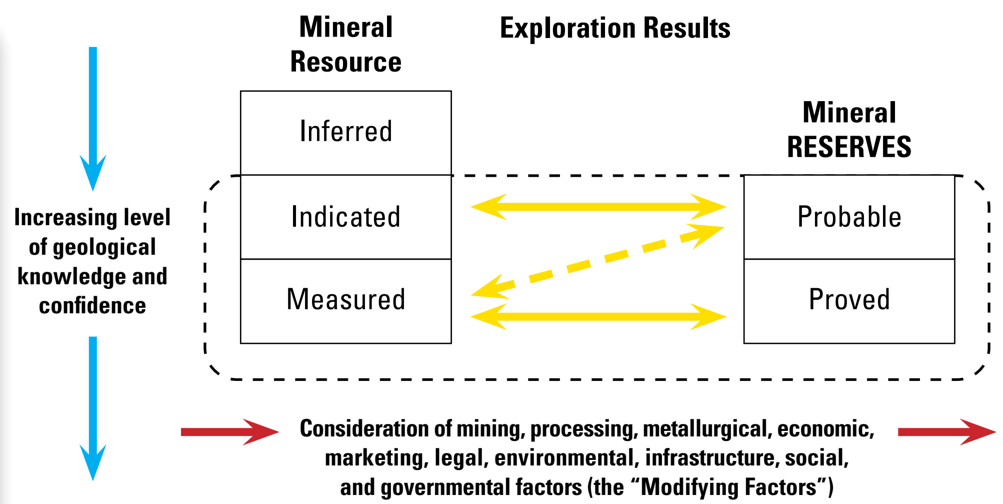

Securities regulators require public companies investing in mineral projects to disclose specific technical information. The Committee for Mineral Reserves International Reporting Standards (CRIRSCO) has consolidated reporting codes and standards to produce a consistent definition of a mineral resource. These do not govern the rules, but instead provide the template and standard definitions upon which reporting codes are based.

Each reporting code has its own disclosure requirements. The Qualified/Competent Person (QP/CP) must have a solid foundation in the relevant reporting codes.

Reporting codes standardise the terms and definitions used in reporting across exchanges, provide confidence to investors through transparency, and provide accountability and responsibility for the estimates through the QP/CP. They do not provide a road map for good practice or mineral resource estimates, nor standardise the level and format of disclosure in different markets.

While the terms, definitions and guiding principles of materiality, transparency and competency remain the same across the codes, there are differences in formats and requirements that need to be understood by the QP/CP. Understanding the formats and when they apply is critical; for example, in Canada, all disclosure is considered under the rulings, from annual and technical report summaries to websites and digital media. In comparison, in the US, only the filings with securities exchange are governed by the rules.

To accompany the rules as defined by the regulators, there are also standards set by industry that detail the recommended standards of best practice.

In the US, Guide 7, which was historically used as the basis for reporting on mining projects, prohibited the disclosure of mineral resource. On 31 October 2018, the US Securities and Exchange Commission adopted new mining property disclosure requirements (S-K 1300). The new rules affect existing primary and secondary listings on US stock exchanges, as well as new listings. To enable the registrant to declare mineral resource, an initial assessment that includes all aspects generally considered under reasonable prospects for eventual economic extraction (RPEEE) must be completed as the minimum requirement. S-K 1300 defines the required level of studies, further highlighting a shift in the importance of the definition of 'potential eventual' economic extraction. Whether this influences the reporting codes to tighten controls remains to be seen, but with JORC currently conducting a survey for a potential update in the near future, it is possible.

The QP/CP should be familiar not only with the reporting codes in the primary listing, but potential impacts on secondary listings related to all mining disclosures. As codes evolve, the QP/CP must ensure their knowledge and understanding of codes and guidelines is current, while maintaining the core principles of materiality, transparency and competency. Ethical practice and reporting should follow the rules and guidelines and provide transparent disclosure, or in other words, 'disclosure with professional accountability'.

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Modern data verification

Data are the basis of the mineral resource estimate. Qualified Persons (QPs) are required to confirm that the data are suitable for use in jurisdictional public reporting, requiring detailed discussions in the technical report on adequacy of the data supporting the estimate. Mineral resource classification can be materially affected by perceived issues in data quality. In some reporting jurisdictions such as S-K 1300, the QP or issuer is legally responsible for the data used in the estimate.

Data verification sections of technical reports often describe the process employed to generate and transcribe data. Actual comparison of source data against the data used for the resource estimate is ordinarily performed against 10% or less of the entire database. This resulting error rate is then assumed to be evenly distributed throughout the database. For many QPs, data verification is a manual procedure involving tedious review of original analytic certificates against corresponding sample IDs. It is often difficult to locate original certificates for all data.

Modern tools have transformed data verification in two ways:

Automation: Automated tools have made it possible for the complete library of analytic certificates to be ingested into digital platforms. By comparing the entire database against all supplied certificates, it is possible to identify material gaps in the source data.

Commodification: These tools have simplified the process to the point that data engineering personnel without geoscientific experience can perform this work.

Without significant budgetary increase, modern data verification tools transform the data verification section of a report from an opinion of the data quality extrapolated from a sample's error rate to a quantitative description of the error rate of the entire population of data. This results in a more robust comparison and a resulting validation that can be relied upon at reduced risk of error.

QPs should consider making modern data verification methods the standard for their practice.

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Example tabulated verification results

Number of samples in the assay file	42,696
Number of CSV certificate laboratory samples compared	38,978
Number of PDF certificate laboratory samples compared	286
Total percentage of samples compared from the assay file	91.96%
Number of tests compared per sample	52
Maximum possible number of matches with the compared samples	2,026,856

Refined reporting of 'exploration targets' for market release

SRK AU is seeing an uptick in requests from junior explorers to provide an exploration target for Australian Stock Exchange (ASX) releases to the market that follow the guidelines of the JORC Code (2012).

Historically, there has been minimal reporting of exploration targets to the market. Potential investors are more technically informed than they were 9 years ago when the JORC Code (2012) was updated, and as such, clients require an increased level of technical content and transparency in their supporting documentation to allow for a better understanding of the reported exploration target in 2021.

When reporting exploration targets, it is important to display the depth of geological and technical understanding. Additional detail should be included, such as constructing informed wireframes of the potential mineralisation, showing the differing geology of the footwall and hangingwall, any regional or local structures/faults/offsets and qualitative descriptions of the mineralisation style and local structure. For a refined approach, a basic geological/resource model should be completed. Any surface mapping or geophysical data should be shown and described.

While no specific confidence level is required to be reported, reasonable ranges of grade and tonnage based on sound geological assumptions are required. Determination of grade range can be informed from quoted percentiles of available data. In determination of the tonnage ranges, the density ranges and density types should also be described. Any mineralogy that may inform recovery should be stated.

It should be noted that an exploration target for release on the ASX also requires:

- a Competent Person's statement
- a cautionary statement that the potential quantity and grade are conceptual in nature, that there has been insufficient exploration to estimate a mineral resource and that it is uncertain if further exploration will result in the estimation of a mineral resource
- a comment on proposed exploration activities designed to test the validity of the target
- a comment on timeframe within which those activities are expected to be completed
- consideration that the mineralisation has prospects of being economically mined within a reasonable timeframe
- that tonnage or grade must not be reported as a 'headline statement'
- that exploration results (if new) have been appropriately reported with an accompanying JORC Code Table 1

This refined approach to reporting exploration targets will better inform the investor and result in improved confidence for clients.

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DAVID SLATER

David is a mineral resource and project evaluation geologist with over 25 years' experience in the mining industry. David has wide experience in evaluation of projects at all stages of the mining cycle in both open pit and underground operations scenarios, where his strengths include optimisation of operations with regard to sampling, grade control, resource estimation, and reconciliation. David has completed considerable due diligence and technical reporting over a range of commodities and locations – these include reporting for the TSX (NI 43-101), SGX, and ASX (JORC Code, 2012).

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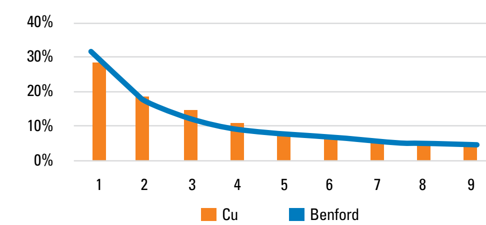
Outside the box, but under the curve: do geological assay data follow Benford's Law?

d	P(d)	Relative size of P(d)
1	30.1%	
2	17.6%	
3	12.5%	
4	9.7%	
5	7.9%	
6	6.7%	
7	5.8%	
8	5.1%	
9	4.6%	

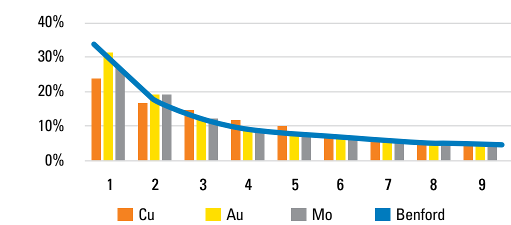
In 1938, Frank Benford compiled over 20,000 observations of random empirical data, ranging from areas of rivers to molecular weights of chemical compounds, cost data, address numbers, population sizes and physical constants. All the various datasets followed an exponentially diminishing distribution, where the leading significant digit was more likely to be small.

Benford's Law, also referred to as the Law of Anomalous Numbers, holds a prominent place in statistical folklore regarding observations about the frequency distribution of leading digits in many naturally occurring numerical datasets. It describes a theoretical probability distribution wherein the number 1 appears first with a frequency of about 30%, while the number 9 appears first less than 5% of the time. The leading significant digits are not uniformly distributed, but instead follow a particular logarithmic distribution.

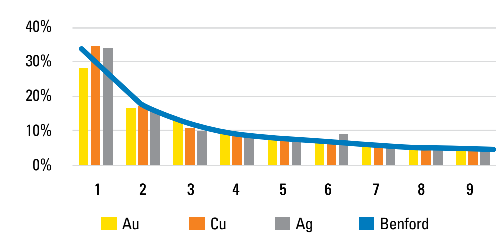
1 Porphyry Cu (n=43,647)



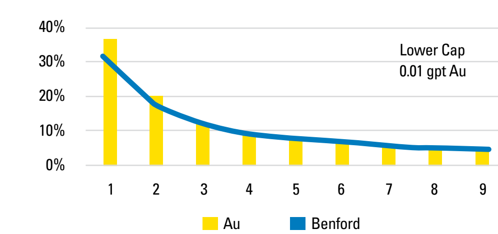
2 Porphyry Cu-Au-Mo (n=42,915)



3 Skarn Au-Cu-Ag (n=16,728)



4 Greenstone Au 1 (n=48,028)



A set of numbers is said to satisfy Benford's Law if the leading digit d (d ϵ {1, ..., 9}) occurs with probability (P):

P(d) = log10(d +1) – log10(d) = log10 ((d +1)/ d) = log10 (1+(1/ d))

The leading significant digits in such a dataset are distributed as in the figure above.

Benford's Law can apply in many empirical contexts. This review investigates whether geological assay data follow Benford's Law and assesses the potential to detect data quality issues, or even duplicitous data, from observing patterns that deviate from the Benford curve.

Assay data from eight metallic ore deposits were randomly selected for review. To evaluate the data, histograms of the first significant digit were abstracted and plotted in Microsoft Excel. Most of the reviewed assay data trends are in conformity with Benford's Law, with good consistency. Failure to follow the significant-digit Benford trend would not necessarily indicate poor or fabricated data, as not all data may behave as forecast. For example, many ore deposits are drilled and sampled selectively, which may skew the results of the assay population.

To investigate the potential to detect data quality issues and possible fraudulent data, several series of random numbers were generated with a uniform distribution. When the random numbers were added to real data, the Benford trend was affected; however, it takes a substantial amount of artificial data, upwards of 20%, before an obvious anomaly is easily discernible. For investigation of potentially fraudulent geological data, though, a Benford analysis is likely insufficient to identify falsified assay results with any surety. However, it might be possible to identify manipulation in datasets over time in populations that previously followed the Benford trend but have now deviated.

Assay data analysis utilising Benford's Law may be considered for investigating data quality concerns, including finding possible repeating data transcription errors or recognising historical values that occur more frequently than anticipated by the logarithmic distribution of significant digits, such as laboratory detection limits varying over time or data variance between past project operators. While Benford's Law should not be used in isolation, it may be a useful screening tool to indicate that a deeper QA/QC analysis is required.

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BERKLEY TRACY

Berkley has 20 years of geoscience experience spanning major miners and small-cap explorers to geotechnical and environmental consultancies. At SRK, Berkley specialises in resource estimation, due diligence, technical evaluation, audit review, exploration targeting, and feasibility study of base and precious metal projects at all stages of development. In the 10 years prior to joining SRK, Berkley was responsible for over 1.5 million feet of notable precious and base metal exploration drilling with combined budgets totalling more than US$100 million. Previous mandates have included providing expert knowledge in resource modelling and geostatistical estimation, consulting on metallurgical and geomechanical concerns, planning and supervising geological logging, sampling, mapping, and feasibility projects, and managing large exploration programs leading to mine development.

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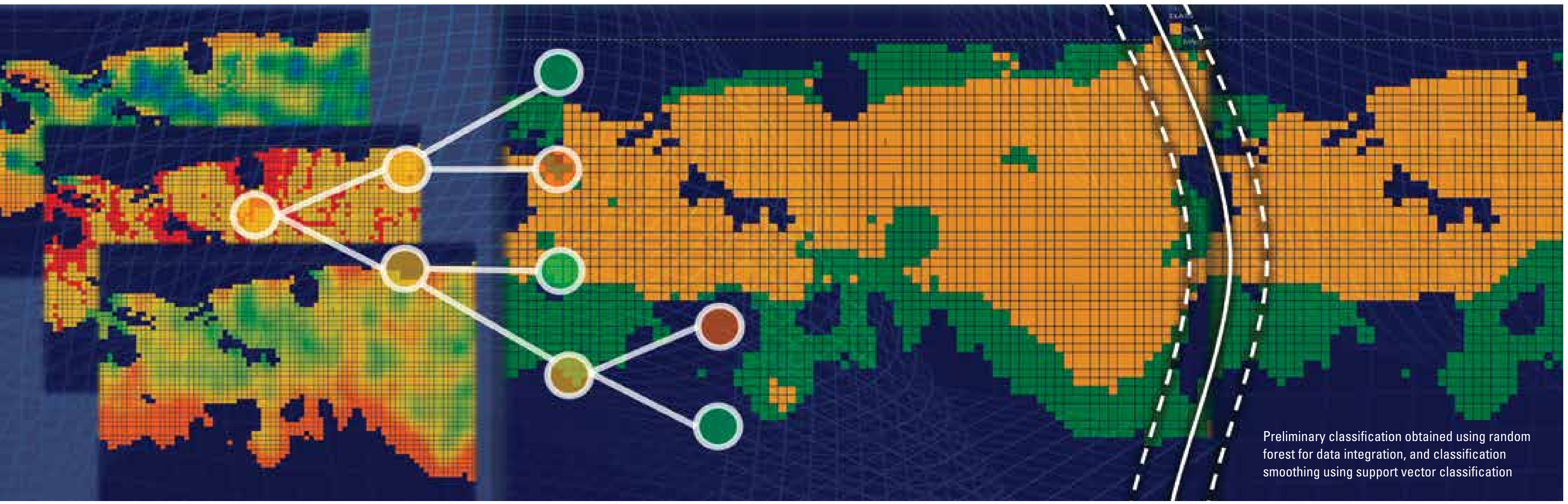
Mineral resource classification using machine learning



Preliminary classification obtained using random forest for data integration, and classification smoothing using support vector classification

Mineral resource classification should consider multiple quantitative and qualitative criteria related to the geological and grade confidence, data quantity and quality, and the prospective mining method. Basing mineral resource classification on a single quantitative criterion is seldom adequate, and often leads to suboptimal results. However, integrating multiple different and sometimes divergent criteria is usually challenging and subject to inconsistency, that is, blocks with similar qualities may end up in different categories. To address this challenge, SRK has successfully implemented machine learning clustering algorithms to develop more comprehensive mineral resource classification schemes. Applying machine learning terminology, these algorithms can be applied in a semi-supervised and unsupervised way, with results always subject to review and editing, if necessary. The result is a consistent classification into mineral resource categories that is comparable to the result of a classification done by a conventional approach, but fully consistent and generated in a short timeframe. The workflow can be easily reproducible; therefore, the result can be easily audited.

The semi-supervised mineral resource classification approach consists of an unsupervised stage followed by a supervised stage. In the first stage the block model is divided into different randomly selected subsets. For each subset a clustering algorithm creates groups of blocks according to how similar their corresponding estimation metrics are. These metrics may include multiple estimation results and parameters, such as the average distance to informing samples and/or drill holes, estimation variances, number of kriging passes, and many others. In the second stage the resulting clusters are used as reference data for classifying the whole block model. By repeating this stage for multiple subsets, it is possible to obtain each block's probability of belonging to each of the mineral resource categories. Finally, a smoothing algorithm is applied to define the final boundaries between mineral resource categories.

For unsupervised classification, a score is given to multiple qualitative and quantitative criteria. Depending on each criterion, a higher score implies higher confidence in the estimation, in the quality of the information, or in the prospects for eventual economic extraction. A weighted average score is calculated with weights assigned to each criterion at the discretion of the Competent Person. The average score is rescaled by the level of geological confidence communicated through the geological model. An unsupervised clustering algorithm creates three spatially correlated clusters and support vectors are used to automatically smooth the boundaries between clusters. Results are validated by the classification criteria statistics and reviewed and edited by the Competent Person in a series of cross sections to produce the final mineral resource category boundaries.

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Applying JORC Code classification to the model built from historical data

The Muruntau gold mine in Uzbekistan is one of the largest gold mines in the world. The mine has an annual gold production of approximately 2 million ounces, and an estimated remaining gold inventory of over 1.5 billion ounces.

SRK Russia was contracted to prepare a mineral resource and ore reserve assessment of Muruntau, applying the JORC Code definitions and reporting standards. Although historical exploration and production information exists, the protocols applied to data collection differ from modern best practice.

Muruntau was explored by surface drilling and channel sampling from underground workings. Exploration was performed according to the standard developed by Geology Committee for Reserves (GKZ). The GKZ protocols were in place during the collection, preparation and analysis of the historical samples, but only summary reports of the quality control sampling were obtained. Core from the historical drilling was also unavailable.

SRK employed an alternative approach to evaluate data quality, comparing the grade control database to historical drilling and underground sampling campaigns. There were two parts to SRK's approach. First, SRK used Leapfrog software to develop a grade control block model. This model produced estimates that aligned with production records. After this reconciliation, SRK formed pairs between the grade control samples and composites from the historical campaigns. Q-Q plots were a useful tool during statistical analysis, because these plots revealed biases related to particular grade ranges that may not be obvious from the summary statistics.

The historical summaries of QA/QC information and the comparison against grade control gave SRK confidence in the resource definition database to assign the Indicated classification that is a prerequisite for declaring ore reserves under the guidelines of the JORC Code.

In summary, grade control and reconciliation information can offer an alternative method of evaluating data quality, which may be appropriate when working with historical databases that do not fully comply with current expectations of QA/QC scope and detail.

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Liubov heads SRK Russia's geological department. Liubov has more than 16 years' experience and specialises in geological modelling, mineral resource estimation, grade control modelling for mining companies, preparation of geological chapters for scoping study, pre-feasibility study, feasibility study and Competent Person's reports and development of mine optimisation programs.

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Linking mineral resource and mineral reserve classification with techno-economic study levels

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Doug is a Professional Geological Engineer with 30 years of experience in resource geology specialising in the evaluation, estimation, and reporting of mineral resource. Doug's experience lies primarily in the study of open pit and underground precious- and base metal exploration properties and acquisition targets in North and South America. He has also worked on open pit PGM and underground gold properties in South Africa and sediment-hosted copper deposits in the DRC and Zambia. His skills include database audits, QA/QC data review and evaluation, geostatistical analysis, resource estimation, due diligence reviews, and he is a master user of Vulcan Software. Doug is a "Qualified Person" for the purposes of NI 43-101 in several deposit types for exploration, geology, and mineral resource, and has co-authored several NI 43-101 and JORC Code reports.

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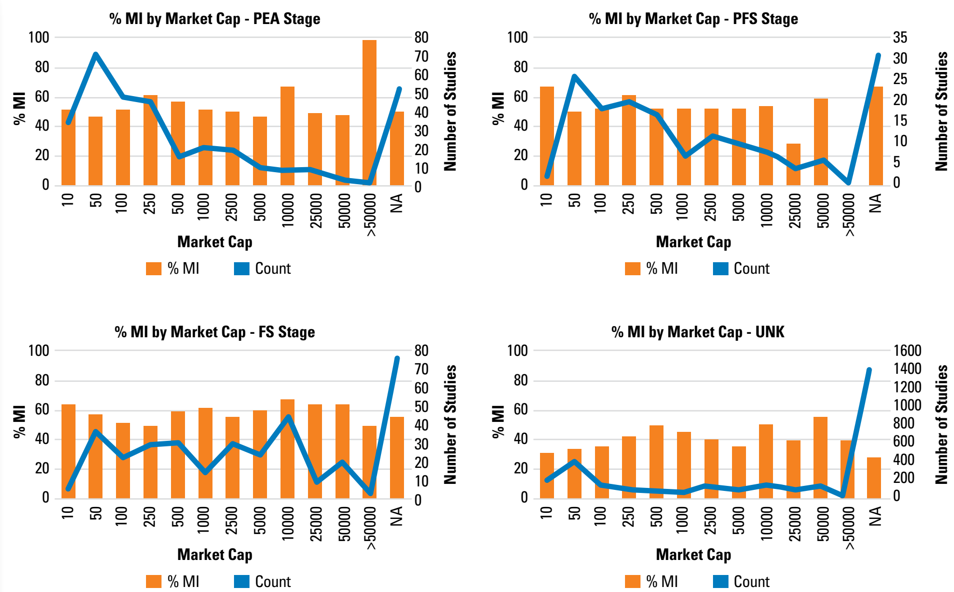
FIG 2 – Trends by market capitalisation



International mineral disclosure standards inform stakeholders about exploration results and resource and reserve estimates. The definitions within these standards facilitate the assessment of pre-development projects.

The feedback now presented addresses the relative reported proportions of Measured, Indicated and Inferred mineral resource at project pre-feasibility study (PFS) and feasibility study (FS) levels.

Industry Practice: Survey

The authors created an international benchmarking survey. The survey was circulated to relevant professionals at 21 mining companies. Invitees were asked to provide their company's view on the topics surveyed, not their personal opinions. Responses were received from 14 companies.

The key questions and results are summarised in Table 1.

Review of Public Data

An April 2021 review of public data also considered a private database collection of public reporting data, which was filtered to companies with a market capitalisation (MCap) of <US$200 billion.

Figure 1 shows the percentage of Measured plus Indicated (M+I) mineral resource material for various commodities at differing levels of study. These results suggest there is little increase in the proportion of M+I to total mineral resources as the study level increases. These results are summarised in Table 2 (PEA – preliminary economic assessments, MP – mine plans, UNK – unknown).

Figure 1 – Averages of percentage Measured+Indicated of total mineral resources by study type

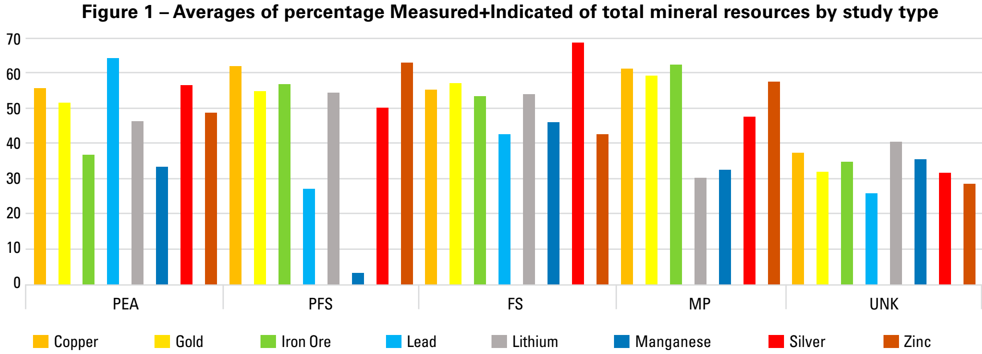


Table 2: Company benchmarking survey summary results

Study Level	No Studies	%M+I
PEA	374	51
PFS	182	56
FS	356	56
MP	161	58
UNK	2,896	33

Figure 2 suggests there is no relationship between MCap and the percentage of M+I to total mineral resources reported.

Conclusions

Review of public data and the feedback from the industry survey provide similar results and indicate inconsistency in the approaches applied and subsequent outcomes.

The risk-averse survey invitees held predominantly bulk commodity deposits and have internal guidelines for resource categories required to inform PFS and FS and generally require Proven Mineral Reserves over the payback period. They typically believe industry peers have similar meanings for resource categories and PFS and FS levels.

The risk-tolerant invitees typically held projects with greater geological complexity. This group generally has detailed internal standards for PFS and FS content, and believe peers have materially different meanings for resource categories and PFS and FS levels.

The authors propose that lender and investor evaluations further influence the industry approaches reported here, which may warrant further review.

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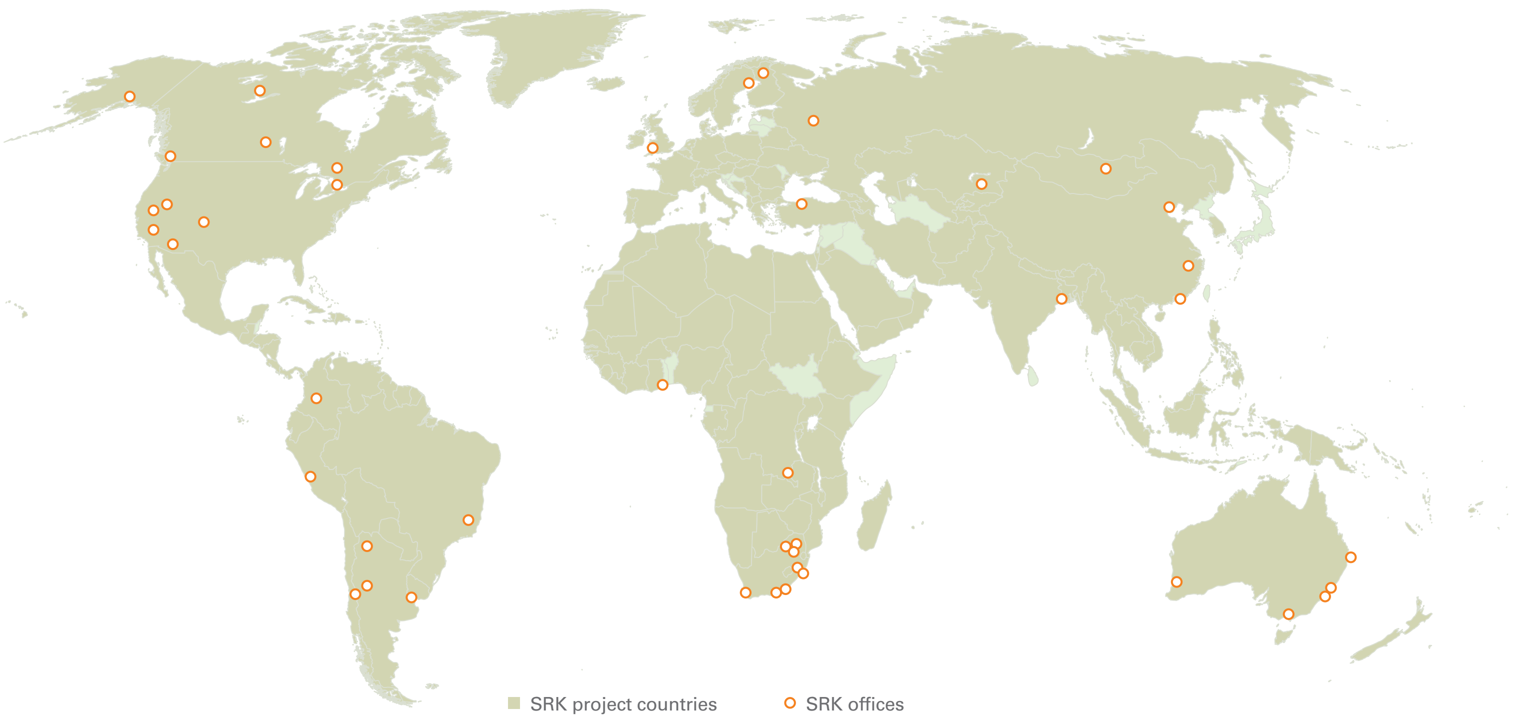
Table 1: Company benchmarking survey summary results

Survey question	Responses proportions
Does your company have internal guidelines on the required proportion of Measured and Indicated mineral resource to support a PFS and FS?	7/14 say 'Yes'.
Does your company insist that Proved Reserves are only possible after an FS level of detail has been completed?	11/14 say 'No'.
Does your company recognise that some deposits are more difficult to assign to a Measured level of resource confidence with resource definition drilling alone at PFS or FS stages?	10/14 say 'Yes'.
Does your company have guidelines to define Measured and/or Indicated mineral resource categories quantitively? If so, please elaborate.	7/14 say 'Yes'.
Does your company have its own detailed standard for PFS and FS content?	9/14 say 'Yes'.
Do peers have the same or similar meanings for Measured and Indicated mineral resource as your company?	11/14 say 'Yes'
Do peers have the same or similar meanings for PFS and FS as your company?	8/13 say 'Yes.



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