



Comparison of the Committee for Mineral Reserves International Reporting Standards Template-based mineral reporting codes with implications for mine planning in mineral development projects

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Abstract

From 2022 to 2040, the global demand for mineral commodities is projected to increase by four-fold to six-fold, largely due to traditional drivers such as population growth and urbanisation compounded by the adoption of decarbonisation technologies that are more mineral intensive than fossil fuel technologies. To meet this projected demand, companies operating in the minerals industry should accelerate the development of mineral projects. Since most of the companies generally operate in multiple geographical, regulatory or legislative jurisdictions, it is critical that the information on Mineral Resources and Mineral Reserves they report on in the public domain should be comparable and consistent across different jurisdictions. The Committee for Mineral Reserves International Reporting Standards fosters alignment of national and regional mineral reporting codes through an internationally accepted template that creates common technical understanding of definitions, classification, estimation processes and the Public Reporting of Exploration Results, Mineral Resources, and Mineral Reserves. The Committee for Mineral Reserves International Reporting Standards Template-based codes guide reporting at respective national and regional levels. Since mine planning is critical in the conversion of mineral resources to mineral reserves, a shared technical understanding should aid comparability of mine planning results. However, differences persist in the way mine planning results are reported. Unlike most previous studies, which have primarily focused on comparing mineral reporting codes, this paper updates and extends such comparisons by exploring how similarities or differences in reporting should influence the mine planning process. It also recommends some principle and process changes to assist mine planning professionals to improve consistency and comparability in reporting mine planning results.

Keywords

CRIRSCO, national reporting codes, mine planning, Competent Person (CP), Competent Person's Report (CPR), Public Reporting

Introduction

The International Energy Agency (2022) estimated in 2022 that to meet the global targets outlined in the 2016 Paris Agreement, the demand for mineral commodities essential for clean energy technologies, could increase four-fold by 2040. Alternatively, in a more accelerated energy transition scenario aiming for net-zero greenhouse gas emissions by 2050, demand could increase up to six-fold compared to 2022. This surge would be driven by the growing need for minerals required for energy transition applications, including electric vehicles, solar panels, and data centres supporting artificial intelligence systems. This projected growth in mineral demand is largely due to traditional drivers such as population growth and urbanisation, compounded by the implementation of decarbonisation technologies that are more mineral intensive than fossil fuel technologies. Therefore, it is critical for mineral industry companies to expedite mineral development projects to meet the anticipated increase in the demand for minerals (Govreau, 2022). However, in trying to fulfil the projected demand through expedited mineral resources and mineral reserves management, it is also important to satisfy various stakeholder expectations of companies operating in the minerals industry. Such stakeholders include customers, financiers, regulators, local communities, native and indigenous peoples, non-governmental organisations and social groups as well as employees, management and shareholders. Stakeholder expectations impose some emerging constraints such as the rising global demand for environmental, social, and governance (ESG) compliance and stewardship to ensure acceptable development and continued operation of mining projects (Sides, Allington, 2024). Typically, mineral industry companies operate mineral development

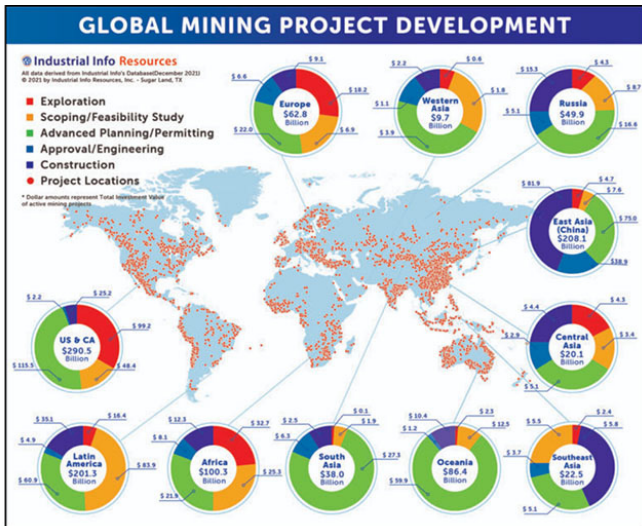


Figure 1—Distribution of global mineral development projects as of 2022 (Source: Govreau, 2022)

projects at various stages across multiple geographical jurisdictions. However, they must navigate these constraints to secure and maintain their social license to operate.

The various stages of mineral development projects include exploration, technical studies such as scoping studies (SS), pre-feasibility studies (PFS), feasibility studies (FS), and engineering and construction works. If successfully actioned and implemented, the result will be the profitable extraction of raw materials or minerals that will be used in the mid- and down-stream stages of the mineral value chain. The evaluation of exploration results typically ends with the declaration and reporting of mineral resources. Subsequently, various technical studies such as SS, PFS, and FS, that are undertaken during mine planning aim to determine optimal ways for extracting the mineral resources. The technical studies culminate in the declaration and reporting of Mineral Reserves, thus, guiding multi-million (or sometimes billion) dollar investment decisions on project advancement. Therefore, mine planning is an important process that is undertaken when converting mineral resources to mineral reserves, which are then reported in Public Reports. Figure 1 is a snapshot of the global distribution of mineral development projects, at various stages of development, as of 2022.

Globally, there are several national and regional mineral reporting codes that guide Public Reporting at national and regional levels. For example, at a regional level some mining companies operating in the European Union (EU) countries report mineral information using the Pan-European Reserves and Resources Reporting Committee (PERC) Standard. It must be noted though, that in the EU it is a company decision to report using the PERC Standard because it is a standard and not a regulatory requirement and the Financial Conduct Authority (FCA) does not specify the code or standard to use, provided it is recognised by CRIRSCO (Sides, Allington, 2024). However, the Critical Raw Materials Act (CRMA), which is a European Commission (EC) legislation, requires the use of the United Nations Framework Classification for Resources (UNFC) (Lepley, 2024).

Companies operating in the minerals industry often operate in multiple geographical, regulatory or legislative jurisdictions, which have different jurisdiction-specific requirements. This requires consistency in the Public Reporting of information on Mineral Resources and Mineral Reserves so that meaningful comparisons

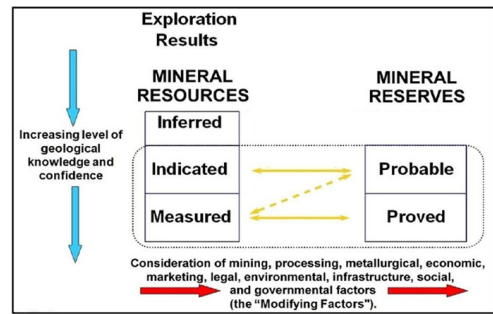


Figure 2—Schematic illustration for categorising Mineral Resources and Mineral Reserves in the CRIRSCO Template (Source: CRIRSCO, 2019)

can be made across different jurisdictions. The challenge to standardise the reporting process so that there is common technical understanding across different regulatory jurisdictions led to the establishment of a global committee in 1994, known as the Committee for Mineral Reserves International Reporting Standards (CRIRSCO). A broad mandate for CRIRSCO is to ensure the alignment of national and regional minerals reporting codes. To achieve this goal, CRIRSCO published a template (the Template) in 2006, which was later updated in May 2013 (Sides, Allington, 2024). At the time of writing this paper, the most current version of the Template had been published in 2019, and that version is also referred to as the International Reporting Template (IRT) (CRIRSCO, 2019; 2024). The Template has gained global acceptance and propelled, inter alia, by the increasing globalisation of investors on different stock exchanges, securities exchanges and equity investors, including royalty and streaming companies. As part of their duty of care, stock and security exchanges must protect their investors by putting systems in place to ensure that the information published by companies listed on those exchanges is, as far as possible, not misleading or false (Njowa et al., 2014). Figure 2 schematically illustrates the CRIRSCO approach to categorising Mineral Resources and Mineral Reserves. Each country under the CRIRSCO umbrella must use the same definitions for comparability in reporting. For example, the definition of an Inferred Mineral Resource in one code must have the same definition in one of the other CRIRSCO Template-based codes, although only the additional guidance may vary, i.e., additional text added to assist and guide the reader as to what additional detail, if any, is required in that respective reporting jurisdiction.

Why it is necessary to compare national and regional minerals reporting codes for mine planning purposes

Unlike previous studies, such as those by Camisani-Calzolari (2004) and Rupprecht (2017a), which primarily focus on comparing mineral reporting codes, this paper updates these comparisons and explores how reporting similarities and differences should inform the mine planning process. This approach aims to promote more consistent and comparable reporting of mine planning results. With this extension, considerations are made regarding how the CRIRSCO Template-based mineral reporting codes can be utilised for better alignment in the Public Reporting of mine planning results.

At a national level, mineral resources and mineral reserves have long been viewed as each country's mineral endowment that is normally assigned to the custodianship of governments on behalf of the country's citizenry. The mineral endowment is an attraction for international investment that contributes towards

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driving the economic growth of the respective country endowed with such mineral resources. For any company operating in the minerals industry, mineral resources and mineral reserves are among the most significant assets, if not the most critical (IASB, 2010; Njowa, Musingwini, 2018). They serve as the lifeblood and foundation of a mining company, determining its future economic viability (Deloitte, 2023). However, if these resources are not reported appropriately, this can mislead investors into making incorrect investment decisions and such reporting fails to comply with ethical and governance expectations of investors. Cases of misleading reporting and associated consequences of such practices were instrumental in driving the development of the CRIRSCO Template. These scandals exposed the dangers and risks associated with a lack of accountability, incompetency, or misleading reports due to the absence of a guiding framework for consistent and comparable Public Reporting of mineral assets. These scandals include the much-publicised Poseidon nickel bubble as well as the Bre-X scandal (Camisani-Calzolari, 2004; Rupprecht, 2017a; Sides, Allington, 2024).

The Poseidon nickel bubble was a stock market bubble that unfolded between 1969 and 1970, driven by speculation around the Australian exploration company Poseidon NL. The company's share price soared after it announced that drilling had uncovered high-grade nickel ore. However, the ore was later found to be of much lower quality, leading to a sharp decline in the stock's value.

Similarly, the Bre-X scandal was a mining fraud that occurred between 1995 and 1997, involving the Canadian company Bre-X Minerals Ltd. The company's stock price surged after it claimed to have discovered a substantial gold deposit at the Busang mine in Indonesia. However, the gold samples were later revealed to be fraudulent, causing the stock to collapse.

To prevent the occurrence of similar scandals in the future, statutory and professional bodies in some leading mineral-rich countries collaboratively developed, together with their respective stock exchanges, standards and codes for guiding the Public Reporting of mineral assets (Njowa et al., 2014). The guidance includes the use of standardised definitions as well as recommendations on the minimum level of experience that the Competent Person (CP) must possess (Njowa et al., 2014). However, it is important to note that neither the CRIRSCO Template nor any of the CRIRSCO Template-based codes prescribe how to estimate, or provide methods to use for the classification of Mineral Resources and Mineral Reserves.

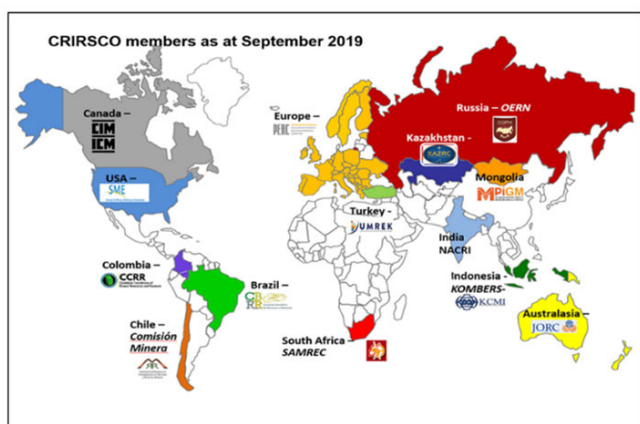


Figure 3—Global mapping of national Mineral Reporting Codes (Source: European Federation of Geologists, 2019)

Figure 3 illustrates the national reporting codes or standards that currently exist worldwide and are aligned with the CRIRSCO Template, at the time of writing this paper. Additional countries are in the process of applying to CRIRSCO, and it is anticipated that the application of the CRIRSCO Template definitions will become mandatory for either national reporting purposes or will be required by all stock exchange regulators.

Despite there being adequate high-level commonality among the various national and regional mineral reporting codes due to their alignment with the CRIRSCO Template, there are subtle, but important differences that can be identified due to jurisdiction-specific requirements, which impact comparable and consistent reporting. The country-specific requirements are the result of:

- Cultural and social contexts
- Legislative and regulatory requirements
- Historical legacies
- Loss in meaning due to language translations to and from English.

In addition, the CRIRSCO Template and various national and regional mineral reporting codes have undergone revisions or updates since their inception (Table 1). What can be observed from these changes is that:

- As national mineral reporting codes develop, they become increasingly detailed as they tend to provide more guidance, explanations and checklists.
- Generally, the revisions are driven by changes in the legislative or regulatory environments as a reaction to fraudulent and other sub-standard practices that may have impacted investors and government revenues.
- Generally, as understanding in using these codes has increased, industry leading practice has also evolved and been adopted by CRIRSCO member countries.
- Requirements for the social license to operate have meant that civil society concerns are making an impact on what and how exploration and mining companies should report into the public domain. A recent example is the ESG reporting requirement, which exploration and mining companies should now report on as part of their published annual reports so that they can demonstrate their ESG compliance and stewardship.
- The reporting codes do not stipulate the estimation methodologies to be applied in estimating mineral resources and mineral reserves, hence inconsistencies will always arise depending on the estimation and classification approaches followed.
- The reporting codes cater for Public Reporting purposes, yet reports can be prepared for reasons other than solely for Public Reporting. Therefore, the reports may contain different levels of detail or emphasis depending on their intended purpose, hence independent reviews are indispensable in trying to minimise inconsistency in reported information or any possibility of information that can be deemed misleading.

One of the achievements of CRIRSCO has been in promoting international mineral reporting, leading practice through standardising definitions for terms used in the reporting of exploration results, mineral resources and mineral reserves (or ore reserves). This standardisation provides high-level assurance to investors who invest across different geographies that there is reporting commonality as the CRIRSCO Template currently provides 16 standard definitions that are used in all the related

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Table 1

CRIRSCO Template-based mineral reporting codes with summary attributes

Country or Region	Language	Status	Code name	Year of first version	Number of updates	Year of current version	Compliance requirements	Applicable Security Exchange or alternative recognition	Length (pages)	Home website
Australia	English	Code	Australasian Code for Reporting of Exploration Results, Mineral Resources and Ore Reserves (JORC)	1989	6	2012	Regulatory	Australian Securities Exchange (ASX); Australian Securities and Investments Commission (ASIC); New Zealand Stock Exchange (NZX)	44	http://jorc.org
Brazil	Portuguese, English	Guide	Commission Brasileira de Recursos e Reservas Guide for Reporting Exploration Information, Mineral Resources and Mineral Reserves (CBRR)	2015	3	2022	Guidance	N/A	84	https://cbrr.org.br/
Canada	English, French	Code	Canadian Institute of Mining, Metallurgy and Petroleum (CIM) Definition Standards for Mineral Resources and Mineral Reserves	2001	3	2014	Legislative	The NI 43-101 incorporates the CIM Standard through direct cross-referencing. The Toronto Stock Exchange (TSX) and TSX Venture Exchange (TSX-V) recognise the NI 43-101.	10 (+44 on Best Practice Guidance)	https://www.cim.org/ OR https://mmr.cim.org/
Chile	Spanish, English	Code	Chilean Code for Reporting Mineral Prospects, Resources and Reserves (Code CH 20.235, CC)	2003	2	2015 (English, 2023 update is in Spanish only)	Legislative	Mining Code CH 20.235	50	https://www.comisionminera.cl/
Colombia	Spanish, English	Code	Colombian Standard for the Public Reporting of Exploration Results, Mineral Resources and Mineral Reserves (ECRR)	2018	1	2018	Legislative	Law 1955 of 2019, Resolution 514 of May 29, 2023, Mineral Resources and Reserves Reconciliation Form	66	https://comisioncolombianarecursosyreservas.com/
Europe	English, Summary Guide in German, Swedish, Finnish, Portuguese, French, Spanish and Italian	Standard	The Pan European Reserves and Resources Reporting Committee (PERC)	2001	5	2021	Guidance / Voluntary Disclosure	Including (but not restricted to) countries of the European Union and European Economic Area, and the United Kingdom	106	https://percstandard.org
India	English	Code	Indian Mineral industry Code (IMIC), For Reporting Exploration Results, Mineral Resources and Mineral Reserves	2019	0	2019	Regulatory	Indian Stock Exchange	62	https://meai.co.in/nacri
Indonesia	Bahasa, English	Code	Komite (Bersama) Cadangan Mineral Indonesia (KCMII), Exploration Results, Mineral Resources and Mineral Reserves Indonesian Joint Committee for Mineral Reserves	2017	0	2017	Regulatory	Indonesia Stock Exchange (IDX) in Regulation IA.1	37	http://www.kcmi.or.id/
Kazakhstan	Kazak, English	Code	Kazakhstan Code for the Public Reporting of Exploration Results, Mineral Resources and Mineral Reserves (KAZRC)	2016	2	2021	Regulatory	Kazakhstan Stock Exchange (KASE)	65	http://kazrc.kz
Mongolia	Mongolian, English	Code	Mongolian Code for the Public Reporting of Exploration Results, Mineral Resources and Mineral Reserves (The MRC Code)	2014	0	2014	Legislative	Minerals Law enacted on 8 July 2006 (Minerals Law)	40	https://crisco.com/portfolio/mpigm/
Russia	Russian, English	Code	Russian Code for the Public Reporting of Exploration Results, Mineral Resources, Mineral Reserves (NAEN)	2011	1	2013	Guidance	N/A	63	https://naen.ru/
South Africa	English	Code	The South African Code for the Reporting of Exploration Results, Mineral Resources and Mineral Reserves (SAMREC)	2000	4	2016	Regulatory	Johannesburg Stock Exchange (JSE)	98 (+ SAMESG with 19 pages)	https://www.samcode.co.za/
Türkiye	Turkish, English	Code	The National Public Reporting of Exploration Results, Mineral Resources and Mineral Reserves Code of Türkiye (The UMREK Code)	2016	2	2023	Regulatory	Various, including the Istanbul Stock Exchange (Borsa Istanbul)	104	https://umrek.com.tr/
USA	English	Code	SME Guide for Reporting Exploration Information, Mineral Resources and Mineral Reserves (The SME Guide)	2017	2	2017	Guidance	N/A	97	https://www.smenet.org/
CRIRSCO	English	Standard	International Reporting Template for the public reporting of Exploration Targets, Exploration Results, Mineral Resources and Mineral Reserves (CRIRSCO Template)	2006	5	2019	Guidance	N/A	79	https://crisco.com/

Note: JORC - Joint Ore Reserve Committee; SAMESG - South African Guideline for the Reporting of Environmental, Social and Governance Parameters

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codes. For example, reference to an Inferred Mineral Resource Report for a hard rock lithium mineral property in Western Australia should have a similar meaning when applied to a hard rock lithium mineral property in Africa, provided that both mineral properties report under CRIRSCO affiliated codes. The commonality of definition allows global investors to compare different mineral properties and choose which property is the preferred investment option when comparing it on a like-for-like technical basis.

Table 1 summarises the 14 mineral reporting codes that fall under the umbrella of the CRIRSCO Template and the dates when the original codes were introduced, together with dates of latest versions, at the time of writing this paper. The mineral reporting codes have used the CRIRSCO Template as a common reference but with additional adjustments that cater for requirements peculiar to a country or region. In the different jurisdictions, national and regional mineral reporting codes may either have legislative or regulatory authority, or merely serve just as guideline documents. However, they all adhere to the same fundamental definitions, guidelines, and terminologies outlined in the CRIRSCO Template for the reporting of exploration results, mineral resources and mineral reserves. However, outside the ambit of the CRIRSCO Template-based codes there are other standards pertaining to mineral reporting but are not the focus of this paper. These include the:

- United Nations Framework Classification for Resources (UNFC), which is a universal standard that can be used

for the sustainable management of all energy and mineral resource endowments to address needs of different stakeholders, such as in policy formulation, capital allocation, and corporate business processes (Hokka et al., 2020).

- Pan African Public Reporting Standard for Minerals and Energy Resources (PARC), which was developed under the auspices of the African Minerals Development Centre (AMDC) as part of a process to coordinate and oversee a continent-wide implementation of the Africa Mining Vision. The PARC Standard seeks to enhance processes for certification of competence in the minerals industry in Africa and harmonise policies and regulatory frameworks relating to the reporting of mineral endowments at a continental level (AMDC, 2023).
- National Instrument 43-101 (NI 43-101), which is a regulatory instrument in Canada to ensure compliance with listing requirements for companies listed on the Toronto Stock Exchange (TSX) and TSX Venture Exchange (TSX-V).
- SK-1300, which is a regulatory instrument in the United States of America (USA) to comply with Regulation S-K [17 CFR 229.1301 - 229.1305] as required by the New York Stock Exchange (NYSE) and US Securities and Exchange Commission (SEC).

According to CRIRSCO (2024), the Template seeks among other things to:

- Integrate the minimum standards that should be adopted in national and regional mineral reporting codes and standards.

Code/Standard/Template	Key Applicability with Inclusions and Exclusions or Key Code Stipulation	Purpose
JORC	Applies to "all solid minerals, including diamonds, other gemstones, industrial minerals and coal". The ASX, ASIC and NSX require compliance with the code as stated in Table 1.	The Code/Standard/Template sets out the minimum requirements, recommendations and guidelines for the Public Reporting of Exploration Results, Mineral Resources and Mineral Reserves (or Ore Reserves)
CBRR (Brazil)	Applies to "all solid mineral raw materials" for which "Public Reporting of Exploration Information, Mineral Resources and Mineral Reserves is required by any relevant regulatory authority". Its applicability excludes water, oil and gas resources.	
CIM Definition Standards for Mineral Resources and Mineral Reserves	Applicable to all solid minerals, including precious stones and industrial minerals. The standard excludes hydrocarbon or maritime resources.	
CH 20.235,CC	Applicable to all solid minerals, including precious stones and industrial minerals.	
ECRR	Regulatory authorities require application of the code for the Public Reporting of Exploration Results, Mineral Resources and Mineral Reserves relating to "all solid minerals, including emeralds and other gemstones, coal, industrial minerals, stone and aggregates"	
PERC	The PERC Reporting Standard applies to all solid mineral raw materials for which Public Reporting is required by any relevant regulatory authority.	
IMIC	The IMIC is applicable to "all solid mineral raw materials" and, in addition, also applies to: • "Oil shales, oil sands and other energy minerals extracted by mining"; • "Metallic or non-metallic minerals extracted by solution mining methods".	
KCMI	Applies to any mineral defined as "any substance, extracted for its economic value, occurring naturally in or on the Earth, in or underwater or in tailings, residues or stockpiles, having been formed by or subjected to a geological process but excludes, water, oil and gas" .	
KAZRC	Applicable to solid minerals only.	
MRC	Applies to "all solid minerals, including diamonds, other gemstones, industrial minerals, stone and aggregates, and coal" for which Public Reporting is required by relevant regulatory authorities.	
NAEN	Applicable to all solid minerals for which Public Reporting is required by relevant regulatory authorities.	
SAMREC	Applies to "all solid minerals, including diamonds, other gemstones, industrial minerals, stone and aggregates, and coal" for which Public Reporting is required by relevant regulatory authorities.	
UMREK	Applies to any mineral defined as "any substance, extracted for its economic value, occurring naturally in or on the Earth, in or underwater or in tailings, residues or stockpiles, having been formed by or subjected to a geological process but excludes, water, oil and gas"	
SME Guide	Applies to any "Mineral Deposit (including coal, diamonds, industrial minerals, and mineral products obtained through in situ recovery methods) is defined herein as an accumulation of mineral(s) of potential economic interest within estimated geological boundaries".	
CRIRSCO	The Template is applicable to all solid mineral raw materials for which Public Reporting is required by any relevant regulatory authority.	The Template is advisory only, and where a national and/or regional code or standard exists, the code or standard will take precedence. It provides minimum standards for adoption in national and/or regional reporting codes and standards for the Public Reporting of Exploration Targets, Exploration Results, Mineral Resources or Mineral Reserves.

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- Provide recommendations and interpretive guidelines for disseminating and promoting effective and well-tested leading practices for Public Reporting.
- Follow a global trend towards more stringent corporate governance and regulation, considering the global amplification of ESG compliance and stewardship expected from companies operating in the minerals industry.

Therefore, this paper sought to compare the CRIRSCO Template-based mineral reporting codes, to highlight their similarities and differences and infer implications for mine planning processes in mineral development projects. The comparison can assist in fostering better comparability in the reporting of mine planning results and in recommending some principle and process changes that can enhance comparability of mine planning results.

Comparison of CRIRSCO Template-based mineral reporting codes

This paper utilised the CRIRSCO Template guidelines to compare how well the national and regional mineral reporting codes align with international leading practice when publicly reporting Exploration Results, Mineral Resources and Mineral Reserves. The comparison considered the degree of alignment with the CRIRSCO Template, deviations from the Template, and similarities or differences among the codes. The relevant comparison categories based on the overall architecture of the CRIRSCO Template included scope, terms and definitions, competence and qualifications of a CP and recognised professional organisations (RPOs), principles and guidelines, and Public Reporting requirements. The codes being evaluated are those listed previously in Table 1.

Scope

The scope of each national and regional mineral reporting code addresses the required minimum standards for the Public Reporting of solid minerals classified as metallic and non-metallic minerals (Table 2). Therefore, water or geothermal energy resources and non-solid energy minerals, such as oil and gas resources, have been excluded and are not considered in the comparisons made in this paper. Under the CRIRSCO Template, it has been globally accepted that it covers solid minerals, and includes, but is not limited to, diamonds, coal, gemstones, industrial minerals, sand, stone, and aggregates. In addition, oil shales, oil sands, or other energy minerals extracted by mining, as well as metallic and non-metallic minerals extracted using solution mining methods, are also included.

The national and regional mineral reporting codes are similar in scope in the following areas:

- They all cover solid minerals only but have some differences in definitions and guidelines to account for local circumstances and conditions. For example, in India, where oil shales are mined, the scope includes guidance on oil shales.
- They utilise the same definitions for the reporting of Exploration Results, Mineral Resources, and Mineral Reserves, including classifications.
- They are not explicit on how to define and report uncertainty inherent in mineral resource estimation and classification, which subsequently impacts how mine planning will be executed, since mine planning is undertaken on declared mineral resources. The uncertainty creates risks associated with the mine planning process.

Generic terms and definitions including equivalents

The language of communication within CRIRSCO is English. If the native language is not English, then the national and regional mineral reporting code should be available in both English and the respective native language of communication. The language translations to and from English can impact the reporting terminology, as meaning may be lost despite best efforts to ensure accurate translation. Therefore, it is important to compare terms and definitions to ensure common technical understanding, which is important for:

- Recognising the international nature of mining and mining investments.
- Comparing technical aspects of exploration and mining projects on a 'like-for-like' basis (e.g., in terms of risk, uncertainty, and opportunity).
- Effective communication.
- Education and training in the reporting of Mineral Resources and Mineral Reserves.

The CRIRSCO Template has 16 standard definitions that must be used in all CRIRSCO member national reporting codes. Table 3 provides commentary on where key terms and definitions are found in the various CRIRSCO reporting codes. These key terms and definitions ensure commonality in technical understanding. It should be noted that the national and regional codes utilise the generic terms and definitions from the CRIRSCO Template but include additional requirements peculiar to their respective jurisdictions. For example, the national reporting codes in Brazil, Chile, and the USA have added guidance on expected ranges of accuracy in estimates of capital and operating cost in technical studies.

The standardisation of the generic terms and equivalents across the national and regional mineral reporting codes has ensured that CRIRSCO can promote industry leading practice in the international Public Reporting of Exploration Results, Mineral Resources and Mineral Reserves. For example, CRIRSCO, (2014) noted that its existence "recognises the truly global nature of the minerals industry and the agreed need for international consensus on reporting standards".

Competence and qualifications of CPs and RPOs

Competence is one of the key requirements that must be satisfied in the reporting of Exploration Results, Mineral Resources and Reserves. The estimation, classification, and reporting of Mineral Resources and Mineral Reserves must be done by a CP who possesses necessary qualifications, training, and experience in the estimation and reporting of Exploration Results, Mineral Resources and Mineral Reserves. Requisite qualifications and minimum experience for a CP are requirements common to all the mineral reporting codes, although there are minor differences in the term used for a CP (note that in the JORC code the acronym CP is also reserved for a Chartered Professional). The minimum experience differs across codes (Table 4). For example, a CP is referred to as a Qualified Professional (QP) in Brazil, Qualified Person (QP) in Canada, Qualified Competent Person (QCP) in Chile, Registered Competent Person (RCP) in India, and Competent Person Indonesia (CPI) in Indonesia.

The CRIRSCO Template stipulates that CPs must possess "a minimum of five years' relevant experience in the style of mineralisation or type of deposit under consideration and the activity", which a CP is undertaking (CRIRSCO, 2019). The

Table 3

A comparative summary indicating where key generic terms and definitions with equivalents are found within the various national and regional mineral CRIRSCO reporting codes (Sources: Home websites as listed in Table 1)

Country or Region	Key Comment on Generic Terms and Equivalents or Key Code Stipulation
Australia	Appendix 1 defines Generic Terms and Equivalents.
Brazil	Appendix 1 defines 15 Generic Terms and Equivalents. Table 2 states the "Study Accuracy Ranges for Capital and Operating Cost Estimates".
Canada	Definitions are contained in the CIM Definition Standards, NI 43-101 Standards for Disclosure for Mineral Projects and the CIM Best Practice Guidelines.
Chile	Appendix 2 defines "Study Accuracy Ranges for Capital and Operating Cost Estimates". Appendix 3 contains 19 definitions, each with their English and Equivalent Spanish Generic Term.
Colombia	Eleven (11) generic terms are defined in the Glossary.
Europe	Appendix 10 defines 38 Generic terms and their generalized meanings.
India	Appendix 1 defines 11 Generic Terms and Equivalents. Appendix 4 defines 26 Acronyms.
Indonesia	Appendix 1 defines nine Generic Terms and Equivalents.
Kazakhstan	Table 2 provides a guideline for the ranges of accuracy in estimates expected in Technical Studies. Appendix 1 defines 17 "Code Terms and Equivalents" (note that they are not in alphabetical order).
Mongolia	Appendix 1 defines 14 Generic Terms and Equivalents (note that they are not in alphabetical order).
Russia	Appendix 1 defines 12 Generic Terms and Equivalents (note that they are not in alphabetical order).
South Africa	Twenty-seven (27) Terms and Equivalents are defined in the Glossary.
Türkiye	Appendix 11 provides a list of 88 technical terms in English and their Turkish equivalents, the definitions or descriptions are found in the Code. Appendix 12 defines 15 Acronyms.
USA (SME Guide)	Table 2 provides the "Study Accuracy Ranges for Capital and Operating Cost Estimates", based on the Third Edition of the Mining Engineering Handbook (2011). Appendix B provides a glossary of 126 terms.
CRIRSCO	Appendix 1 defines 12 Generic Terms and Equivalents.

CRIRSCO Template-based reporting codes generally require five years of relevant experience. However, some countries have modified this requirement. For example, Brazil, Colombia, and India mandate ten years of professional experience in the mining industry, with at least five years being relevant experience. Meanwhile, Türkiye and the USA have adjusted the requirement to seven years of relevant experience. These differences bring into question whether the minimum number of years can be interpreted as a meaningful measure of competence, based on a CP's curriculum vitae. Table 4 summarises requirements for competence and registration for a CP across the different CRIRSCO affiliated codes.

In a recent global study by Waltho et al. (2022), the Australian Securities and Investments Commission (ASIC) highlighted the issue of 'relevant experience' as being interpreted differently by individual CPs worldwide. This concept remains misunderstood, to such an extent that: "Relevance also needed to be extended beyond experience with different styles of mineralisation and be clearer on requiring Competent Persons to report within their field of expertise (e.g., geologists should not assess non-geological modifying factors which could be more appropriately addressed by a mining engineer, metallurgist or other professional)" (Waltho et al., 2022). In the same perspective, other professionals should do the same by only assessing modifying factors appropriate to their respective field of expertise.

The national and regional mineral reporting codes have subtle differences in the following areas when defining competence:

- Registration with a statutory body or membership of a professional body that has disciplinary powers.
- Licensing.
- Relevant education and training in the reporting of Exploration Results, Mineral Resources and Mineral Reserves.

The codes are similar in that there is a requirement for professional registration or membership of a professional body that has disciplinary powers. Reciprocity relationships between countries, through the recognised overseas professional organisations (ROPO) framework, though not always guaranteed, may allow CPs to be recognised across different jurisdictions (Njowa et al., 2014). However, in relation to rules for defining a Qualified Person, Waltho et al. (2022) noted that the disclosure requirements in the USA differed from other CRIRSCO Template-based codes in the way they define Qualified Persons and how the ROPO principle is articulated.

Given the preceding observations, it can be noted that the interpretation and application of the requirement on competence remain a challenge. As a result, different jurisdictions have applied various interim solutions to mitigate or address this issue.

Guiding principles and additional guidance

Transparency, materiality, and competence in the CRIRSCO Template, are the core principles that guide the estimation and reporting of Exploration Results, Mineral Resources and Mineral Reserves. The CRIRSCO Template-based codes uphold these three principles (Njowa et al., 2014). It should be noted that the Canadian Institute of Mining, Metallurgy and Petroleum (CIM) Definition Standards, including the associated NI 43-101, do not explicitly mention the three core principles. However, the three core principles implicitly apply since the CIM Definitions Standards comply with the CRIRSCO Template.

Table 5 outlines how each of the codes directly addresses these principles on an 'if not, why not' basis, including their implications for the CP. A fundamental reason for the 'If not, why not' requirement is to deter ambiguity and selectivity in reporting; hence, improve 'transparency' and 'materiality' of Public Reports and build more confidence in the Public Reports. The 'If not, why not' requirement also assists CPs in including all aspects that a reasonable stakeholder, investor, and professional advisor would reasonably expect to find in a Public Report. This reporting requirement also assists CPs in providing details pertaining to all relevant risks and uncertainty. Table 5 also indicates where a code does not explicitly address the three core principles and how that is addressed through other provisions.

Each item under the Checklist appended as a table with the title 'Table 1' to the national and regional codes has been considered using the 'if not, why not' basis and any material year-on-year variance is to be explained in a Competent Person's Report (CPR) or Qualified Competent Person's Report (QCPR). It should be noted that very few of the CRIRSCO codes have opted to exclude the 'if not, why not' basis for reporting. These include codes from Canada, Chile, Kazakhstan, Mongolia, Russia, and the USA. The Checklist appended to the codes as 'Table 1' is a comprehensive checklist of several technical aspects that must be considered to declare Exploration Results, Mineral Resources, or Mineral Reserves in that specific jurisdiction. In this regard, Lomberg and Rupprecht (2017a,) argued that: "The use of the checklist for every declaration is considered best practice and if completed properly it can provide

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Table 4 A comparison of competence and registration requirements for CPs (Sources: Home websites as listed in Table 1)						
Country or Region	Code/Standard/Template	Term used for Competent Person	Specified Qualifications and/or Experience as per Code Stipulation	Registration Requirement as Specified in Cod	RPO	Additional Comments with any Code Stipulation
Australia	JORC	Competent Person	A minimum of five-years' relevant experience	Member or Fellow of the Australasian Institute of Mining and Metallurgy, or of the Australian Institute of Geoscientists	Member of a recognised RPO	Aligned to the CRIRSCO Template
Brazil	CBRR	Qualified Professional	"At least 10 (ten) years of professional experience, a minimum of five years of relevant experience in the style of mineralisation and type of deposit under consideration and in the activity which that person is undertaking, including at least 3 (three) years in a Position of Responsibility"	Registered with the Brazilian Commission of Resources and Reserves (CBRR)	Member of recognised RPO	"The term 'Position of Responsibility' means that the individual was depended on for significant participation, management and decision-making relevant to their respective area of technical competency. Position of responsibility does not necessarily imply a managerial, hierarchical position or corporate interest. Managerial, hierarchical position or corporate interest cannot be automatically recognised as 'Position of Responsibility'".
Canada	CIM Definition Standards for Mineral Resources and Mineral Reserves	Qualified Person A minimum of five-years' relevant experience	Refer to: NI 43-101 Standards of Disclosure for Mineral Projects, Form 43-101F1 Technical Report and Related Consequential Arrangements.	Member of a recognised RPO	Aligned to the CRIRSCO Template	
Chile	CH 20.235, CC	Qualified Competent Person	Must be "registered in the Public Registry of Qualified Competent Persons, with a University degree that dates back at least 10 years in one of the specialties associated to the mining business and a minimum of five years' relevant experience" .	Registered in the Public Registry of Qualified Competent Persons	Member of a recognised RPO	Certificate of Qualified Person standing issued by the Mining Commission "to act as a Qualified Competent Person in the" preparation of the respective document.
Colombia	ECRR Competent Person	A minimum of ten (10) years of professional experience in the mining industry, and a minimum of five (5) years of relevant experience	Registered in the Colombian Commission of Mineral			
Resources and Reserves	N/A	No international professional bodies recognised by the commission.				
Europe	PERC	Competent Person	A minimum of five years' relevant experience	RPO as Recognised by PERC	RPO as recognised by PERC	Aligned to the CRIRSCO Template
India	IMIC	Registered Competent Person	A minimum of ten years professional experience, which includes five years relevant experience	"A Member of a Professional Organisation headquartered in India and approved by the National Committee for Reporting Mineral Resources and Reserves in India (NACRI)".	Member of a recognised RPO	Annual exam to be taken and passed.
Indonesia	KCMI	Competent Person Indonesia	A minimum of five-years' relevant experience	Member of and registered as a Competent Person Indonesia (CPI) with the Association of Indonesian Geologists (IAGI) or CPI with the Association of Indonesian Mining Professionals (PERHAPI).	Member of a recognised RPO	Documentation must be completed in Bahasa.
Kazakhstan	KAZRC	Competent Person	A minimum of five years' relevant experience	Registered with the Public Society of Independent Experts of the Subsurface Resources (PONEN).	Member of a recognised RPO	Aligned to the CRIRSCO Template
Mongoli	MRC	Competent Person	A minimum of five years' relevant experience	Member or Fellow with the Registered Professional certification of the Mongolian Professional Institute of Geosciences and Mining.	Member of a recognised RPO	Aligned to the CRIRSCO Template
Russia	NAEN	Competent Person	A minimum of five years' relevant experience	A member of the Russian Society of Subsoil Use Experts (OERN)	Member of a recognised RPO	Aligned to the CRIRSCO Template
South Africa	SAMREC	Competent Person	A minimum of five years' relevant experience	A person who is registered with the South African Council for Natural Scientific Professions (SACNASP), Engineering Council of South Africa (ECSA), or South African Geomatics Council (SAGC), or is a Member or Fellow of the Southern African Institute of Mining and Metallurgy (SAIMM), Geological Society of South Africa (GSSA) or Institute of Mine Surveyors of Southern Africa (IMSSA).	Member of a recognised RPO	The professional bodies must have disciplinary powers over their members and have continuous professional development requirements.
Türkiye	UMREK	Competent Person	A minimum of seven years' relevant experience	Professional Member of the Association of Geosciences, Mining and Metallurgy Professionals (YERMAM).	N/A	The professional bodies must have disciplinary powers over their members and have continuous professional development requirements "and that has been certified by UMREK with a Certificate of Competence" .
USA	SME Guide	Competent Person	A minimum of seven years' relevant experience	A registered member of the Society for Mining, Metallurgy & Exploration (SME).	Member of a recognised RPO	The professional bodies must have disciplinary powers over their members and have continuous professional development requirements.
CRIRSCO	International Template	Competent Person/ Qualified Person/ Qualified Competent Person	A minimum of five years' relevant experience	National Reporting Organisation (NRO) will name the appropriate membership class and name of Professional Organisation (PO) and other Recognised Professional Organisation (RPOs).	N/A	The professional bodies must have disciplinary powers over their members and have continuous professional development requirements.

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Table 5

A comparison of guiding principles among the national and regional mineral reporting codes (Sources: Home websites as listed in Table 1)

Country or Region	Code or Standard	Guiding Principles	Statement on 'If not, why not'	Principle Key Commentray or Code Stipulation on adherence with "if not, why not" Principle	Key Commentary or Code Stipulation on Public Reporting and the CP	Additional Comments
Australia	JORC	Transparency, Materiality, Competence	Table 1 in the code must be complied with based on the 'if not, why not' principle for Public Reporting of significant projects.	Be aware of requirements of ASX, ASIC and NZX	Disclose the CP's name and state if they are a full-time employee of the company for which the Public Report has been prepared. Any potential conflict of interest must also be disclosed. The CP must provide written consent for the Public Report to be published.	Additional requirements are defined in terms of stock exchange listing rules.
Brazil	CBRR	Transparency, Materiality, Competence	"For significant projects, the reporting of all criteria in Sections 1 and 2 of 'Table 1' on an 'if not, why not' basis is required" .	"If only one Qualified Professional signs the Mineral Resource or Mineral Reserve documentation, that person is responsible and accountable for whole of the documentation" .	The QP must be named along with their qualification, professional and corporate affiliations and relevant experience. Written consent must be provided by the QP for a Public Report to be published.	Aligned to the CRIRSCO Template with no additional requirements.
Canada	CIM Definition Standards for Mineral Resources and Mineral Reserves	Not specifically mentioned	Not specifically stated	Must read NI 43-101 in conjunction with CSA and CIM requirements, guidance and best practice notes. Public Reports, specifically Technical Reports, are subject to review by the regulator. Each QP should accept responsibility for his or her particular contribution. The QP determines materiality.	Prior, written consent, is not needed for annual resource and reserve declaration purposes.	CP can be sued in their personal capacity.
Chile	CH 20.235, CC	Transparency, Materiality, Competence. Furthermore, the QCP must demonstrate knowledge, experience and judgement	Not specifically stated	The responsibility of the QCP in charge should be absolute. Appendix 2 (Rules of Conduct and Guidelines) must be complied with.	Disclose the QCP's name in the Public Report and state if they are a full-time employee of the company for which the Public Report has been prepared. If not, the QCP's employer must be named.	Certificate of good professional standing of Qualified Person issued by the Mining Commission to act as a Qualified Competent Person is required in the preparation of the respective document.
Colombia	ECRR	Transparency, Materiality, Competence, Impartiality	An 'if not, why not' basis applies to the Checklist in 'Table 1' as well as to the content "within Public Reporting for significant projects" .	If there is doubt about what should be reported, it is better to err on the side of providing too much information rather than too little.	The CP is to be named in a Public Report along with their "qualifications, professional and corporate affiliation(s), relevant experience and state whether the Competent Person is a full-time employee of the company, and if not, the name of the Competent Person's employer".	"A Competent Person is a minerals industry professional (geologist, engineering geologist, mining engineer or mining and extractive metallurgy engineer) registered in the Colombian Commission of Mineral Resources and Reserves" .
Europe	PERC	Transparency, Materiality, Competence, Accountability	The 'if not, why not' basis applies to all aspects of PERC reporting.	The CP must recognise "that they are responsible for ensuring that activities comply with the legal and regulatory requirements relevant to such Public Reporting" .	The CP is to be named in a Public Report along with their "qualifications, professional and corporate affiliation(s), relevant experience and state whether the Competent Person is a full-time employee of the company, and if not, the name of the Competent Person's employer" . Written permission from the CP is required prior to the release of any documentation.	If the CP is "relying on a report, opinion or statement of another expert who is not a Competent Person, disclose the date, title and author of the report, opinion or statement, the qualifications of the other expert and why it is reasonable for the Competent Person to rely on the other expert, any significant risks and any steps the Competent Person took to verify the information provided" .
India	IMIC	Transparency, Materiality and Competence	The 'if not, why not' principle is applicable when reporting using IMIC	"When an Indian Stock Exchange listed company with overseas interests wishes to report Exploration Results, Mineral Resource or Mineral Reserve estimates prepared by a person who is not a member of a PO or RPO, it is necessary for the company to nominate a Registered Competent Person or Persons recognized by NACRI to take responsibility for the Exploration Results, Mineral Resource or Mineral Reserve estimate".	Disclose the CP's name in a Public Report along with their "qualifications, professional and corporate affiliation(s), relevant experience and state whether the Competent Person is a full-time employee of the company, and if not, the name of the Competent Person's employer. The Registered Competent Person's Consent Form(s), or other evidence of the Registered Competent Person's written consent, should be retained by the company and the Registered Competent Person to ensure that the written consent can be promptly provided if required".	Aligned to the CRIRSCO Template with no additional requirements.
Indonesia	KCMI	Transparency, Materiality, Competence	The 'if not, why not' principle applies	"When a company with overseas interests wishes to report Exploration Results, Mineral Resource or Mineral Reserve estimates prepared by a person who is not a member of the IAGI, PERHAPI, or an RPO, it is necessary for the company to nominate a Competent Person or Competent Persons to take responsibility for the Exploration Results, Mineral Resource or Mineral Reserve estimate. The Competent Person or Competent Persons undertaking this activity should understand that they are accepting full responsibility for the estimate and supporting documentation".	Where there is a clear division of responsibility within a team, each Competent Person Indonesia and his or her contribution, should be identified and responsibility accepted for that particular contribution. If only one CPI signs the Mineral Resource or Mineral Reserve documentation, then under the Code, that person is responsible and accountable for entire documentation relating to the Public Report.	Aligned to the CRIRSCO Template with no additional requirements.
Kazakhstan	KAZRC	Transparency, Materiality, Competence	Not specially stated	Not specially stated	Not specially stated	The 'if not, why not' principle is not explicitly addressed in the current version of the KAZRC Code.
Mongolia	MRC	Transparency, Materiality, Competence	Not specially stated	Not specially stated	"It is recognised that companies can be required to issue reports into more than one regulatory jurisdiction, with compliance standards that may differ from this Code. It is recommended that such reports include a statement alerting the reader to this situation" .	"Reports which are required by State regulations, using the Mongolian Government classification system, are not considered as Public Reports within the scope of the Code" .
Russia	NAEN	Transparency, Materiality, Competence	Not specially stated	Not specially stated	Not specially stated	The 'if not, why not' principle is not covered in the current version of the NAEN Code.
South Africa	SAMREC	Transparency, Materiality, Competence	The 'if not, why not' principle applies	Be aware of the Johannesburg Stock Exchange (JSE) listing requirements and the need for the crossreferencing of a CPR. Public Reports are subject to review by the JSE Readers Panel.	"By reporting Exploration Results, Mineral Resources and/or Mineral Reserves in terms of the guidelines of the Code or where reference is made to the Code, whether reported publicly or not, the Competent Person takes full responsibility for the declaration. In these instances, a report detailing all aspects of the work shall be prepared that should be available, if requested. The report cannot be reasonably withheld and should be made available within a timeframe relevant to the immediate situation"	If the CP is "relying on a report, opinion or statement of another expert who is not a Competent Person, disclose the date, title and author of the report, opinion or statement, the qualifications of the other expert and why it is reasonable for the Competent Person to rely on the other expert, any significant risks and any steps the Competent Person took to verify the information provided. State the full name, registration number and name of the professional body or RPO, for all the Competent Person(s) and Technical Specialists. State the relevant experience of the Competent Person(s), Technical Specialists and other key technical staff who prepared and are responsible for the Public Report" .

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Table 5 (Continued)
A comparison of guiding principles among the national and regional mineral reporting codes (Sources: Home websites as listed in Table 1)

Country or Region	Code or Standard	Guiding Principles	Statement on 'If not, why not'	Principle Key Commentary or Code Stipulation on adherence with "if not, why not" Principle	Key Commentary or Code Stipulation on Public Reporting and the CP	Additional Comments
Türkiye	UMREK	Transparency, Materiality, Competence	The 'If not, why not' principle applies	"A site visit to or inspection of the mineral property being evaluated should be undertaken by the Competent Person(s) and appropriate member(s) of the team. In cases where a site visit does not occur, the reasons and its insignificance must be specified".	"Any other relationship between the Competent Person and the company must be disclosed. In the case where the Competent Person or Competent Person's immediate family hold shares, bonds or rights of purchase and franchise documents issued by the company and where there is a direct or indirect relationship between the company and the Competent Person, this relationship must be disclosed. Such a statement must be included in the section where the Competent Person provides their written consent".	In the case of "a Borsa Istanbul (BIST) registered company receiving financing in Türkiye, and having foreign interests and reports on foreign Exploration Targets, Exploration Results, Mineral Resource estimates or Mineral Reserve estimations prepared for a foreign project by a person not meeting the requirements set forth in Article 3.6, the company must commission a Competent Person or Persons that are members of a Recognized Professional Organization to take responsibility for the Exploration Results, Mineral Resource estimates or Mineral Reserve estimates. The Competent Person or Persons undertaking this responsibility need to be aware of their full responsibility regarding the report and supporting documents submitted in line with the Istanbul Stock Exchange (BIST) and Banking Credit Legislation rules, and they should not regard this action as a 'rubberstamping' exercise and should make all required assessments expected of them".
USA	SME Guide	Transparency, Materiality, Competence, and Consistency between Financial Reports, Technical Studies and International Markets	Not specially stated	The SME Guide does not constitute legal advice nor guidance. The SME disclaims "responsibility for the adequacy of disclosures made in accordance with the SME Guide under these or any other laws and any liabilities arising therefrom". Be aware of other relevant requirements and legislation in the USA, including the SK-1300, Sarbanes-Oxley and Dodd-Franks.	"A Competent Person should have visited the property that is the subject of the Public Report within at most the past 18 months if accessible and/or have visited sample preparation facilities, analytical laboratories, and metallurgical testing laboratories as appropriate, before initial disclosure of Exploration Information, Mineral Resources or Mineral Reserves".	"When estimates of foreign Exploration Information, Mineral Resources and Mineral Reserves, are prepared by a person who is not a Registered Member of the SME or someone having the appropriate membership designation in a RPO as listed in Appendix A, the company should nominate a Competent Person to take responsibility for the Exploration Information, Mineral Resources, or Mineral Reserves estimate. The Competent Person(s) undertaking this activity should appreciate that they are accepting full responsibility for the estimate and supporting documentation and should not treat the procedure merely as a 'rubberstamping' exercise".
CRIRSCO	International Template	Transparency, Materiality, Competence	An 'if not, why not' basis applies	"If only one Qualified Professional signs the Mineral Resource or Mineral Reserve documentation, that person is responsible and accountable for whole of the documentation".	The principle of "if not, why not" means that each item listed in the relevant section of 'Table 1' must be discussed, otherwise the Competent Person must explain why it has been omitted".	This is the standard template with the minimum standards informing standards for all the other codes.

Table 6
Comparison of additional guidance among the national and regional mineral reporting codes (Sources: Home websites as listed in Table 1)

Country or Region		Comments
Australia	Reporting of "Mineralized Fill, Remnants, Pillars, Low-grade Mineralization, Stockpiles, Dumps and Tailings"	Separate coal reporting guidelines (Australian Guidelines for the Estimation and Classification of Coal Resources) are available and must be used.
	Reporting of "Coal Resources and Reserves, Reporting of Diamond Exploration Results, Mineral Resources and Ore Reserves".	Lithium Brine guidelines are available and must be used.
	Reporting of "Industrial Minerals Exploration Results, Mineral Resources and Ore Reserves".	None
	Reporting of "Metal Equivalents"	
	Reporting of "In-Situ or In-Ground Valuations"	
Brazil	Reporting of "Mineralized Fill, Remnants, Pillars, Low-grade Mineralization, Stockpiles, Dumps and Tailings"	This Code requires that Public Reports must discuss the environmental, social performance and governance (ESG) and health and safety context and aspects of the project or operation that could materially affect the project during development and operations and after closure.
	Reporting of "Industrial Minerals Exploration Results, Mineral Resources and Mineral Reserves".	
	Reporting of "Diamond and Other Gemstone Exploration Results, Mineral Resources and Mineral Reserves".	
	Reporting of "Coal Exploration Results, Coal Resources and Coal Reserves".	
Canada	Reporting of "Unconventional energy resources".	
	Reporting of Coal Reserves.	Must refer to 'Best-Practice' Guidelines.
	Reporting of Industrial Minerals.	A comprehensive Lithium Brine reporting standard is available.
Chile	Reporting of Diamonds and Gemstones.	None
	Non-Metallic deposits.	This code does not consider hydrocarbons or maritime resources
Colombia	Artificial Deposits.	
	Reporting of "Mineralized Fill, Pillars, Low-grade Mineralization, Stockpiles, Dumps and Tailings".	Application of all the modifying factors grants viability and feasibility to a mining project, now backed by the Extractive Industries Transparency Initiative (EITI), Corporate Social Responsibility and Shared Value.
	Reporting of "Exploration Results, Resources and Reserves for Coal".	
	Reporting of "Exploration Results, Mineral Resources and Mineral Reserves for Emeralds and other gemstones".	
	Reporting of "Exploration Results, Mineral Resources and Mineral Reserves for Industrial Minerals and Construction Raw Materials".	
Reporting of "Metal Equivalents".		
Reporting of "Unconventional energy resources".		

the Competent Person with assurance that no technical inputs or practices have been omitted. It also provides users with confidence that the declaration is fully compliant and can be relied upon". Most of the national and regional mineral reporting codes have included a requirement to report against the 'Table 1' Checklist on an 'if not, why not' basis for maiden declarations or when a material change has occurred for a mineral project or mining operation that would have a material impact on the project or the parent company. Where aspects of the Checklist of 'Table 1' have not been included in the

Public Report, the CP should explain why those aspects have been omitted.

Table 5 provides some guiding principles contained in the national and regional mineral reporting codes and Table 6 indicates some aspects of additional guidance where these are specified in some of the codes.

Table 6 Comparison of additional guidance among the national and regional mineral reporting codes (Sources: Home websites as listed in Table 1)

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Table 6 (Continued)

Comparison of additional guidance among the national and regional mineral reporting codes (Sources: Home websites as listed in Table 1)

Country or Region	Key Items or Additional Code Stipulation on Specific Reporting Guidelines	Comments	
Europe	As Appendices	Includes specific requirements for Metal Equivalents and combined grades, commodity pricing and marketing, permitting and legal requirements, and ESG.	
	Reporting of "Mineralized Fill, Pillars, Low-grade Mineralization, Leach Pads, Stockpiles, Dumps and Tailings".		
	Reporting of "Coal Exploration Results, Coal Resources and Coal Reserves".		
	Reporting of "Exploration Results, Mineral Resources and Mineral Reserves for Diamonds and other gemstones".		
	Reporting of "Exploration Results, Mineral Resources and Mineral Reserves for Industrial Minerals, Cement Feed Materials and Construction Raw Materials".		
	Reporting of "Exploration Results, Mineral Resources and Mineral Reserves for Dimension Stone, Ornamental and Decorative Stone".		
	Reporting of "Exploration Results, Mineral Resources and Mineral Reserves for Oil Shales, Oil Sands, and other energy minerals.		
India	Reporting of "Exploration Results, Mineral Resources and Mineral Reserves for metallic and non-metallic minerals extracted by solution mining methods" .	National coal reporting guidelines must be used in conjunction with IMIC (https://coal.nic.in/)	
	"Disclosure of estimates of mining waste and other waste material of potential economic value" .		
	Reporting of Mineralized Fill, Pillars, Low-grade Mineralization, Stockpiles, Dumps and Tailings.		
	Reporting of Coal Exploration Results, Resources and Reserves.		
Indonesia	Reporting of Diamond and Other Gemstone Exploration Results, Mineral Resources and Mineral Reserves	Diamonds: Supplementary guidelines are available in the SAMREC Code under the Reporting of Diamond Exploration Results, Diamond resources and Diamond Reserves (and other Gemstones, where relevant).	
	Reporting of Industrial Minerals Exploration Results, Mineral Resources and Mineral Reserves		
	Reporting of Industrial Minerals Exploration Results, Mineral Resources and Mineral Reserves.		
Kazakhstan	Reporting of Mineralised fill, pillars, low grade mineralisation, stockpiles, dumps and tailings.	"Where the 'Unconventional Energy' resource is a solid mineral, then the MRC Code is to be applied for the Reporting of Exploration Results, Mineral Resources and Mineral Reserves".	
	Reporting of Coal Resources and Coal Reserves.		
	Reporting of Diamond Exploration Results, Mineral Resources and Mineral Reserves.		
	Reporting of Industrial Minerals Exploration Results, Mineral Resources and Mineral Reserves.		
	As Appendices:		Additional guidance by means of a Table, for coal diamonds and industrial minerals and Dimension Stone is provided in the relevant Appendices.
	Reporting of "Metal Equivalents" .		
Reporting of "Mineralized Fill, Pillars, Low-grade Mineralization, Stockpiles, Dumps and Tailings".			
Reporting of "Coal Exploration Results, Mineral Resources and Mineral Reserves" .			
Reporting of "Diamond and Other Gemstone Exploration Results, Mineral Resources and Mineral Reserves"			
Reporting of "Industrial Minerals, Cement Feed Materials and Mineral Reserves".			
Mongolia	Reporting of "Exploration Results, Mineral Resources and Mineral Reserves for Dimensional, Decorative, or Ornamental Stone" .	Provides Appendix 1 being the generic terms and equivalents that are commonly used in the industry	
	Reporting of Coal Exploration Results, Resources and Reserves.		
	Reporting of Diamond and Other Gemstone Exploration Results, Mineral Resources and Mineral Reserves.		
	Reporting of Industrial Minerals Exploration Results, Mineral Resources and Mineral Reserves.		
Russia	Reporting of Unconventional energy resources.	When reporting coal reserves, a clear distinction must be made between quantity of coal that has been taken into account by the State balance ("Russian Reserves" are quantity of coal in seam with no adjustments for dilution with waste rock layers) and saleable product ("Russian Industrial Coal Reserves" sometimes described as recoverable or run-of-mine, mining and processing losses have been included).	
	Reporting of Metal Equivalents.		
	Specific points on: Reporting of Exploration Results, Mineral Resources and Mineral Reserves for Technogenic Minerals, Coal Diamonds and Industrial Minerals; however, not as detailed as in other codes or the CRIRSCO Template.		
	Reporting of Coal Exploration Results, Coal Resources and Coal Reserves.		
South Africa	Reporting of Diamond Exploration Results, Diamond Resources and Diamond Reserves.	Specific coal (SANS) and Diamond Reporting Guidelines	
	Reporting of Exploration Results, Mineral Resources and Mineral Reserves for Industrial Minerals.		
	Reporting of Metal Equivalents.		
Türkiye	In the Code: Reporting of Metal Equivalents, Commodity pricing and marketing.	Coal: Due to the effects on planning for land use, the administrative management (ETKB, TKI, EUAS and others) may need to have inventory coal estimations that are not limited by short- and mid-term economic issues. The UMREK Code does not govern these issues.	
	As Appendices: Reporting of Mineralized Fill, Pillars, Low-grade Mineralization, Stockpiles, Dumps and Tailings.		
	Reporting of Coal Exploration Results, Resources and Reserves.	Diamonds: Other industry guidelines (Precious Metals and Precious Stones Market, Ministry of Development Mining Specialised Commission Reports, etc) on the estimation and reporting of diamond resources and reserves may be useful but will not under any circumstances override the provisions and intentions of the UMREK Code.	
	Reporting of "Exploration Results, Mineral Resources and Mineral Reserves for Industrial Minerals, Cement Feed Materials and Construction Raw Materials (Aggregates) .		
	Reporting of "Exploration Results, Mineral Resources and Mineral Reserves for Dimension Stone, Ornamental and Decorative Stone".		
	Reporting of "Exploration Results, Mineral Resources and Mineral Reserves for metallic and non-metallic minerals extracted by solution mining methods".		
USA (SME Guide)	Reporting of "Exploration Results, Mineral Resources and Mineral Reserves for Oil Shales, Oil Sands, and other energy minerals extracted by mining methods".	None	
	Reporting of "Exploration Results, Mineral Resources and Mineral Reserves for Industrial Minerals, Cement Feed Materials and Construction Raw Materials (Aggregates) and Dimension Stone are specifically defined.		
	Commodity Pricing and Marketing.		
	Mineral title and Permitting Requirements.		
	Environmental, Social, and Health and Safety Considerations.		
	Mineralized Fill, Pillars, Low-grade Mineralization, Stockpiles, Dumps and Tailings.		
	Exploration Information for Coal, Coal Resources and Coal Reserves.		
Exploration Information, Mineral Resources and Mineral Reserves for Industrial Minerals.			
CRIRSCO	Exploration Information, Mineral Resources and Mineral Reserves for Diamonds.	The is the general template that is used as the base by all the National Reporting Organisations as they develop their own codes. It covers all the minimum requirements/standards.	
	Exploration Information for In-Situ Recovery (ISR), ISR Resources and ISR Reserves.		
	Reporting of Metal Equivalents.		
	Commodity Pricing and Marketing.		
	Mineral title and Permitting Requirements.		
	Sustainability Considerations		
	Reporting of Mineralized Fill, Pillars, Low-grade Mineralization, Stockpiles, Dumps and Tailings.		
	Reporting of Exploration Information for Coal, Coal Resources and Coal Reserves.		
Reporting of Diamonds and other Gemstones Exploration Results . Mineral Resources and Mineral Reserves			
Reporting of Exploration Information, Mineral Resources and Mineral Reserves for Industrial Minerals, Cement Feed Materials and Construction Raw Materials			
Reporting of Exploration Information, Mineral Resources and Mineral Reserves for Dimension Stone, Ornamental and Decorative Stove			

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Additional guidance has been included in the national and regional mineral reporting codes that fall under the CRIRSCO Template, aimed at providing guidance to the CP and readers of Public Reports. For example, with respect to guidance on commodity prices and metal equivalents, the CIM has a leading practice document for metal prices, hence, discrepancies exist despite the codes having the same definitions and guidance. If additional guidance across codes is not carefully adopted, some differences in interpretation and variations in disclosure can cause misinterpretation of reported results.

Public Reporting

It is important that the reporting of Exploration Results, Mineral Resources and Mineral Reserves, whether in the public domain or as per industry leading practice, should foster common technical understanding, regardless of differences that may arise due to jurisdiction-specific requirements. Table 7 outlines how the different codes address the issue of Public Reporting. All CRIRSCO Template-based codes specify that a minimum of a PFS or FS should be completed as part of the process of estimating and declaring Mineral Reserves (or Ore Reserves), while some jurisdictions specify that a mine planning output in the form of a life of mine (LOM) plan and production schedule should also be included when declaring Mineral Reserves.

Implications of similarities and differences in reporting codes to reporting of mine planning results

Links between mine planning and mineral reporting codes

The Checklist of 'Table 1' in the codes assists as a reference framework when developing mine plans. Kapageridis (2007) demonstrated how to use mineral reporting code guidelines to

estimate Mineral Resources and Mineral Reserves using a software package. Generally, the mine planning process is linked to mineral reporting codes for several reasons which include:

- Mining company Chief Executive Officers (CEOs) make public pronouncements on issues such as production guidance that are primarily informed by outputs from the mine planning process. These outputs are generated following guidance from mineral reporting codes, thus highlighting the link between mine planning and Public Reports.
- Regulatory authorities typically require applications for mining licenses or mining rights at the mineral development stage to be accompanied by appropriate mine plans. These plans indicate how the part of the Mineral Resource, which will be extracted as Mineral Reserves are taken through the process of conversion from Mineral Resources to Mineral Reserves following guidance from CRIRSCO affiliated reporting codes.
- Compliance with the listing requirements of a stock exchange is required when companies want to list, or remain listed on the respective stock exchange. Companies that want to list must comply with reporting requirements set out in the mineral reporting code recognised by the respective stock exchange that they want to list on. However, unlisted companies do not need to comply with listing requirements on stock exchanges, so their mineral reporting does not need to be code-compliant, and this exacerbates inconsistencies in mineral reporting.
- During mergers and acquisitions, due diligence is conducted on the respective mining companies that are party to the transactions. This includes performing due diligence on mine plans and publicly reported Mineral Resources and Mineral

Country or Region	Report Name	Key Comments or Key Code Stipulation
Australia	Independent Geologists Report (IGR); Independent Technical Report (ITR)	Must have a complete JORC 'Table 1' attached. Be aware of additional VALMIN and ASX/ASIC requirements. Public documents will be reviewed by relevant regulators.
Brazil	Qualified Persons Report (QPR)	"For entities issuing concise or similar annual reports, or other summary reports, inclusion of material information relating to Exploration Results, Mineral Resources and Mineral Reserves is recommended. In cases where summary information is presented, it should be clearly stated it is a summary, and a reference attached giving the source and location of the Guide-compliant Public Reports or Public Reporting on which the summary is based".
Canada	Technical Report Provisional Economic Assessment (PEA)	Must completely be in the NI 43-101 format. Public documents will be reviewed by the relevant regulators.
Chile	Qualified Competent Persons	Report (QCPR) Reports and documentation must be well organized and archived such that competence is clearly demonstrated. The QCP should be registered with the Mining Commission.
Colombia	Competent Person's Report (CPR)	CRIRSCO terminology and guidance is used.
Europe	Competent Person's Report (London Stock Exchange – LSE; Alternative Investment Market – AIM)	"In cases where summary information is presented, the Public Report must clearly state that the information is a summary. A reference must be provided, giving the source and location of the PERC Reporting Standard-compliant Public Report(s) or Public Reporting on which the summary is based".
India	Registered Competent Person Report (RCPR) - Public Report	CRIRSCO terminology and guidance is used.
Indonesia	Technical Report	CRIRSCO terminology and guidance is used. A complete 'Table 1' is not required.
Kazakhstan	Competent Person's Report (CPR)	CRIRSCO terminology and guidance is used. "The list of terms used should be given in the Public Report".
Mongolia	Competent Person's Report (CPR)	"Reports which are required by State regulations, using the Mongolian Government classification system, are not considered as Public Reports within the scope of the Code. To facilitate converting to the Mongolian classification categories of Resources and Reserves, which are used in Mongolian State reporting into the Code categories, a Competent Person may use the Guidelines on Alignment of Mongolian State Minerals Reporting Standards and the Code as background material to give an indicative mapping of the Mongolian and the MRC Code classification systems".
Russia	GKZ terminology for reports will be encountered e.g., TIO (Technical Study)	Reports which are required by State regulations are generally not published and are not considered as Public Reports within the scope of the NAEN Code.
South Africa	Competent Person's Report (CPR)	CPRs (and other public documents) will be reviewed by the JSE Readers Panel.
Türkiye	Competent Person's Report (CPR)	"Of particular concern should be postings made using social media where it may be inferred that the information being released comprises a Public Report. Companies may also prepare and submit reports to other institutions and organizations other than aforementioned ones, or other regulatory jurisdictions. Therefore, in such circumstances, an explanation should be added to the report. To avoid confusion and to the extent possible, companies are encouraged to prepare reports that are in accordance with the UMREK Code".
USA (SME Guide)	Competent Person's Report (CPR); Technical Summary Report (TRS)	The SME Guide "does not constitute legal advice or guidance. Users of the Guide are cautioned to obtain legal advice as to the disclosure requirements of state and federal securities laws and corresponding foreign laws when offering, selling, or purchasing securities or other investment interests in mining properties".
CRIRSCO	Competent Person's Report (CPR); Qualified Persons Report (QPR)	CRIRSCO terminology and guidance is used, as the basis or minimum standard for all the other codes.

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Reserves, which should have been reported, or must be evaluated, following the guidelines of the respective mineral reporting code.

- For operating mines, Mineral Resources and Mineral Reserves are depleted annually and ongoing exploration must be undertaken to replace the depleting Mineral Resources for later conversion to Mineral Reserves. This is reflected in the company's published annual reports, that are prepared as part of the company's annual reporting cycle, wherein Mineral Resources and Mineral Reserves are declared or reported following requirements specified in the applicable mineral reporting codes.

The preceding sections have outlined some key similarities or differences among the different national and regional mineral reporting codes. When Mineral Resources have been reported, the subsequent process of mine planning is impacted by the subtle, but important differences arising from jurisdiction-specific requirements, which impact comparable and consistent reporting. The various national and regional mineral reporting codes are not prescriptive in how the information used in estimating Mineral Resources should be collected and analysed. Some of the issues related to the estimation of in situ Mineral Resources include the following:

- Data limitations, for example, widely spaced data points that limit available geological information, incomplete or poor-quality sampling, and poor-quality assaying techniques that affect accuracy of estimations.
- Geological complexity, for example, irregular shapes and variable grade distributions that reduce the reliability of resource estimations.
- Differences in the assumptions made by the CP conducting the estimation(s), based on their previous experiences and qualifications. There is no standardised approach to estimating Mineral Resources, hence, the selection of the estimation method, input parameters, and even the cut-off grades chosen can introduce biases and influence the reliability of the results and subsequent mine planning process.
- Different software used for the estimations can give different results, depending on the architecture of the software, thus, impacting on the subsequent mine planning results.

To investigate the effect of these, the Australasian Institute of Mining and Metallurgy (AusIMM) Parker Challenge was initiated (K2fly, 2023; AusIMM, 2023), which was initially sponsored by Rio Tinto in 2023 and subsequently by Barrick in 2025. The instruction to entries into the 2023 challenge was to: "develop a classified and reportable mineral resource estimate from the supplied data. The estimate will be used to inform long-term mine planning and investment decisions" (K2fly, 2023). The entries were reviewed to consider the differences in estimation approaches, the range of outcomes and the differences in classification decisions using the same copper (Cu) dataset. In total, 29 submissions compiled by either individuals or teams, who estimated and classified the resource, were made. The results highlighted differences in how different CPs arrived at different resource estimates using the same dataset. These differences directly impact the subsequent process of mine planning and the reported mine planning results.

The estimated metal volumes between the different submissions were quite varied (Dunham, 2023a). For example, when considering estimates classified at the Measured and Indicated levels of confidence, the reported Cu grades ranged from 0.59% to 1.13%,

whilst the total ore tonnage ranged from 180,000 Kt to 1,900,000 Kt. The average estimated Cu metal content was estimated to be 5,930 Kt, whilst the difference between the lowest and highest was close to 10,000 Kt (from 2,000 Kt to 11,340 Kt). The lowest metal content estimates were 66% below the average, whilst the highest estimates were 91% above the average, and these results were after excluding outliers that could distort the results (Dunham, 2023a). The variability displayed in the estimated grades and volumes can lead to significantly different mine plans as well as economic outcomes.

The similarities and differences already discussed in this paper affect how mine planning results are reported in the public domain. As noted from the AusIMM Parker Challenge, despite the existence of mineral reporting codes, comparable reporting of mine planning results remains a challenge. This discrepancy may be ascribed to how different CPs interpret the reporting code requirements, the assumptions that they make as well as the way in which they interpret the available data. This is why this paper seeks to highlight how the subsequent process of mine planning will be impacted by the similarities and differences in reported Mineral Resources estimates. To outline how the similarities and differences impact the mine planning process the same comparison categories already discussed in this paper were utilised. These categories are scope, terms and definitions, competence, and qualifications of a CP and RPOs, principles and guidelines and Public Reporting requirements.

Implications of code scope to mine planning

Mine planning is undertaken to evaluate mineral industry development projects and producing mineral properties. The scope of each of the codes limits their application to solid minerals on which mine planning is undertaken. The scope implication is that there is clear guidance to mine planning in the type of mineral on which mine planning and design is undertaken. However, the scope is not explicit on how to define and report uncertainty inherent in the estimation and reporting processes, resulting in risk, which creates differences in reported mine planning results and the way the results are reported. Therefore, the mine planning process must consider the uncertainty that exists in the Mineral Resource estimates on which it is undertaken and seek to minimise risk from additional uncertainty arising from subjectivity in assumptions that must be made by the CPs for other mine planning input parameters. Therefore, mine planning results should reflect the existence of uncertainty.

Implications of generic terms and definitions to mine planning

The various reporting codes do not prescribe how the CP should classify an in situ Mineral Resource into each of the Measured, Indicated, and Inferred Resources categories. Classification is based on understanding and evaluating the uncertainties related to the in situ estimations and considering the risks associated with the uncertainties. Whilst the various codes give broad guidelines for classifying Mineral Resources into the three categories, these should ideally provide clear guidance for classification methodologies because clustering of data does not necessarily equate to accuracy (K2fly, 2023; Dunham, 2023b). Despite the importance of estimating Mineral Resources reliably, since the process has a knock-on effect on mine planning, the methods used to assess uncertainty in Mineral Resource estimates are applied inconsistently across the mining industry. This is because the parameters used in the process are often subjectively chosen by the CP responsible for the report (Owusu, Dagdelen, 2024).

Considering the results of the Parker Challenge, there is variation in both the estimation and classification of Mineral Resources that significantly impact reported results (Dunham, 2023a). A recent study of 45 technical reports published on the System for Electronic Document Analysis and Retrieval (SEDAR+) has shown that CPs provide reasons for choosing their classification parameters (Owusu, Dagdelen, 2024). The study from the SEDAR+ platform further assumes these are acceptable as per the CIM leading practice guidelines for public disclosures but acknowledges that the impact of applying different assumptions by CPs to the same dataset can result in discrepancies regarding grades, tonnages, and metal contents. These can result in misleading public disclosures and affect project outcomes. The study emphasises the need for a uniform classification framework with specific parameter ranges tailored to different deposit types, based on available geological and geometallurgical data. Such a framework would reduce the impact of individual CP assumptions, thus, improving investor confidence in mining projects (Owusu, Dagdelen, 2024). If such discrepancies in Mineral Resource estimates can be minimised, this will in turn positively impact mine planning results.

Implications of competence and qualifications of CPs for mine planning

The tools and skills used in estimating in situ Mineral Resources are different compared to those required for converting the in situ Mineral Resources into Mineral Reserves. Geologists tend to dominate the resource estimation space. However, a review of bachelor geology curriculum at a range of universities from the USA, Europe, South Africa, and Australasia show that although statistics is a common subject, geo-spatial data science and geostatistics are rare (Keystone, 2024a). Even MSc degrees in Geology and programmes focused on mining and geological engineering tend to have geo-spatial data science as an elective, rather than as a core subject (Keystone, 2024b). Therefore, the education and training of geology graduates should incorporate geo-spatial data science and geostatistics which are tools that assist in reducing uncertainty that creeps into the mine planning process.

The process of converting Mineral Resources into Mineral Reserves is a function of applying modifying factors, which are generally grouped under the following broad categories:

- Mining technical factors;
- Mineral processing and metallurgical factors;
- Environmental factors;
- Location and infrastructure considerations;
- Market and economic factors;
- Legal considerations including land tenure, and third-party ownership;
- Social considerations; and
- Governmental and regulatory requirements.

The modifying factors are associated with uncertainty and introduce risk into the Mineral Reserve estimation process. Therefore, an understanding of the risk associated with mine planning decisions requires the mine planning CP to decide how to classify Mineral Reserves into either the Proven or Probable category. The CP must ensure that the inputs used are realistic and not overly optimistic or overly conservative. It is advisable that technical specialists support the CP in verifying the accuracy of these inputs and identifying potential risks. Key factors to consider include ramp-up schedules, development rates, mining loss and dilution estimates (such as run-of-mine grades), metallurgical recovery rates, price assumptions, operating and capital costs,

and identification of risks (Rupprecht, 2023). These observations indicate that a single CP is unlikely to have the necessary range of skills to cover both the Mineral Resources as well as Mineral Reserve components, as also confirmed by the Waltho et al. (2022) study. In addition, an independent review of the assumptions, process and procedures followed will assist in mitigating the risk so that a more reliable estimation and reporting of Mineral Reserves can be achieved.

A key issue raised by the Parker Challenge is the level of experience. Perhaps, the issue is that less experienced estimators are more likely to rely on procedures of estimation than having many reference points to calibrate and benchmark outcomes. Importantly, experience is not simply a time-related issue, although that may play a part, but that the breadth and depth of experience of geostatistics applied to very different geological mineralisation styles and modes is important (Hutton, 2024). The more experience someone is, the less likely they are to classify a resource at the Measured level of confidence (Hutton, 2024). On the other hand, less experienced individuals are more likely to classify a resource as 'Inferred' due to limited confidence arising from limited experience (Hutton, 2024). Also, resource estimates are more consistent as the classification level increases and when a resource is more certain, there is less guesswork, leading to fewer personal biases and, therefore, less variation in the estimates (Dunham, 2023b).

Without explicit knowledge of the mineralisation style and an adequate description of how the estimator decided on how to estimate a deposit with due recognition for domains, estimations are more likely to lack credibility. As Harry Parker stated, "*In general, an ounce of geology is worth a pound of geostatistics; this may be disappointing to geostatisticians with no geological background; tough*" (Searston, Smith and Verly, 2020). An estimation hypothesis should be the beginning of all estimations, as are geological and structural models to underpin the thesis. The foregoing observations highlight how uncertainty and risk in the Mineral Resource estimation and reporting process will impact the reliability of the subsequent mine planning process.

Implications of guiding principles and additional guidance to mine planning

Based on the three principles of transparency, materiality and competence, it is important to note that since there are different purposes or reasons for preparing Public Reports, the level of detail and focus or emphasis of a report will depend on its intended purpose. Therefore, it is important to have independent reviews since CPs generally must determine the contents of a report so that the report is appropriate for its use, unless the report is prepared following a prescribed format such as the one provided by NI 43-101. This has a direct bearing on the principle of materiality enshrined in the codes. Another challenge is related to the poor application of 'Reasonable Prospects of Eventual Economic Extraction (RPEEE)' for Mineral Resource Classification at the date of declaration. Therefore, it is important to include a discounted cash flow (DCF) analysis to demonstrate that Mineral Reserves are 'economically mineable' at the date of declaration and the cut-off grade used must be realistic not optimistic. This indicates that mine planning assumptions directly impact Mineral Reserves which must be reported according to mineral reporting codes (Rupprecht 2017b).

Implications of Public Reporting requirements to mine planning

Mineral development projects and operating mines inherently contain significant risks associated with the process of estimating

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and declaring Mineral Resources and Mineral Reserves, although these must be reliably estimated, consistently reported and competently managed (Deloitte, 2023). However, while Public Reporting codes acknowledge the risk in mineral reporting, they generally stipulate deterministic reporting of estimates (Mullins et al., 2023). The uncertainty associated with reported resource and reserve estimates, introduces inconsistencies in reporting such as those noted among mines from different mining companies mining the same or similar type of mineral deposit regarding how Mineral Resource cut-off grades are applied. For example, Sibanye-Stillwater applies a generic resource cut-off grade of 400 cmg/t for its Kloof and Driefontein operations (Sibanye-Stillwater, 2023). A financial cut-off grade and all the modifying factors are then taken into consideration when declaring the Mineral Reserve. However, Harmony, which mines gold reefs that are like those mined by Sibanye-Stillwater, calculates a financial cut-off grade using the current metal prices and cost structures for its Witwatersrand gold mines. This financial cut-off grade is applied as the mineral resource cut-off grade and is effectively the reserve cut-off grade too (Harmony, 2023). How mines interpret the requirement to justify the Mineral Resource requirement for RPEEE at the date of declaration is open to interpretation and the codes are not clear on which approach would be considered more appropriate in a case such as this one. What is important is that the cut-off grade used is realistic.

It is also noted that some companies only report the Mineral Resources including the Mineral Reserves, whilst others present the Mineral Resources including Mineral Reserves and then as a separate table, the Mineral Resources excluding the Mineral Reserves. These variations indicate the different interpretations of 'inclusive vs. exclusive' reporting of Mineral Resources and Mineral Reserves. From the schematic illustration for categorising Mineral Resources and Mineral Reserves (Figure 2) in the CRIRSCO Template, it should be clear that Mineral Reserves are a subset of Mineral Resources with the modifying factors applied. With some companies reporting Mineral Resources excluding Mineral Reserves, it indicates that there are different interpretations to what should be a clearly defined CRIRSCO concept.

The language that a CPR should be written in should be aimed at investors and their advisors, rather than subject experts like geologists and mining engineers. It is noted that technical reports containing complex language, sales pitches, and unrealistic or misleading statements are a common phenomenon in recent years (Rupprecht, 2023).

Whilst inadequate reporting of ESG considerations has been highlighted as a problem, there is often duplication between what the various reporting codes require and what the regulators require (Rupprecht, 2023). Environmental impact assessments already require extensive social and environmental reporting and CRIRSCO runs the risks of competing with these other established guidelines. Therefore, it is important for timeous and appropriate incorporation of these parallel guidelines into the CRIRSCO reporting frameworks, so that mine planning results are aligned with relevant contemporary developments.

Some recommendations on principle and process changes to mine planning related to mineral reporting codes

Given the inconsistencies that exist in the estimation and Public Reporting of Exploration Results, Mineral Resources and Mineral Reserves, despite the existence of mineral reporting codes, some principle and process changes may assist in further minimising the

frequency and magnitude of the inconsistencies. Some principle and process changes are the following:

- LRegulatory authorities should make compliance with mineral reporting codes mandatory, whether a mining company is or not listed on a stock exchange as this will foster awareness of the need to align with the CRIRSCO Template for comparable and consistent reporting of Exploration Results, Mineral Resources and Mineral Reserves.
- LTo avoid inconsistencies emanating from the different interpretations of the 'inclusive vs. exclusive' reporting, it should be preferable to report Mineral Resources inclusive of Mineral Reserves and then report Mineral Reserves separately so that it is clear from the 'if not, why not' basis that certain portions of Mineral Resources were not converted into Mineral Reserves during the mine planning process.
- LIt is important to minimise the 'fear' of CPs being sued especially for discrepancies relating to reported Mineral Resources and Mineral Reserves, despite inclusion of disclaimers allowed for by the mineral reporting codes since investors can exercise their right to come after the CPs. It is recommended that codes mandate independent technical reviews of mine planning process controls and procedures before a company declares its Mineral Resources and Reserves estimates. This recommendation will minimise unintended consequences to mine planning CPs and reduce their 'fear' and this will also resonate with the Mineral Resources and Mineral Reserves governance framework recommended by Deloitte (2023).
- LBased on the arguments presented by Waltho et al. (2022), the definition of a CP's relevant experience should be limited to their area of expertise. When converting Mineral Resources to Mineral Reserves, geologists should desist from assessing non-geological modifying factors since mining engineers, metallurgists or other specialists can more appropriately evaluate such factors (Waltho et al., 2022). Similarly, other professionals should avoid assessing modifying factors beyond their own expertise. This change requires clear recognition that the Mineral Reserve estimation should be undertaken as a team effort comprising multidisciplinary technical specialists within a well-structured Mineral Resource Management organisational structure.

Concluding remarks

Generally, for ensuring international comparability, any committee responsible for developing or updating a national and regional mineral reporting code must collaborate with other members of CRIRSCO so that the respective code is compatible with the CRIRSCO Template and other CRIRSCO Template-based codes (CRIRSCO, 2019; 2024). However, no single code can cover all accepted industry practices, eliminate risks inherent in Mineral Resources estimation and reporting thereof, nor assist with all possible unforeseen situations that are encountered in the estimation and reporting of Exploration Results, Mineral Resources and Mineral Reserves. Consequently, there will invariably be challenges associated with consistent and comparable estimation and reporting of Mineral Resources and Mineral Reserves. Therefore, the CRIRSCO Template exists to provide guidance on the best current knowledge regarding reporting practices, thus, fostering more comparable mineral reporting with minimised risk. CPs must exercise competency and diligence when applying a national or regional mineral reporting code by carefully

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balancing industry leading practices and a mineral deposit's unique circumstances and characteristics. Although codes are in place, it does not remove the need for CPs to be able to defend their work before their peers as they must take responsibility for their findings and interpretations. Therefore, there is strong emphasis on the implementation of a safety net that requires independent technical reviews before results are publicly reported.

The CRIRSCO Template has been recently updated considering leading practice in the world. However, there remains some unresolved issues that practitioners would need to make a choice and make disclosures based on the selected option, for example, the reporting of Mineral Resources inclusively or exclusively of Mineral Reserves. There is no right or wrong way of reporting, hence CRIRSCO decided to leave the Template open to both options. The issue of licensing and registration of CPs into a centralised database has been left to CRIRSCO member countries to address considering peculiar circumstances specific to their different jurisdictions. The effort required for CPs to comply with the updated CRIRSCO Template must not be underestimated, but the minerals industry should see changes to the Template improving understanding and communication to facilitate the accelerated development of mineral projects to meet the projected global demand for mineral commodities.

By analysing the different CRIRSCO Template-based mineral reporting codes, this paper contributed to the important area of Public Reporting of Exploration Results, Mineral Resources and Mineral Reserves. Additionally, the comparison of the codes was made with implications to mine planning so that there can be an improvement in consistency in mine planning processes across different jurisdictions and operations, hence foster comparable conversion of Mineral Resources to Mineral Reserves among the mine planning fraternity. An issue associated with consistency in the application of the reporting codes is centered on ethical and governance compliance expected within ESG frameworks. It is assumed that, to meet ethical and governance expectations within an ESG framework, the reporting requirements must promote ethical reporting. Their comprehensive checklists are intended to reinforce ethical practices and help prevent future scandals. However, reporting codes do not entirely prevent false or misleading reporting, as loopholes exist within the requirements. Variations in the interpretation of these requirements can lead to inconsistencies. Therefore, principle and process recommendations such as those presented in this paper can help minimise these discrepancies, hence assist the mine planning fraternity in undertaking the important role of converting Mineral Resources to Mineral Reserves.

Credit authorship contribution statement

Mark Burnett conceptualised the research study and designed the research methodology; Mark Burnett, Cuthbert Musingwini, Godknows Njowa and Clinton Birch conducted the literature review, analysed the CRIRSCO Template-based codes, evaluated mine planning implications and participated in compiling both the original draft paper and the final submitted version of the paper.

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The Authors declare that there is no conflict of interest in the production of this work.

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Ethical compliance considerations

The work reported in this paper did not make use of any human or animal participants, hence did not require ethical clearance. However, care was taken to conduct the work ethically.

Declaration of generative AI and AI-assisted technologies

The authors utilised Grammarly and ChatGPT to review grammar and readability only.

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