THE SOUTH AFRICAN CODE FOR REPORTING OF MINERAL RESOURCES AND MINERAL RESERVES AND THE GEOSTATISTICAL IMPLICATIONS INVOLVED.

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ABSTRACT

The paper deals with the recently compiled South African Code for reporting of Mineral Resources and Mineral Reserves or SAMREC Code. The main aspects of the Code are listed and elaborated upon. The Code has been written with the participation of the major South African stakeholders in the field including Government institutions, the Association of Law Societies and the mining industry. Relevant foreign organisations, such as the AusIMM Joint Ore Reserve Committee ('JORC') and the United Nations, contributed to its compilation, and supported it. The Code thus enjoys endorsement both locally and, to a large extent, overseas.

The paper elaborates to some length on the disclosure of the evaluation methods and parameters utilised in arriving at the estimates of Resources and Reserves and comments on confidence intervals for the various Resource and Reserve categories. The essential implications for geostatisticians are briefly discussed.

INTRODUCTION

The first serious attempt to compile a South African Code for reporting Reserves and Resources dates back to 1992 when a committee was formed by the Geological Society of South Africa ('GSSA'), including the Geostatistical Association of South Africa ('GASA') for that purpose, in response to a request to that effect by the international Council of Mining and Metallurgical Institutions ('CMMI'). The final draft ('Draft 6') was presented under the auspices of the South African Institute of Mining and Metallurgy ('SAIMM') at the 1994 CMMI conference at Sun City, South Africa. Draft 6, though amply discussed at the Conference, failed to be endorsed by the JSE and by the major role-players, such as the SAIMM and the Chamber of Mines of South Africa ('CoM') and remained in the drawing board.

In 1994, the CMMI formed an ad-hoc International Definitions Group to create a set of international definitions for reporting Mineral Resources and Mineral Reserves with representatives from mining and metallurgical institutions from the United States ('SME'), Australia ('AusIMM'), Canada ('CIM'), the United Kingdom ('IMM') and South Africa (SAIMM). The breakthrough came in October 1997 when the CMMI International Definitions Group met in Denver, Colorado and reached a provisional agreement (the 'Denver Accord') on definitions of Mineral Resources and Mineral Reserves [1]. This agreement was

endorsed by the United Nations Economic Commission for Europe (UN-ECE) as their standard for the UN Framework Classification at a joint meeting held in Geneva on October 1998 between the CMMI International Definitions Group and the UN-ECE Task Force on Resource and Reserve Definitions [2].

Following the Denver Accord, the SAIMM constituted the *South African Mineral Resource Committee* ('SAMREC') in January 1998 for the purpose of compiling the South African Code, to be known as the *South African Code for Reporting of Mineral Resources and Mineral Reserves* (the 'SAMREC Code') [3]. The definitions in the SAMREC Code are consistent with those agreed in the Denver Accord by the CMMI participants and are modeled on the *Australasian Code for Reporting of Mineral Resources and Ore Reserves* ('JORC Code') [4].

PARTICIPATION AND RECOGNITION

Following the failure of Draft 6 to be adopted by the major stake-holders, SAMREC realised that it had to be fully representative of the major role-players in South African mining, and therefore it opted right from its inception for a wide participation in its committee. The SAMREC Committee consists of representatives of the SAIMM, the South African Council for Natural Scientific Professions ('SACNASP'), GSSA, GASA, the South African Council for Professional Land Surveyors and Technical Surveyors ('PLATO'), the Association of Law Societies of South Africa, the General Council of the BAR of South Africa, the Department of Minerals and Energy, the Johannesburg Stock Exchange ('JSE'), the Council for Geoscience, the South African Council of Banks and the Chamber of Mines of South Africa ('CoM'). The Code has been endorsed by SAIMM and SAMREC member organisations and is therefore binding on members of those organisations. The Code is being incorporated into the JSE Listing Rules.

During the last two years, which is the time it took to develop the Code, SAMREC regularly sent each new draft of the Code to equivalent committees in Australia (JORC), USA, Canada, England and the United Nations and continually liaised with them. This was done in order to have a common approach and standard for public reporting in the Western World but still keeping local conventions alive. The recommendations of these foreign committees were incorporated and the SAMREC Code can now be considered as having been 'endorsed' by them.

PRINCIPLES GOVERNING THE SAMREC CODE

The SAMREC Code is a required minimum standard for Public Reporting. As such it sets out standards, recommendations and guidelines for Public Reporting of Exploration Results, Mineral Resources and Mineral Reserves in South Africa. It consists of clauses and guidelines. In this first edition of the SAMREC Code, the guidelines have been placed after the respective clauses to provide improved assistance and guidance to readers in interpreting the Code. These guidelines are indented and are in italics. The same indented italics typeface formatting has been applied to any appendix to the Code.

In line with the JORC Code and internationally accepted standards, the main principles governing the operation and application of the SAMREC Code are transparency, materiality and competence. 'Transparency' requires that the reader of a Public Report is provided with sufficient information, the presentation of which is clear and unambiguous, to understand the report and is not misled. 'Materiality' requires that a Public Report contains all the relevant information which investors and their professional advisers would reasonably require, and reasonably expect to find in the report, for the purpose of making a reasoned and balanced judgement regarding the mineralisation being reported. 'Competence' requires that the Public Report be based on work that is the responsibility of a suitably qualified and experienced person who is subject to an enforceable professional code of ethics [4].

Other main aspects of the SAMREC Code are as follows:

i. Mineral Resources are tonnages and grades of the in-situ ore estimated over a realistic stoping width while Mineral Reserves are estimates of grades and tonnages of the material reporting to the mills (Run-of-Mine) and inclusive of all relevant factors such as Mine Call Factor, metallurgical recovery factors etc.

ii. Economic viability becomes the fundamental parameter in the SAMREC Code. Mineral Reserves are the economically mineable portions of a deposit, for which extraction is reasonably justified at the time of reporting. Mineral Resources must have reasonable and realistic prospects for eventual economic extraction. Also, portions of a deposit that do not have reasonable and realistic prospects for eventual economic extraction must be excluded from Mineral Resources. This implies that a minimum but realistic cut-off grade must be applied when estimating Mineral Resources.

iii. SAMREC introduces the concept of 'Modifying Factors' in line with the Denver Accord. These are considerations of mining, metallurgical, economic, marketing, legal, environmental, social and governmental factors, which have to be taken into account and be fully satisfied when converting Mineral Resources into Mineral Reserves.

iv. The classification of Mineral Resources and Mineral Reserves is primarily based on the level of confidence in the estimates.

v. Mineral Resources can be reported either inclusive of Mineral Reserves or exclusive of Mineral Reserves. The Code is not prescriptive on the matter. However, in the case where Mineral Resources are reported inclusive of Mineral Reserves, the relevant details (such as grades and tonnages) of the Mineral Resources which have not been modified to produce Mineral Reserves for economic or other reasons must be included in the report.

vi. Public Reports on Exploration Results, Mineral Resources and Mineral Reserves, must be based on and fairly reflect the report of the Competent Person (CP) and shall require his written approval for the relevant parts of his report included in the document. In addition, the Public Report shall disclose the CP's qualifications, professional affiliations and relevant experience.

vii. The requirements in order to qualify as a CP have been formally defined for the first time in South Africa. A CP is such on his own recognisance but he must be clearly satisfied in his own mind that he could face his peers and demonstrate competence in the commodity, type of deposit and situation under consideration. In addition, the Code also requires that he belongs to a statutory organisation recognised by SAMREC. The main reason for this is that such organisation would be empowered to discipline members who have acted contrary to its code of ethics. In any event, a CP is legally accountable for the relevant parts of a Public Report for which he has signed responsibility.

viii. The accreditation of foreign professionals as a CPs would be via an organisation recognised by SAMREC.

MAIN DEFINITIONS

There are seven major definitions for Mineral Resources and Mineral Reserves which fully comply with the definitions of the Denver Accord and those of the CMMI [1], JORC Code, the USA Guide [5] and UN-ECE [6] (Fig. 1).

They are:

i. A 'Mineral Resource' is a concentration or occurrence of material of economic interest in or on the Earth's crust in such form and quantity that there are reasonable and realistic prospects for eventual economic extraction. The location, quantity, grade, continuity and other geological characteristics of a Mineral Resource are known, estimated from specific geological evidence and knowledge, or interpreted from a well constrained and portrayed geological model. Mineral Resources are subdivided, in order of increasing confidence in respect of geoscientific evidence, into Inferred, Indicated and Measured categories.

ii. An 'Inferred Mineral Resource' is that part of a Mineral Resource for which tonnage, grade and mineral content can be estimated with a low level of confidence. It is inferred from geological evidence and assumed but not verified geological and/or grade continuity. It is based on information gathered through appropriate techniques from locations such as outcrops, trenches, pits, workings and drill holes that may be of limited or uncertain quality and reliability.

iii. An 'Indicated Mineral Resource' is that part of a Mineral Resource for which tonnage, densities, shape, physical characteristics, grade and mineral content can be estimated with a reasonable level of confidence. It is based on exploration, sampling and testing information gathered through appropriate techniques from locations such as outcrops, trenches, pits, workings and drill holes. The locations are too widely or inappropriately spaced to confirm geological and/or grade continuity but are spaced closely enough for continuity to be assumed.

iv. A 'Measured Mineral Resource' is that part of a Mineral Resource for which tonnage, densities, shape, physical characteristics, grade and mineral content can be estimated with a high level of confidence. It is based on detailed and reliable exploration, sampling and testing information gathered through appropriate techniques from locations such as outcrops, trenches, pits, workings and drill holes. The locations are spaced closely enough to confirm geological and grade continuity.

v. A 'Mineral Reserve' is the economically mineable material derived from a Measured and/or Indicated Mineral Resource. It is inclusive of diluting materials and allows for losses that may occur when the material is mined. It also allows for any improvement due to selective mining. This is usually experienced at the final stage of prospecting when a large number of data is available. Appropriate assessments, which may include feasibility studies, have been carried out, including consideration of, and modification by, realistically assumed mining, metallurgical, economic, marketing, legal, environmental, social and governmental factors. These assessments demonstrate at the time of reporting that extraction is reasonably justifiable. Mineral Reserves are sub-divided in order of increasing confidence into Probable Mineral Reserves and Proved Mineral Reserves.

vi. A 'Probable Mineral Reserve' is the economically mineable material derived from a Measured and/or Indicated Mineral Resource. It is estimated with a lower level of confidence than a Proved Mineral Reserve. It is inclusive of diluting materials and allows for losses that may occur when the material is mined. It also allows for any improvement due to selective mining. This is usually experienced at the final stage of prospecting when a large number of data is available. Appropriate assessments, which may include feasibility studies, have been carried out, including consideration of, and modification by, realistically assumed mining, metallurgical, economic, marketing, legal, environmental, social and governmental factors. These assessments demonstrate at the time of reporting that extraction is reasonably justified.

vii. A 'Proved Mineral Reserve' is the economically mineable material derived from a Measured Mineral Resource. It is estimated with a high level of confidence. It is inclusive of diluting materials and allows for losses that may occur when the material is mined. It also allows for any improvement due to selective mining. This is usually experienced at the final stage of prospecting when a large number of data is available. Appropriate assessments, which may include feasibility studies, have been carried out, including consideration of and modification by realistically assumed mining, metallurgical, economic, marketing, legal, environmental, social and governmental factors. These assessments demonstrate at the time of reporting that extraction is reasonably justified.

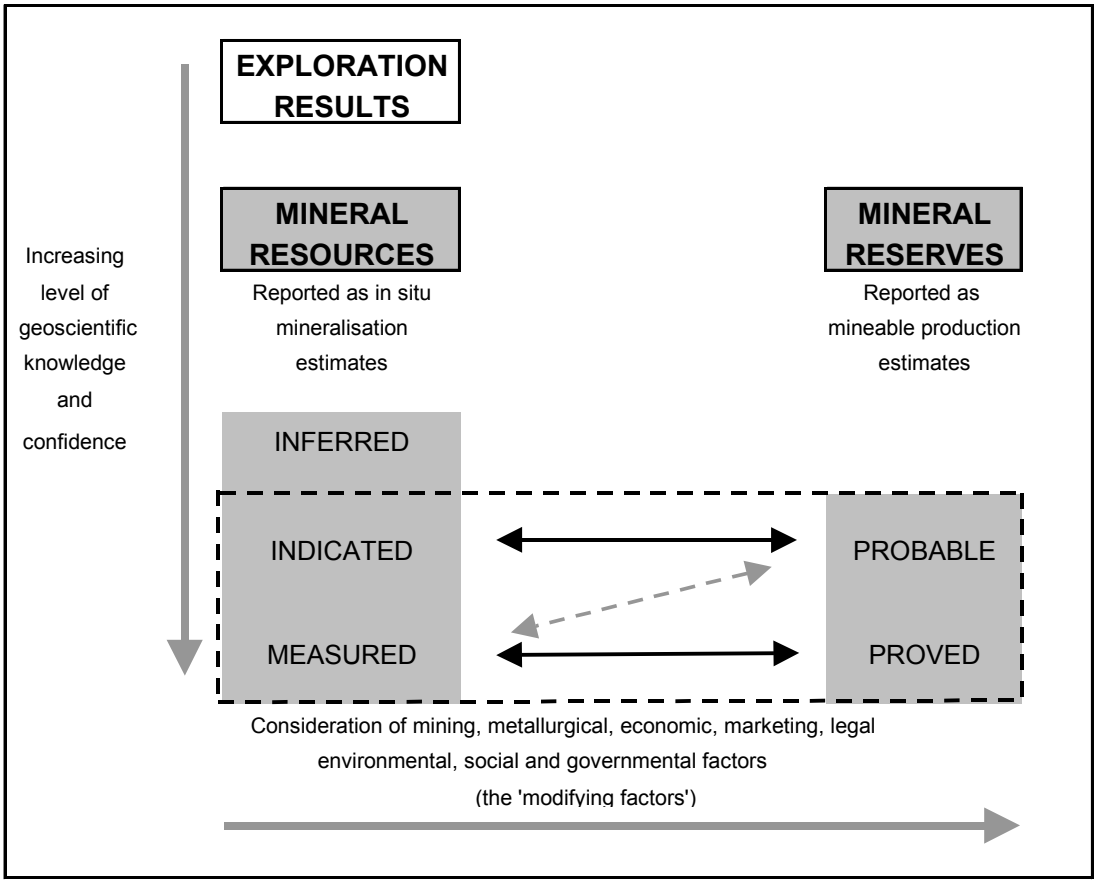

Figure 1. Relationship between Mineral Resources and Mineral Reserves

In addition, there are two definitions which do not appear in the CMMI definitions. They are included in the JORC Code and the USA Code ('SME Guide') and are being incorporated into the IMM Code and the Canadian Code. These definitions have been slightly modified in the SAMREC Code, when relevant, to suite the South African mining environment. The modifications have been approved by JORC and the SME Code committee.

i. A Public Report or Public Reporting is a report or reporting on Exploration Results, Mineral Resources or Mineral Reserves, prepared for the purpose of (a) informing investors or potential investors and their advisers or (b) satisfying regulatory requirements. Companies are encouraged to provide information which is as comprehensive as possible in their Public Reports.

ii. A 'Competent Person' is a person who is a member of the South African Council for Natural Scientific Professions (SACNASP), and/or the Engineering Council of South Africa (ECSA), and/or the South African Council for Professional Land Surveyors and Technical Surveyors (PLATO) or any other statutory South African or international body that is recognised or may be approved by SAMREC. A Competent Person should have a minimum of five years experience relevant to the style of mineralisation and type of deposit under consideration and to the activity which that person is undertaking. If the Competent Person is estimating, or supervising the estimation of Mineral Resources, the relevant experience must be in the estimation, assessment and evaluation of Mineral Resources. If the Competent Person is estimating, or supervising the estimation of Mineral Reserves, the relevant experience must be in the estimation, assessment, evaluation and economic extraction of Mineral Reserves.

GEOSTATISTICAL IMPLICATIONS

GENERAL

The Code is not prescriptive on the techniques to be used in the estimation of Resources and Reserves apart from the requirements of the disclosure of all relevant information, transparency, materiality, clearness, unambiguity and proper disclosure of all factors most likely to affect the accuracy of the estimates. The level of confidence in the estimates is of paramount importance throughout and must determine the classification of the Resources and Reserves. Whereas, techniques other than geostatistics are admissible, they are generally based on arbitrary parameters or on judgmental decisions based on experience and/or practices in use elsewhere. Geostatistics provides the only basis for estimates with the lowest expected error variance, free of global and conditional biases and which, at the same time, can provide estimates of the confidence levels for the estimates.

It is anticipated that, in the near future, codes with the same essential requirements will be adopted not only by the major mining countries but also internationally via the UN. This means that it will become obligatory for all the geostatisticians involved with the evaluation of Mineral Resources and Mineral Reserves, locally or internationally, to be familiar with and to apply the requirements of the relevant code(s) in reports prepared for mining companies. This subject is, therefore, an appropriate one for discussion at this Congress; if possible, broad consensus should be reached on the major issues involved.

GEOLOGICAL BACKGROUND

The Code requires the input of geological information on the style and nature of mineralisation, geological continuity and the model of mineralisation. This is also a prerequisite for any proper geostatistical analysis. In particular, the spatial structure as estimated must be compatible with the geological model; also the use of any ore body subdivisions. Apart from any geostatistical analyses, geological considerations must also convey proper weight in decisions concerning the classification of resources and reserves.

TONNAGE AND GRADE ESTIMATES

The Code requires estimates of tonnages and grades for Resources and Reserves with confidence levels. This involves both accuracy, i.e. *the absence of biases*, and precision, i.e. *limits of error* [7]. All of which are subject to requirements of reasonable and realistic prospect for eventual economic extraction and, where applicable, positive result from Feasibility Study. Confidence in the project will depend largely on the lower confidence limit for the grade.

The following scenarios can be visualised for projects to be valued in terms of the Code.

i) Only limited exploration data are available and only global estimates can be made of the mineralisation either as a whole or in respect of logical subdivisions. Neither individual block estimates nor a reliable indication of the effects of possible selective mining to a cut-off grade will be practical. Such an occurrence would in most cases be classified under Inferred Resources or at best as Indicated Resources.

ii) As for i) above, but the data permit some estimate(s) of the spatial structure(s) of the data overall, or within the subdivisions. On this basis a provisional estimate of the expected global tonnage and grade above any cut-off can be made. Such estimates are required for long term mine planning and for feasibility studies, but would not assist in the detailed mine planning on a block by block basis. These estimates would normally be classified as Indicated Resources and, if

warranted, as Probable Reserves. The authors suggest a lower confidence limit for the grade of the order of -15%.

iii) As for ii) above but where the data permit the valuation of individual blocks of ore, either of small mining unit ('SMU') size or larger. Due to the data limitations such block estimates can normally only be used for general mine planning, because it could involve the selection of some blocks below cut-off which are actually above cut-off, and vice-versa. This results from the smoothing effect of the limited data by kriging and would generally lead to too low a global average grade and to too large a tonnage above cut-off. Realistic block estimates are required for more detailed mine planning. Provided the smoothed block estimates are *conditionally unbiased*, adjustments to correct for this smoothing effect can, however, be made with the use of techniques such as uniform conditioning. This will provide acceptable figures for general, but not for detailed mine planning or for the selection of specific blocks. However, such corrected estimates could still be useful for provisional mine planning. The resource estimates could at best be classified as Measured Resources but, after application of the required Modifying Factors, only as Probable Reserves. The authors suggest a lower confidence limit for the grade of the order of -10%.

Where the blocks are valued on a limited search routine with the objective of providing overall grade and tonnage estimates above cut-off close to that expected at the final SMU stage, the individual block estimates will be subject to significant conditional biases. In that case, they will not meet the 'accuracy' (lack of bias) requirements of the Code and cannot be reported as Indicated or Measured Resources, or Reserves. These block estimates would also be misleading if used in planning any detailed selection of individual blocks above cut-off [7]. Simulation techniques are also used for resource estimates and repeated simulations can provide a measure of the uncertainties involved, provided the data used are adequate to ensure the absence of significant global biases and uncertainties, as well as a good estimate of the spatial structure of the data.

iv) Where the final selection stage has been reached, the available data will permit the proper valuation of the SMU blocks and, depending on the confidence level, these blocks will form the basis of Measured Resources and Proved Reserves. This situation could also prevail at the prospecting stage where the level of available data is close to that expected at the final selection stage and where the estimates are not expected to differ significantly from the true values. However, all these block estimates must also meet the requirement for 'accuracy', i.e. the absence of conditional and global biases. The confidence level required is set by the Code at 'high' and 'highest'. The authors suggest a level for the lower limit of error for this purpose of the order of -5%.

v) Confidence limits as suggested above could apply firstly, to global - life of mine – estimates but secondly, also to more limited planned mining periods, e.g. early annual production periods.

Bearing in mind the significant difference in the levels of data available and hence the confidence levels attached to those two types of estimates, the lower confidence limits suggested above, can serve only as a general guide and must be adjusted to the requirements of the project concerned. Whatever technique is used, the danger of conditional biases and of misleading uncertainty levels in the second type of estimates must be borne in mind and should be discussed by the CP.

CUTTING OF HIGH GRADES

The Code calls for the disclosure of the nature and the net effects of any such adjustments. From a geostatistical point of view, it is essential that where cutting or capping is done, the frequency distribution pattern be analysed properly in order to verify that any such high grade(s) cannot be accepted as normal member(s) of the data population.

VALIDATION

Where the resources and/or reserves are based on grade estimates for individual blocks, the Code requires the geostatistical technique used to be fully disclosed including search parameters and block sizes. It also calls for a validation of the appropriateness of the technique via validations based on production records, data from mined-out areas, etc. This implies reconciliation studies of previous block estimates based on the same technique with follow-up data inside the mined-out blocks, and/or simulation studies of standard blocks based on the available data grid and superimposed on comprehensive data in mined-out areas with similar follow-up comparisons. Alternatively, at least a theoretical confirmation of the expected absence of conditional biases in the block estimates should be disclosed.

CONCLUSION

The SAMREC Code has been compiled with the participation of the main stakeholders in mining, government, finance, professional institutions and the JSE and is therefore binding on members of these organisations. Cooperation from, and approval by, SAMREC equivalent committees in the major mining countries of the Western World and the United Nations give the SAMREC Code the international acceptance and endorsement currently enjoyed by the JORC Code and significantly contributes to the universal standardisation of public reporting.

As part of the policy of disclosure and fairness to investors, to whom public reports are aimed at, the Code recommends that the valuation techniques and parameters utilised in arriving at the estimates be divulged. These include, when relevant and amongst others, kriging methods, SMU size, confidence levels, valuation biases, etc. These aspects, which are listed in broad guidelines in the appendix to the Code, have been interpreted and elaborated upon by the authors in the paper. In doing so, the authors closely adhered

to the spirit and interpretation which the members of the Working Group responsible for the compilation of the SAMREC Code gave on the matter over the past two years.

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