A practical review of the evolution of international reporting standards for mineral resources and mineral reserves

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Abstract

The purpose of this article is to show the evolution of international reporting standards for the public reporting of exploration results, mineral resources, and reserves, from the first initiatives to the current days. Particularities, similarities, and components, which ensure that the information provided complies to various worldwide instruments, are discussed. We also examined the recent changes in the national/regional Codes and guides, including the CRIRSCO Template published in late 2019. The systematization promotes understanding of company risks from the capital market and other financing mechanisms, making it possible to compare projects and do benchmarking analysis, allowing mining companies to comply in a more efficient, transparent, and less costly way to the jurisdictions under which they operate. Finally, presented is a chronology and evolution of the standardization and the localization of similar topics within the Codes of the CRIRSCO Family. The international reporting standards are a relevant and consistent instrument with reliable statements, clear language, and are recognized from one jurisdiction to another by financial institutions, which helps to improve and increase confidence in the mining industry. The objective of the CRIRSCO members is to provide and promote the understanding of the practices for mining investment decisions, being successful around the world.

Keywords: international reporting standards, mineral resources, CRIRSCO, JORC, NI 43-101.

1. Introduction

Since it is becoming more required by the market and stock exchange regulators throughout the world, international standards for the public reporting of exploration results, mineral resources, and mineral reserves are one of the major factors for reliability increase within the mineral industry after the Bre-X scandal, the most well-known mining fraud of history.

The technical reports are developed according to guidelines of international standards in line with the Committee for Mineral Reserves International Reporting Standards (CRIRSCO) and must be compatible with the proposed practices to be accepted by any jurisdiction. The reports

must assume the current development stage concerning mineral premises to expressly provide investors and advisers with this information in a summarized way. The application of recommended good practices brings about consequent risk reduction for investors and increases the attractiveness of the business environment. These are important practices to support fusions, acquisitions, and other corporate agreements, including offers to sell securities and to provide company executives and other mining investment decisions concerning resources and reserves with a basis for assessing relative risk. For this, CRIRSCO rules have been rendered compatible.

Stephenson and Miskelly (2001) highlighted as major benefits of the standardization of international reporting: "Mining is international, as is investment. Many companies domiciled in one country have foreign parents or associates. Similarly, it has become increasingly common for mining companies to diversify their exploration, development, and production using foreign countries. Exploration joint ventures often have ownership spread amongst several countries. In the absence of an international reporting standard, it would not be unusual to be required to comply with, say, three or more different reporting regimes and sets of definitions. The Tower of Babel story may have modern analogies. The problems of differing standards are compounded when debt and/or equity financing is sought for development. The source of such financing may originate from many countries. Differing standards therefore involve unnecessary effort and cost. Standardized reporting would assist in the free flow of investment funds both direct and portfolio, since there would be a clearer understanding at all levels of the resources/reserves reporting chain. Providers of equity and loan funds would be better able to refine their risk management techniques. Better quality information about exploration results, Mineral Resources and Mineral Reserves could reasonably be expected on a worldwide basis to siphon off, either in primary issues or in the secondary market, funds that might otherwise be attracted into the non-mining sector. Hence the overall cost of capital to mining development may fall".

2. Materials and methods

This research adopted a qualitative approach, with its development based on the best practices adopted in the mining industry worldwide. The materials used throughout the project were predominantly web query and extraction, discussions, interviews, conversations with professionals, document analysis, management of bibliographic references, organization, and treatment of research data in spreadsheets. The study compares more than 30 documents and versions of instruments, guides, and Codes.

3. Results

Codes are instruments presenting guidelines and recommendations of good practices for the Public Reporting of Exploration Results, Mineral Resources and Mineral Reserves. This standardization of the Codes is one of the great advantages of adopting methodology and systematization, which renders equivalent and dynamic application and adequacy throughout the globe. With the standardization, comparing similar projects and establishing benchmarking can be done through the same approach presented, with high-quality information, more and more required by investors and financial markets.

The standards adopted items, concepts, and formats, some of them described herein-after, include:

- Principles: materiality, transparency, and competence;
- Defined terms definitions: relevant phrases and words highlighted and defined to ensure consistency in use;
- Clauses: requirements, criteria, and guidelines for public reporting and recommendations to be complied with;
- Interpretations: support and guidelines to readers when applying clauses and definitions;
- Figure of the adopted classification system;
- Checklist of assessment and reporting criteria (the famous "Table 1" of JORC);
- Appendixes. There are clauses or appendixes exclusively dedicated to recommendations for coal, diamond, industrial minerals and construction minerals, dimension stones, and other commodities, since there are specific issues to be considered for these items, having been described in detail in some Codes.

CRIRSCO member countries' intentions and efforts focus on keeping the same conductive line, by including a few particularities. Figure 1 presents a summary of the assessment of all instruments to indicate which components are mentioned in which clauses.

Specifically, regarding competence, Codes highlight a special item (Competence and responsibility) to state that reporting must be conducted, performed, planned, executed, and signed off by a responsible professional, qualified, experienced, and specialized in the mineralization type.

Professionals who want to act as qualified persons in the mining industry must adhere to a code of conduct and be affiliated with a recognized professional organization that has disciplinary and regulatory powers. Documentation for public reports must be prepared by qualified individuals or supervised by them, with ultimate responsibility resting with the company's board.

These professionals must be experienced and independent, capable of selecting the best exploration and assessment techniques while being able to justify their decisions to their peers. Criteria for becoming a Competent Person/Qualified Person generally include five-to-ten years of industrial experience, registration with a Recognized Professional Organization (RPO), and at least five years of relevant experience in the type of mineralization or deposit being assessed, as well as in the specific activity being undertaken.

Additionally, some countries require a minimum period of time in a position of responsibility and recommend participation in Continuing Professional Development (CPD) programs to stay current in their field. CPD may be necessary for professional registration renewal in some RPOs, with reassessments occurring every three to five years.

Topic	IRT Template (2019)	CBRR Guide (2022)	PERC Code (2021)	PMRC Code (2020)	IMIC Code (2019)	S-K 1300 (2018)	ECRR Code (2018)	SME Guide (2017)	KCMI Code (2017)	UMREK Code (2017)	SAMREC Code (2016)	KAZRC (2016)	IG 7 (2016)	CH 20235 (2015)	CIM Definitions Standards (2014)	MRC Code (2014)	JORC Code (2012)	NI 43-101 (2011)	NAEN Code (2011)
Foreword	(*)	(*)	(*)	1			1	i-v	1	1	1	1		(*)	(*)	1	1		1
Introduction	1.1-1.10	1.1-1.10	1.1-1.9	2-3		(*)	2-3	1-3	2-3	2-3	2	2		1-5;7		2	2-3		2-3
Scope	2.1-2.23	2.1-2.23	2.1-2.36	4-9	1-5	(*)	4-8	4-7	4-7	4-8	3-6	3-7		8-9	(*)	3-7	4-8		4-6
Competence and responsibility	3.1-3.12	3.1-3.12	3.1-3.17	10-13	6-9	(*)	9-11	8-16	8-10	9-11	7-11	8-11	(*)	10-11	(*)	12-16	9-11	(*)	7-9
Reporting terminology | general	4.1-4.9	4.1-4.9	4.1-4.11	14-19	10-14	(*)	12-18	17-30	11-15		12-19	12-16		12-15	(*)	8-11	12-17	(*)	10-11
Reporting of exploration targets	5.1-5.6	5.1-5.6	5.12-5.19	20	15			31-32			21-23					17			
Reporting of exploration results	6.1-6.9	5.7-5.15	5.1-5.11	21-22	16-18	(*)	19-21	33-34	16-18		20	17-20		16		18-20	18-19		12
Reporting of mineral resources	7.1-7.23	6.1-6.23	6.1-6.22	23-31	19-27	(*)	22-29	35-40	19-27	20-28	24-34	21-29		20-25	(*)	21-29	20-28		13-20
Reporting of mineral reserves	8.1-8.23	7.1-7.23	7.1-7.27	32-41	28-34	(*)	30-37	41-48	28-35	29-38	35-43	30-36	(*)	26-29	(*)	30-36	29-36		21-28
Technical studies	9.1-9.9	8.1-8.9	8.1-8.8	42-45	35-38	(*)	38-40	49-52	36-39	39-42	44-47	37-40		17-19	(*)	37-40	37-40	(*)	
Reporting of metal equivalents	10.1-10.5	9.1-9.5	9.1-9.5	46			50			61	74	52				52	50		
Commodity pricing and marketing	11.1-11.5	10.1-10.5	10.1-10.5	48-52				53-57										(*)	
Permitting and legal requirements	12.1-12.8	11.1-11.8	11.1-11.8	53-60		(*)		58-60											
Sustainability considerations / ESG	13.1	12.1-12.2	12.1-12.3	61				61											
Check list of assessment and reporting criteria	T1	T1	T1	T1	T1		T1	T1	T1	T1	T1	T1		A1		T1	T1		T1
Guideline for technical studies	T2	T2	T2		T2		(*)					A1		A2					
Generic terms and equivalents | list of acronyms | glossary	A1	A1	A10	A1 / A2	A1	(*)	A1	AB	A1	A1	(*)			A3			A4	(*)	
Certificate of competent person | consent forms	A2	A2	A11	A4	A2;A4			AC;AE		A2	A2						A2	(*)	A1
Reporting of mineralised fill, pillars, low grade mineralisation, stockpiles, dumps and tailings	A3	A3.1-A3.7	A1.1-A1.7	A5.1-A5.4	39		41	62	40	43		41				41	41		
Reporting of coal	A4	A4.1-A4.7	A2.1-A2.7	A6.1-A6.4	40-42		42-44	63-67	41-43	44-47	48-59	42-44			(*)	42-44	42-44		
Reporting of diamond and other gemstone	A5	A5.1-A5.12	A3.1-A3.12		43-46		45-48	72-76	44-47	48-51	60-72	45-48			(*)	45-48	45-48		30
Reporting for industrial minerals, cement feed materials and construction raw materials	A6	A6.1-A6.13	A4.1-A4.12	A7.1-A7.10	47-48		49	68-71	48	52-59	73	49-50			(*)	49-50	49		31
Reporting for dimension stone, ornamental and decorative stone	A7	A7.1-A7.16	A5.1-A5.16	A8.1-A8.13						60									32
Reporting for bituminous shales and other energy minerals extracted by mining methods			A6.1-A6.9																
Reporting for metallic or non-metallic minerals extracted by solution mining methods			A7.1-A7.9																
Disclosure of estimates of mining tailings and other tailings of potential economic value			A8.1-A8.11																
Disclosure of previously declared estimates			A9.1-A9.2																
Summary criteria | table of contents						(*)		AD		38	A1							(*)	
Rules of conduct		A2												A4					
Compliance statements				A3	A3		A2			A3	A3						A3		
Historical notes					(*)	(*)	(*)	AH						2-4					
List of recognized professional organisation (RPO)		A3						AA		A4		A2						(*)	
Other issues				47; 62-64		(*)	51	77-80		62-66		51	(*)		(*)	51	51	(*)	29

Figure 1 - Comparison between the Code components. (*): described in the text (not as clauses); A1/AA (Appendix 1/A); T1 (Table 1); 1-5 (clause one to five).

3.1 Standardization origins and literature review

Concerns about the appropriate methodology for identification, acknowledgment and definition of mineral resources have existed since the historical works regarding mineral research, described in the oldest mining treaty De Re Metallica (Agricola, 1950): "*It is complained that some sellers and buyers of the shares in mines are fraudulent. I concede it. But can they deceive anyone except a stupid, careless man, unskilled in mining matters? Indeed, a wise and prudent man, skilled in this art, if he doubts the trustworthiness of a seller or buyer, goes at once to the mine that he may for himself examine the vein which has been so greatly praised or disparaged, and may consider whether he will buy or sell the shares or not. But people say, though such a one can be on his guard against fraud, yet a simple man and one who is easily credulous, is deceived. But we frequently see a man who is trying to mislead another in the way deceive himself, and deservedly become a laughingstock for everyone, or very often the defrauder as well as the dupe is entirely ignorant in mining*".

Herbert H. Hoover (1909) wrote The Principles of Mining, discussing the relevance of appropriate sampling, analysis quality (including duplicates), estimation accuracy, and specifically, precautions required to be taken against fraud: "*Much has been written about the precautions to be taken against fraud in cases of valuations for purchase. The best safeguards are an alert eye and a strong right arm. However, certain small details help. A large leather bag, arranged to lock after the order of a mail sack, into which samples can be put underground and which is never unfastened except by responsible men, not only aids security but relieves the mind. A few samples of country rock form a good check, and notes as to the probable value of the ore, from inspection when sampling, are useful. A great help to examination is to have the assays or analyses done coincidentally with the sampling. A doubt can then always be settled by resampling at once, and much knowledge can be gained which may relieve so exhaustive a program as might be necessary were results not known until after leaving the mine*". It also illustrates the occurrence of ore in a lengthwise profile and breaks down mineral reserves into the following classes: Proved Ore: "*ore where there is practically no risk of failure of continuity*"; Probable Ore: "*ore where is some risk, yet warrantable justification for assumption of continuity*"; Prospective Ore: "*ore which cannot be included in the above classes, nor definitely known or stated in any terms of tonnage*".

Within Eastern Europe, reserve classification principles were established around 1940 in the Soviet Union, and later applied to the Comecon countries (Jakubiak, 1994), to support the mineral resource supply planning for governmental decisions, with consolidated reserves being synthetized into State Mineral Inventories. In 1954, the Hard Rock Mineral Reserve Classification Standards of the Soviet Union were published, from criteria defined in the previous decade. The system inspired the Chinese standardization version, in 1956, with a classification system analogous to the Soviet one (Stoker, 2009). In Canada, since the early 70s, Canadian Securities Administrators (CSA) required an enhanced reserve classification system, under the National Policy 2-A practices (CIM, 2000).

Some actions stand out as causing factors for standardization discussion in Australia, such as: a) Outset of the system with terms classifying mineral Resources as measured, indicated and inferred by the United States Bureau of Mines (USBM) in 1943, arising from mineral supply concerns during World War II, which ended up influencing the adoption of such terms by later classification systems; b) Establishment, in 1953, of the committee of The Australasian Institute of Mining and Metallurgy (AusIMM) to go over the "Nomenclature for Classification of Mineral Reserves". Although having discussed the matter then, the group concluded that recommendations could not be put together to be widely accepted at that time; c) Proposal by the Society of Economic Geologists (SEG) in 1956 of an international mineral reserve nomenclature system, recommending the term "resources" for regional and national scale statements and "reserves" for deposit scale (Stephenson *et al*., 2001).

Due to the efforts and organization of the Melbourne Stock Exchange (currently, Australian Stock Exchange, ASX) and the Federal Government Senate Select Committee, the Australasian Joint Ore Reserves Committee (JORC) was established in 1971, comprising the AusIMM and the Australian Mining Industry Council (AMIC), currently Minerals Council of Australia (MCA), resulting in the first draft of the JORC Code in 1972. That document pioneered the establishment of terminologies, such as Competent Person, resources (measured | indicated | inferred) and reserves (proven | probable | possible).

Meanwhile in the USA, Vincent E. McKelvey – director of the United States Geological Survey (USGS), who dedicated over one decade to developing a mineral reserve classification methodology – published in 1972 a diagram to promote better mineral demand-supply planning under the technological and economic conditions of that time (McKelvey, 1972). In his research, McKelvey discusses in a pioneering way the issues of estimating potential resources and their uncertainty, inherent to the difficult determination of extension and quality of the many mineral deposits, and states that the quantity of available mineral resources will always be added by progress in science, technology, economy and investments in mineral exploration, especially when the information is used for domestic mineral inventory consolidation.

According to McKelvey, class differentiation is given by the degree of reliability in the existence of materials and by the economic feasibility of their recovery. Feasibility categories are designated by terms, such as recoverable, paramarginal and submarginal. Paramarginal resources have been defined as those recoverable at prices up to 1.5 times the moment of assessment, and submarginal are those below that. The deposits of such a category are understood to be rendered commercial with the increase of prices arising from economic matters or enhancement of existing technology. The resources are defined as not discovered and reserves are identified as proven, probable and possible. In 1973 Brobst and Pratt, for the USA Mineral Resource Inventory, changed the previous classification, bestowing less emphasis on the economic feasibility and more emphasis on reliability degrees associated with the existence of the deposit (Brobst *et al*., 1973).

Identified resources include deposits whose existence and location are known, which may have been assessed regarding extension and grade or not. When grades and nature are such that can be profitably extracted with existing technology and price levels in force, they are defined as reserves. When the available technology and cost-effectiveness do not render mineral deposits feasible, they are considered subeconomic and conditional resources (grouped by the authors under paramarginal and submarginal categories from McKelvey Diagram), eventually becoming reserves when economic and technological conditions are attained. Remaining potential resources are defined as not discovered, under two categories: hypothetical, when they can be found within known distances; and speculative, when they can occur in other locations, within conventional deposits in large geological grounds where no discoveries have been made, or nonconventional resource types only recently recognized as having some potential. The integration of the two previous systems occurred in USGS/USBM Bulletin 1450-A with the inclusion of undiscovered hypothetical and speculative resources to the McKelvey Diagram (USBM, 1976).

The classification included in USBM (1976), highlights that with public (government) and commercial (companies) planning, in the light of new geological knowledge, science and technology progress, there are increases in the likelihood of discovering new deposits, the development of new economical extraction processes, and improvement to economic and political conditions. The resources should be classified into two categories: a) purely geological or physical/chemical characteristics, e.g., grades, quality, tonnage, thickness and depth; b) profitability analyses based on material extraction and commercialization costs in a certain economy, at a certain point in time.

At the same time, the Eastern European classification system was updated in the early 1980s, based on Polish legislation (Stoker, 2009). Correlations and equivalences between classification systems in force at that time were made by considering that the standards applied in Comecon were stricter. Reserve classes were broken down and categorized as per geological parameters [documented (A, B, C1, C2), prospective–predicted (D1, D2, D3) and theoretical (E) reserves] and economic parameters (feasible, non-economical reserves). Drilling grid density is a vital element guiding the scope of required investigations for the various categories and economic parameters of documented reserves.

Prognostic reserves may be deduced by indirect indications (geochemical, geophysical, etc.), isolated sampling, surface observations (outcropping, disseminated mineralization halos, weathering halos, etc.) and quantified as per statistical studies of known reserves in the neighborhood or by analogies with distant production areas. Undiscovered reserves, deduced by considerations about occurring in a certain geological context, considering lithological, structural, metallogenic and other relevant data, are considered theoretical reserves and are not quantified. Some particularities and differences have been observed from country to country in less reliable categories, for prospective reserves. Also, recommendations have been identified regarding estimation accuracy, so that errors would not exceed (per class): 10% (A), 30% (B), 50% (C1), 70% (C2), and 90% (D1) [4].

The 1989 revision of the JORC Code (AusIMM, 1989) defined a new standard for international standardization since the first classification figure version was presented, thus consolidating some of the terminologies for reporting, which have been adopted by Codes worldwide from then on, with later adjustments, enhancement, and changes. The sketch of "Table 1" was also presented in the JORC Code version, describing the concepts associated with resource and reserve conversion by distinct factors (economic, mineral, metallurgical, market, environment, social and governmental), competence, with some criteria recommended for resource assessment. The JORC Code was immediately incorporated by the listing rules of ASX, becoming mandatory for the companies listed on the stock exchange. It was also adopted as an international Code of AusIMM and for all its members. This process, mandatory for professionals and listed companies, was a determining factor for such Code to be successfully adopted in the country. In 1992, the practices were adopted by the Australian Institute of Geoscientists (AIG) and incorporated into the listing rules of the New Zealand Stock Exchange (NZSE).

In 1991, The Institution of Mining and Metallurgy (IMM) in the United Kingdom created a working group and revised the reporting standards. In December of that year, the IMM Board approved the new definitions in the document *The IMM Definitions of Reserves and Resources and Guidelines and Criteria* (IMM, 1991) to meet the demand of the London Stock Exchange (LSE), which started demanding for its listed companies to adhere to the guidelines of AusIMM/AMIC system, similarly to the ASX (Armitage, 1994). The definitions were based on the JORC Code 1989 but with some subtle terminology differences. The authors considered that such discrepancies might bring about potentially ambiguous and deceitful interpretations to investors, depending on the system used for reporting. Thus, they have highlighted the importance of standardization, with a single system being adopted. The Canadian Institute of Mining, Metallurgy and Petroleum (CIM), in 1991, through its mineral economy society, set up a Special Committee for Reserve Definitions, whose report was presented to the CIM Board in May 1994, and published in October 1994 (CIM, 2000).

In January 1992, the *Guide for Reporting Exploration Information, Resources and Reserves* was published in the United States, as a result of a group named Working Party #79, put together in 1989 by the Society for Mining, Metallurgy, and Exploration (SME), which later would become SME Resources and Reserves Committee. In the same year, Czechoslovakia abolished the Comecon classification system and introduced its categorization (Stoker, 2009). According to the definition, the detected reserves had to comply with shape, sizing, configuration, and structural conditions verified by exploration efforts, with grade, technical and metallurgical characteristics defined by small or large-scale tests, with geological and geotechnical conditions, proving that the reserves could be explored. After the publication, Poland and the other Comecon countries decided to revise their classification system.

Riddler (1994) compared the various classification systems in operation at that time and emphasizes in his

article how relevant clarity is when categorizing and checking what classification nomenclatures really mean, to ensure that decisions made are based on a solid understanding of the criteria applied, and states: "*The problem is that there are many different national approaches to the classification of mineral resources that are inconsistent and of differing standards*. (...) *While the process involved in the data analysis | estimation | modeling | interpretation stage has to vary, since the data are site | technology | time specific, there is certainly scope for a harmonization of the nomenclature used to describe the resultant classified categories of mineral resources after that stage is complete*". In the same year, the Council of Mining and Metallurgical Institutions (CMMI) created a task force for international standardization of mineral resource and reserve reporting definition, with representatives from major National Reporting Organizations (NRO): United States (SME), Australia (Aus-IMM), Canada (CIM), United Kingdom (IMM) and South Africa (SAIMM - Southern African Institute of Mining and Metallurgy). The agreement took place in Sun City, South Africa, on the 15th. CMMI Congress. As part of the CMMI, CRIRSCO was created in the event, as a committee strictly governed by its Terms of Reference and Organizational Bylaws.

In 1996, CIM published the first version of the *Mineral Resource and Reserve Classification*: *Categories, Definitions and Guidelines*, as a document with recommendations and guidelines (CIM, 2000). The main recommendation of the report comprising the results of the Ontario Securities Commission (OSC) and Toronto Stock Exchange (TSE) task force for the definition of the new standards was the creation of a National Instrument (which would result in the National Instrument NI 43-101 a few years later) and the adoption of CIM Guidelines by the CSA. In 1998, CSA published the first draft of NI 43-101 Standards of Disclosure for Mineral Projects, to replace the National Policies 2-A and 22.

The most well-known mining fraud of all times came on the scene in 1997: The Bre-X scandal. Bre-X Minerals Ltd. was a Canadian mining company listed on the Alberta Stock Exchange (ASE) in 1989, whose shares were worth only some cents of a dollar (penny stock), with its small-size prospects in northern Canada. In 1993, the occurrence of hydrothermal gold was disclosed in the northeastern portion of Borneo, Indonesia, at a location known as Busang. In April 1996, the company made its Initial Public Offering (IPO) at the TSE, with share prices negotiated at over US$ 200 and reported reserves of 47 million ounces.

Following some attempts by major companies to act as partial rights holders or controlling shareholders, and strong interventions with the Indonesian government, suspected irregularities threatened the company's reliability, culminating in Bre-X expropriation recommendation in February 1997. This was hand in hand with the Joint Venture (JV) announcement, with governmental participation. Upon the merge, a resource update announcement was made, validated by an international consultancy, bringing it up to virtually 71 million ounces of gold. One of the JV shareholders started the due diligence, whose first results would not confirm Bre-X numbers. Upon completion of resample/reanalysis, the final report stated that unprecedented tampering had happened, which brought about collapsing reliability on mining projects worldwide (Miskelly, 2003)

This event helped leverage the effective standardization of international instruments guiding public reporting of companies to attract investments in the financial market. Standards had been recognized as desirable for quite a long time, to provide accurate communication with a common language, to improve the quality of information to be disclosed to the public by the mining industry, required for national decisions to be made, based on well-understood and reliable information, by investors, governments, community leaders and the general public. Although regulations themselves were recognized as not being sufficient to hold back the Bre-X fraud, the lack of standardization, mechanisms and procedures may have been perceived as a significant contributing factor (Nicholls, 1999).

3.2 Post-BRE-X mining standard actions

Against this backdrop, a meeting was held in Denver, Colorado, USA, in 1997, in which the International Definition Group of CMMI completed a preliminary agreement, known as The Denver Accord. The representatives agreed upon the pressing requirement of standardizing the definition of major mineral resource and reserve categories, as an incentive to the application of good practices, to rescue the financial market's credibility. The document was published in the CIM Bulletin in February 1998.

In January 1999, the JORC Code effectively represented the consensus of all CMMI member countries, whose definitions were subsequently incorporated into the other existing instruments, mostly unchanged, except for Canada due to consistency with regulatory documents (JORC, 1999). That version of the JORC Code consolidated guidelines and policies into organized terms with appropriate formatting to emphasize the mandatory points regarding transparency, materiality and competence principles, resource, and reserve classes, modifying factors and other standard definitions. In this version, there was also included the term "*reasonable prospects for eventual economic extraction*", which has been used to date.

In a report published in 1999 by the Toronto Stock Exchange and Ontario Securities Commission Mining Standards Task Force, Canadian stock exchanges made recommendations for all aspects of mineral exploration, from site work execution to estimations, with the key concept introduced under the responsibility of the Qualified Person, reflecting JORC Code Competent Person definition, with a larger range of activities and responsibilities (TSE/OSC MSTF, 1999). Consolidated recommendations from regulations were in force from February 2001. In the same year, SME published a revised version of their guide, according to CMMI's recommendations. However, it was not adopted in the United States by the U.S. SEC, which keeps using the version established in 1981 for stock exchange regulation, named Industry Guide 7 (IG7), under the topic Description of property by issuers engaged or to be engaged in significant mining operations (Form S-18, Item 17A), adjusted and revised from time to time (the latest version

is from 2019). IG7 does not allow, for instance, the term "Mineral Resource", amongst other definitions lacking in the regulation.

In March 2000, the South African Mineral Resource Committee (SAMREC) published the first version of the Code and was incorporated into the listing rules of the Johannesburg Stock Exchange (JSE) in that same year. In August, the CIM Board adopted the CIM Standards on Mineral Resources and Reserves Definition and Guidelines, developed by the CIM Standing Committee on Reserve Definitions (CIM, 2000), which included detailed explanations on a Qualified Person and other guidelines and definitions, highlighted and formatted for enhanced understanding. The institutionalization of practices occurred with the publication of NI 43-101, developed by CSA, and made official in February 2001, with later amendments in 2005 and revisions in 2011, and approval by each province and territorial legislature in Canada. NI 43-101 establishes how companies should report technical-scientific and technical information on mineral projects to the public, and disclosure standards apply to oral statements, written documents and posts on websites (CSA, 2001). NI 43-101 conduct applies to information from companies listed on Canadian stock exchanges, which also includes foreign exploration and mining companies doing business within the country, supervised by the CSAs, or listed in other stock exchanges adopting NI43-101 requirements.

The International Council on Mining and Metals (ICMM) was established in 2001 to enhance the social and environmental performance of the mining and metal industry, with representation by major mining companies worldwide and industry associations. In June 2001, the group comprising the British Institution of Mining and Metallurgy (IMM), currently Institute of Materials, Minerals and Mining (IMMM, IOM3), European Federation of Geologists (EFG), Institute of Geologists of Ireland (IGI) and Geological Society of London (GSL) issued the IMM Code, whose definitions were incorporated to the listing rules of LSE (Yellow Book, Section 19 – Mineral Companies) in October 2003 (IMM, 2001).

In 2002, CRIRSCO established a partnership with ICMM, taking over the workgroup of the extinct CMMI and became recognized as the international organization representing mining industry initiatives associated with reporting Code template for public statements, which endowed it with high levels of credibility and responsibility. In addition to the acknowledgment by ICMM, CRIRSCO is also accredited by the United Nations Economic Commission for Europe (UN-ECE) and by the International Accounting Standards Board (IASB), an organization encompassing stock exchanges worldwide, setting an accounting framework through international standards, the International Financial Reporting Standards (IFRS).

CRIRSCO completed the first international terminology and classification consolidation model in 2006, with the publication of the *International Reporting Template (IRT) for the Public Reporting of Exploration Results, Mineral Resources and Mineral Reserves* (CRIRSCO, 2006). From the first to the current version, the template integrates minimum standards adopted for national/regional reporting Codes and standards worldwide, with interpretations, recommendations and guidelines to contribute to disseminating and promoting efficient and well-tested good practices, widely adopted by national and regional reporting committees, in line with stricter corporate governance regulation trends, with application of best practices in mineral resource management, based on high-standard public reporting, in processes performed by Competent Persons. The Template does not replace existing reporting standards; it is only for consultation purposes, and has no regulatory or legal strength.

Form 43-101F1 came into force in the NI 43-101 revision of 2011, at the same time the guidelines on the organization of the technical reports' chapters for disclosure were updated, as well as the required content regarding terminologies, availability, and responsibility, in addition to other guidelines. Since then, documents have been filed in official repositories (The System for Electronic Document Analysis and Retrieval), which summarize scientific and technical information associated with mineral exploration, development, and production activities in premises relevant to the company. Companion Policy, 43-101CP, introduces CSA opinions on how to interpret and apply certain provisions of NI 43-101 and Form 43-101F1, referring to Good Practice Guidelines of CIM for Mineral Exploration, Resources and Reserves, to be complied with by the Qualified Person.

At that same time, the Mining Technical Advisory and Monitoring Committee (MTAMC) was established to provide consultancy to CSA on technical issues associated with disclosure requirements of NI 43-101 for the mining industry and serves as a forum for ongoing communication (CIM, 2014). Complementarily, CIM Definition Standards on Mineral Resources and Reserves were in force, as well as other specific documents introducing definitions and guidelines in line with CRIRSCO template for mineral exploration, estimation, coal, laterite deposits, placers, potassium, diamonds, and uranium.

The JORC Code was updated in 2012 and introduced the expression "if not, why not", which means "*that each item listed in the relevant section of [JORC's] Table 1 must be discussed and if it is not discussed then the Competent Person must explain why it has been omitted from the documentation", to clarify and bring more transparency to the public reporting process (JORC, 2012). Also introduced by the Code as an explanation of such assumption is that "additional disclosure is particularly important where inadequate or uncertain data affect the reliability of, or confidence in, a statement of Exploration Results; for example, poor sample recovery, poor repeatability of assay or laboratory results, etc.*".

In The United States, recommendations by The U.S. SEC are officially in force, regulating the reports from companies subject to SEC filing and reporting requirements, as stated in its Regulation S-K, Industry Guide 7 and staff communication (SEC, 2019), which prescribes the minimum content of the reports, records and public dissemination by rules, regulations and interpretations of SEC. In June 2016, SEC announced that it had proposed new rules to modernize the disclosure for mining properties by aligning them with current industrial and global regulatory practices and standards. In October 2018 the new SEC regulations (Disclosure by Registrants Engaged in Mining Operations - S-K 1300) were released, following years of requests to bring the U.S. into line with countries following the CRIRSCO template Codes. The main advantage of such

adequacy is for dual-listed companies that will benefit from decreased compliance costs, since before that, companies listed in the U.S. and a country following the CRIRSCO convention for mineral resource and mineral reserve reporting were compelled to produce different annual reports and other public disclosure documents dealing with resources and reserves for different markets. Reporting by the new rules came into force in early 2021.

3.3 Different classification standards

Camisani-Calzolari (2003) breaks down the Codes for reporting mineral resources and mineral reserves into three groups: a) those for public disclosure for investors, aligned with the CRIRSCO template, as described previously; b) those for public disclosure for governments (section 3.3.1); c) those for public disclosure for agencies (section 3.3.2.). This classification can also be complemented with a fourth group: the government-CRIRSCO hybrid (section 3.3.3.), such as the Chinese and Russian cases where the companies are state-owned but also listed in stock exchanges.

3.3.1 Government reporting standard

To keep a consolidated global inventory of strategic commodities, mainly focusing on establishing a complete image of current and future fossil and mineral energy supply for efficient resource management, a board of experts was put together by the United Nations Economic Commission for Europe (UN-ECE) in the early 90s, which met to consolidate the international classification, first introduced in November 1996, known as United Nations International Framework - Classification for Reserves / Resources for Solid Fuels and Mineral Commodities, initially rather complex, having 10 different categories. In 1998, following agreements between CMMI and UN-ECE made during the meeting in Geneva, the United Nations International Framework was revised to five resource and reserve categories, aimed at being used by national mineral inventories, incorporating the standard definitions by the CMMI to the common categories of both systems (CIM, 2000).

In 2009, the United Nations Framework Classification for Fossil Energy and Mineral Reserves and Resources (UNFC) revised its classification, which had been extended to hydrocarbons (oil and gas) and titanium in 2004, mainly aiming at renewable and nonrenewable resource management and sustainability. UN-ECE classification meets the needs of a globalized economy, by ensuring accurate and consistent estimations of fossil energy and mineral resources and reserves, aligning with other scientific, social, and economic information (UNECE, 2013). The classification has some similarities with the other classification systems and is based on three criteria/axes: E (economic and social feasibility, sustainability), F (project status and technical-operational feasibility), and G (geological knowledge, reliability).

3.3.2 Super-national reporting standard

In 1998, the International Atomic Energy Agency (IAEA) issued a publication aiming at harmonizing classification systems in force at that time for nuclear energy, by synthetizing research, technical consultancy studies and events conducted from 1992 to 1996, especially for global uranium reserves. The objective was to define which changes were required for conciliation of the various systems, to provide a uniform and significant classification of such mineral resources, and to assist experts and regulators of participating countries in being consistent with international standards (IAEA, 1998). The stated primary objectives of the classification were to promote cooperation between its member governments on the safety and regulatory aspects of nuclear development and to assess the future role of nuclear energy as a contributor to economic progress (Camisani-Calzolari, 2003).

3.3.3 Hybrid reporting standard initiatives

Chinese classification was updated in 1999, based on UNFC categorization, with classes not thoroughly overlapped, but bearing virtually equivalent characteristics. The classification of this system is based on geological knowledge and interpreted continuity, as well as on project cost-effectiveness and feasibility study status. It contains 16 categories and includes the "basic reserve" concept, which stands for the total quantity of *in situ* resources forming the basis of the recoverable reserve and can be considered equivalent to the mineral resource converted into reserve, by JORC and other CRIRSCO standards (Stoker, 2009). Reserves do not include a provision for dilution and ore loss, being essentially reported as in situ material. The distinction between marginally economic and subeconomic is the application of variable market parameter conditions, instead of specified cutoff conditions.

In 2006, the GKZ (The Russian State Commission on Mineral Reserves) Code was published, with significant conceptual differences. The Russian system, initially developed in the USSR in the 60s, aimed at achieving total objectivity, with a prescription of the exploration, estimation, and reporting processes, with little or no space for professional judgment application (GKZ, 2006). The Russian system was applied to play a relevant role in state economic modeling, since resources and mineral rights belong to the State and all mineral resources are subject to mandatory state technical audit; mineral extraction is authorized only after the State checks the resource estimation; and such verification is the basis for including resources in the State Mineral Inventory. National raw material inventory is shown as a reserve balance of all types of minerals that can be used to calculate the national net worth. The individual operation of a mining company changes the balance of state reserves, and there is an assumed responsibility for the company when taking measures to restore the raw material balance, convert resources and reserves, and expand surveys. One of the particularities is that the estimation methods applied at that time (classical methods) were predefined and inspected by regional committees, except for the use of geostatistics. Russian classification was broken down into 7 categories, based on the

level of exploration efforts developed: fully explored reserves or resources (A, B, C1), assessed resources or reserves (C2) and forecast resources (P1, P2, P3), this shows a potential correlation with the JORC Code and others.

The current Russian Code is integrated into CRIRSCO template and still has some particularities and categorizations when compared to the other existing Codes. The Code prescribes the density of the drilling grid and minimum trenches, depending on the deposit type, shape, and geological complexity, which are parameters to define the classes (Micon International, 2016).

A key feature of this methodology is that the class is defined, revised, and approved by a government committee based on various parameters (such as cutoff grade, ore thickness, and stripping ratio). If the committee determines that the project contains a significant amount of mineralized material, it may include it in the National Mineral Inventory. This classification system laid the groundwork for regional definitions, adopted in Kyrgyzstan, Armenia, and other Eastern European and Central Asian countries, including China. Since the NAEN Code's acceptance by CRIRSCO, the categorizations associated with these classes have enabled the conversion of historical reports for these countries (CRIRSCO, 2008).

4. Discussion

Companies listed on the stock exchange are subject to the capital market rules and each country has its regulatory framework, which may comprise laws and standards of government, nongovernment, industrial, professional, statutory, securities commissions and stock exchange agencies. The legal and regulatory system governs the disclosure and reporting by listed public companies, and mainly comprises corporation law, security acts, and listing rules. The reporting standard Codes are usually regulated by the corporation laws, which contain disclosure requirements for takeover documentation, with clear definitions of criminal offenses and civil liability, when information declared is materially adverse from the point of view of an investor. The system also establishes the responsibility for losses arising from reports with potential inaccuracies, whose loss is considered economic (Phillips, 2000). Some stock exchanges, such as ASX, prefer cooperative self-regulation for the integrity of the financial markets rather than governmental legislation or regulation (AusIMM, 2001).

For a Code to gain acceptance in another jurisdiction, it must adhere to the standards set by major stock exchanges (such as ASX, TSX/TSXV, LSE/AIM, JSE, and others) and CRIRSCO template recommendations. National Committees are required to include Reciprocal Recognition Agreements (RPO lists) in their guidelines, updated periodically. Table 1 displays the current agreements by country, although it's important to note that these agreements are established between organizations rather than strictly by country,since the table was designed for illustrative purposes.

Table 1 - Agreements between CRIRSCO members as of December 2022[1].

Country		In agreement with			Country		In agreement with		
	AUS	- Canada - Chile - Europe	- South Africa - Russia - USA			USA	- Australia - Brazil - Canada	- Chile - Europe - Kazakhstan	- Mongolia - South Africa - Russia
	BRA	- Chile - Europe - USA				KAZ	- Europe - USA		
	CAN	- Australia - Europe - South Africa	- USA			MON	- Europe - South Africa - USA		
	CHI	- Australia - Brazil - Canada	- Colombia - Europe - South Africa	- Russia - USA		SA	- Australia - Canada - Chile	- Colombia - Europe - Mongolia	- Russia - USA
	COL	- Chile - South Africa				RUS	- Australia - Chile - Europe	- South Africa - USA	
	EUR	- Australia - Brazil - Canada	- Chile - Kazakhstan - Mongolia	- South Africa - Russia - USA					

[1]India, Indonesia, Philipines and Turkey may have agreements with other CRIRSCO members, but this information is not published yet so they were removed from this table.

Since the NI 43-101 and JORC updates in 2011 and 2012, respectively, other countries with mineral activity have used the bases of ITR CRIRSCO (versions 2006, 2013, and 2019) to develop their Codes or revise existing versions, as illustrated in the consolidated timeline shown in Figure 2. This timeline shows, by committee and country/region, when each Code was created, when they adopted CRIRSCO template, and the dates of subsequent updates to the regulations.

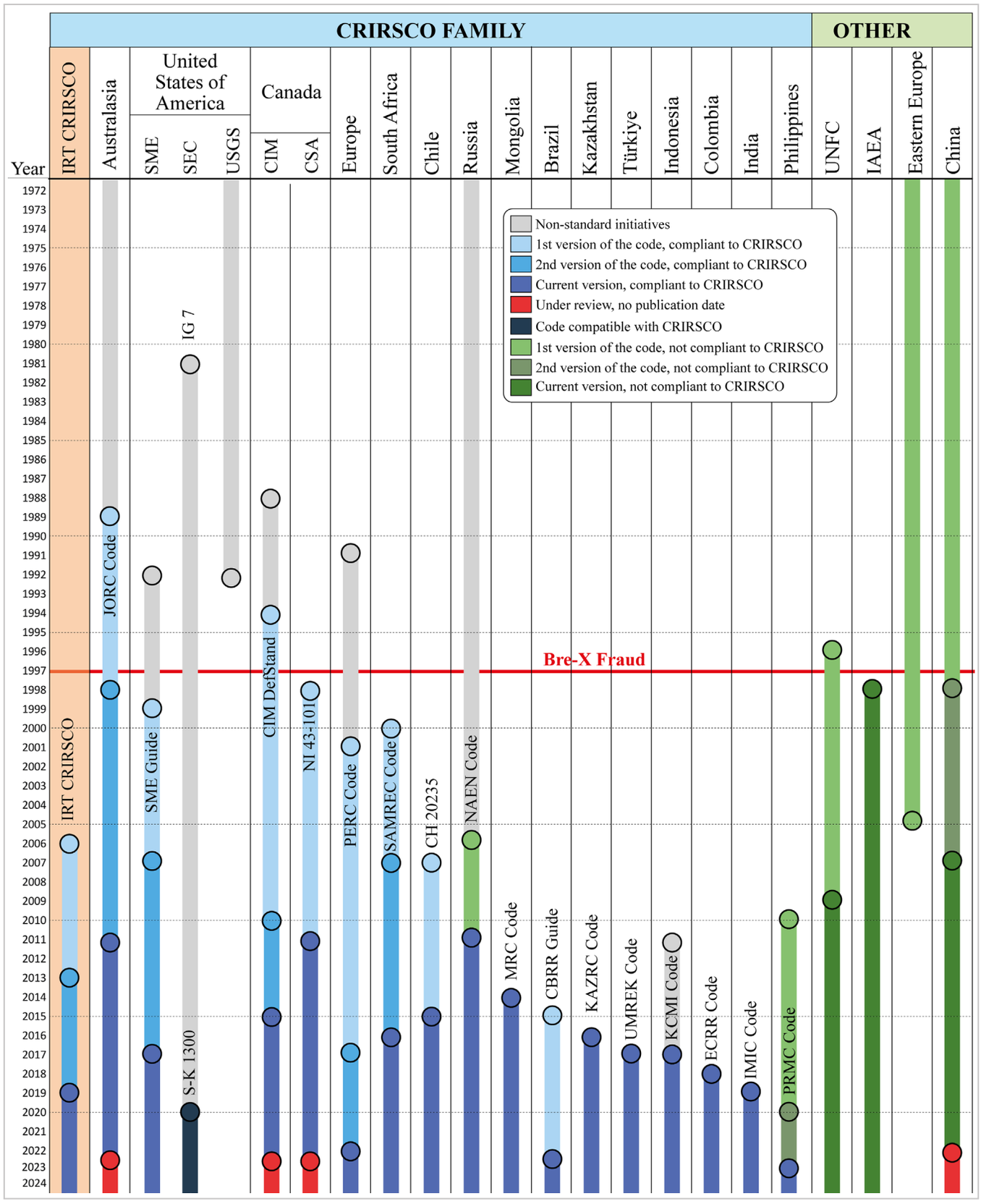

Figure 2 - Chronology and evolution of international resource and reserve Codes adhering to CRIRSCO.

Other initiatives that are increasing are the Environmental, Social and Governance (ESG) policies, seeking to characterize investments not only by income, but also by their accountability, sustainability, and worthiness. An exemple is the SAMESG, a code on South Africa for ESG.

In April 2022, the CSA opened the 90-day public consultation in Canada to obtain feedback on the effectiveness of several key provisions of NI 43-101 and understand what the priority requirements for review, updating and improvement are and whether regulatory changes would address the concerns expressed by the various stakeholders. Certainly, when the new National Instrument will be published, great progress in global standardization will come.

JORC Committee published a public call for members of AusIMM and AIG to participate in the Code update process

in June 2022, with a survey of interest in open forms to receive suggestions. The new version of the Code should be available in late 2024.

5. Conclusions

International reporting standards are essential and consistent tools, providing reliable statements in clear language recognized worldwide by financial institutions, markets, and stock exchanges. Investors prioritize economically exploitable opportunities within a relatively short timeframe, with promising prospects under expected market conditions, meeting the interests of the financial community.

Government reporting, super agencies, and hybrid initiatives aim to objectively inventory potential long-term resources and occurrences, critical for national and regional strategic planning.

Following the release of the new CRIRSCO Template, which includes updates and ensures compatibility with existing standards after years of discussion among National Reporting Organizations (NROs), a movement began in 2020 to update various guidelines. Some organizations, such as JORC, CSA/CIM, have already announced new workgroups for review in their websites or annual activity reports.

Systematization enhances the understanding of companies' risk profiles in the capital market and other financing mechanisms, enabling project comparison and benchmarking analyses. The alignment of standards, ethical principles, conduct rules, and RPO accreditation methods allows mining companies to operate more efficiently, transparently, and cost-effectively across diverse jurisdictions. CRIRSCO members aim to facilitate and promote global understanding of best practices in mining investment decisions concerning resources and reserves, achieving success worldwide.

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