The major mining countries of the English-speaking world have similar, but not identical, definitions of mineral resources and reserves. Even small differences in terminology are potential problems for an industry which increasingly operates across international borders.

Norman Miskelly analyses the definitions and the prospects for conformity.

The reporting of “ore reserves” (a common term until recently) and exploration information by mining companies has grown haphazardly over the years, mostly on a country-by-country basis, with no attempt to reach consensus and consistent, compatible reporting across international boundaries.

In general, reporting by mining companies worldwide at the exploration, development and production stages has lagged well behind the advances in financial reporting. This applies particularly to relevant and useful information about the most significant asset of most mining companies — their ore-bodies, which are the source of future income.

In 1989 the joint committee of the Australasian Institute of Mining and Metallurgy and the Australian Mining Industry Council published a completely new Australasian code for reporting of identified mineral resources and ore reserves. This was followed in May 1990 by the guidelines to this code, which were designed to assist both technical and non-technical persons in its use. Both publications were updated in September 1992 and an appendix relating to diamond reporting was added in October 1993.

Since 1989, the introduction and operation of the code, which incorporates the necessary definitions for mineral resources and reserves, has been very successful and it is well recognised as an important step in promoting standards of best practice in regard to...
resources and reserves reporting at both the professional and company levels.

Most important, from July 1, 1989, the code and guidelines were incorporated by the Australian Stock Exchange into its Listing Rules, thereby giving them a legislative imperative for all publicly listed companies. One consequence is that transnational companies with subsidiaries listed on the ASX must comply with the Australasian code when reporting the subsidiaries' results to the exchange and to shareholders. Because the Australasian code is simple in concept and wording, it has been readily accepted by the nontechnical sector, especially investors and financiers. In brief, it is user-friendly and it works!

**Standard definitions**
The benefits of standard definitions are largely self-evident:

- Mining is international, as is investment. Many companies domiciled in one country have foreign parents or associates. Similarly, it is becoming increasingly common for mining companies to diversify their exploration, development and production into foreign countries. Exploration joint ventures often have ownership spread among several countries. In the absence of an internationally standardised reporting code it would not be unusual to be required to comply with, say, three or more different reporting codes and 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. Such financing may originate in several countries. Differing standards involve unnecessary effort and cost.

- Standardised 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.

**The way ahead**
Two factors suggest that standard definitions can be achieved. First, there exists a large degree of commonality in existing or proposed standards in the five countries analysed here. This is due, in part at least, to other countries using the Australasian code as a starting point. Second, the definitions in the five standards or codes are concerned exclusively or predominantly with reporting rather than estimation or the associated methodology of estimation. This clear focus should facilitate consensus. Inertia or resistance to change, however, is a common human trait: why change the old system?

Significantly, the Australian code dates only from 1989, the British definitions' date from 1991, the American standards also from 1991, and those of South Africa and Canada are still "proposed". Therefore, it is timely to resolve the outstanding points of difference before the differences become entrenched.

To this end, it is proposed that the next step should be a set of suggested or "preferred" definitions that incorporate the best elements of the existing or proposed definitions. This should facilitate a meeting of the minds to enable a consensus set of international standard definitions, acceptable to all, to be derived. The following comparative analysis examines and comments on the eight key definition areas (expressed in Australasian terminology) of resources, measured resources, indicated resources, inferred resources, reserves, proved reserves, probable reserves and competency.

Some matters of detail have not been included in the analysis, including the data required for assessment criteria. If satisfactory consensus on the key definition areas is reached, these remaining details should fit readily into place.

**COMPARISONS**
The following eight sections summarise the definitions currently in use (Australasia, the UK and the US) or proposed (South Africa and Canada) for the reporting of resources and reserves.

- **Mineral resource**
  - **Australasia**
    - A "Mineral Resource" is defined as an identified-in-situ mineral occurrence from which valuable or useful minerals may be recovered. Mineral Resources are subdivided into:
      - Inferred Mineral Resources
      - Indicated Mineral Resources and
      - Measured Mineral Resources

  - **United Kingdom**
    - A mineral resource is a tonnage or volume of rock or mineralisation or other material of intrinsic economic interest the grades, limits and other appropriate characteristics of which are known with a specified degree of knowledge.

  - **Guidelines and Criteria**
    - Although a clear demonstration of economic workability is required to define reserves, this does not necessarily apply to resources; however, portions of a deposit that are unlikely to be demonstrable as worth extracting in the foreseeable future should not be included in resources.

  - **United States**
    - **Resource.** A concentration of naturally occurring solid, liquid or gaseous material in or on the Earth's crust in such form and amount that economic extraction of a commodity from the concentration is currently or potentially feasible. Location, grade, quality and quantity are known or estimated from specific geological evidence. To reflect varying degrees of geological certainty, resources can be subdivided into measured, indicated and inferred.
The term “resource” is recommended over the terms “mineral resource”, “identified resource” and “in-situ resource”.

South Africa

RESOURCE: A concentration of naturally occurring solid, liquid or gaseous material in or on the Earth’s crust in such form and amount that economic extraction of a commodity from the concentration is currently or potentially feasible. Location, grade, quality and quantity are known or estimated from specific geological evidence. To reflect varying degrees of geological certainty, resources can be subdivided into measured, indicated and inferred.

Canada

Resource is the estimated quantity and grade of mineralisation that is of potential economic merit. A resource estimate does not require specific mining, metallurgical, environmental, price and cost data, but the nature and continuity of mineralisation must be understood.

Comment

Should the definition be for “resource” (US, South Africa, Canada), “mineral resource” (UK) or “identified mineral resource” (Australasia)? The IMM does not specify whether the resource is “in-situ” or “mineable”, but it would be happy to go along with the Australasian definition in this respect. The SME definition is more comprehensive than either that of the AusIMM or the IMM, whereas the CIMM proposal is compatible in concept with the other definitions. The AusIMM states there is a clear implication that there are reasonable prospects for eventual economic exploitation. The IMM says that a clear demonstration of economic workability is not necessarily required for resources and, in addition, that portions of the deposit unlikely to be demonstrable as worth extracting in the foreseeable future should not be included in resources.

Measured mineral resource

Australasia

The term “Measured Mineral Resource” means a Mineral Resource intersected and tested by drill holes, underground openings or other sampling procedures at locations which are spaced closely enough to confirm continuity and where geoscientific data are reliably known. A Measured Mineral Resource estimate will be based on a substantial amount of reliable data, interpretation and evaluation which allows a clear determination to be made of shapes, sizes, densities and grades.

Guidelines

Mineralisation may be classified as a Measured Resource when the nature and amount of data is such as to leave no reasonable doubt, in the opinion of the Competent Person determining the Mineral Resource, that the tonnage and grade of the in-situ mineralisation can be estimated to within close limits and that any variation from the estimate would be such as not significantly affect potential economic viability. This degree of confidence necessarily requires a firm understanding of the geology and controls of mineralisation.

An Indicated Mineral Resource estimate will be more reliable than an Inferred Mineral Resource.

United Kingdom

A measured mineral resource is that portion of a mineral resource for which tonnage or volume is calculated from dimensions revealed in outcrops, pits, trenches, drill-holes or mine workings, supported where appropriate by other exploration techniques. The sites used for inspection, sampling and measurement are so spaced that the geological character, continuity, grades and nature of the material are so well defined that the physical character, size, shape, quality and mineral content are established with a high degree of certainty.

Guidelines

Mineralisation may be classified as an Indicated Resource when the nature and amount of data is such as to allow the Competent Person determining the Mineral Resource to confidently interpret the geological framework and to assume continuity of mineralisation. Confidence in the estimate would be
such as to allow the application of technical and financial parameters and to enable an evaluation of economic viability.

**United Kingdom**

An *indicated mineral resource* is that portion of a *mineral resource* for which quantity and quality are estimated with a lower degree of certainty than for a *measured mineral resource*. The sites used for inspection, sampling and measurement are too widely or inappropriately spaced to enable the material or its continuity to be defined or its grade throughout to be established.

**United States**

Quantity and grade and (or) quality are computed from information similar to that used for measured resources, but the sites for inspection, sampling and measurement are farther apart or are otherwise less adequately spaced. The degree of assurance, although lower than that for measured resources, is high enough to assume geological continuity between points of observation.

**South Africa**

Quantity and grade and/or quality are computed from information similar to that used for measured resources, but the sites for inspection, sampling and measurement are farther apart or are otherwise less adequately spaced. The degree of assurance, although lower than that for measured resources, is high enough to assume geological continuity between points of observation.

**Canada**

Indicated resource is the estimated quantity and grade of part of a mineralised body for which the continuity of grade, together with the extent and shape, is so well established that a reliable grade and tonnage estimate can be made for a deposit of potential economic merit.

**Comment**

Similar, except that the IMM states, in effect, that [the data] are insufficient to enable the material or its continuity to be defined or its grade throughout to be established. The AusIMM and SME state that the [data are] sufficient to be able to assume continuity of mineralisation or geological continuity — a major difference. Because Canada does not have a measured resource category, probable reserves are derived from indicated resources and proven reserves from probable reserves. The other countries’ definitions allow proved reserves to be derived directly from measured resources.

**Inferred mineral resource**

**Australasia**

The term “Inferred Mineral Resource” means a Mineral Resource inferred from geoscientific evidence, drill holes, underground openings or other sampling procedure where the lack of data is such that continuity cannot be predicted with confidence and where geoscientific data may not be known with a reasonable level of reliability.

**It should not necessarily be assumed that all or part of an Inferred Resource will be upgraded.**

**Guidelines**

This category is intended to cover situations where mineralisation has been identified and some measurement and sampling completed, but where the data are insufficient to allow the geological framework to be confidently interpreted and continuity of mineralisation to be predicted. It should not necessarily be assumed that all or part of an Inferred Resource will be upgraded to Indicated or Measured Resources by continued exploration. Caution should be exercised if this category is considered in preliminary economic studies.

**Canada**

Indicated resource is the estimated quantity and grade of a mineralised body, or a part thereof, that is determined on the basis of limited sampling, but where there is sufficient geological information and a reasonable understanding of the continuity and distribution of metal values to outline a deposit of potential economic merit.

**Comment**

The IMM discarded the term “inferred” in relation to resources and substituted “mineral potential”. Australasia has the category “pre-resource mineralisation”, which is designed to provide a means of reporting exploration information, but falling short of reporting tonnage and grade. The IMM has said that the distinction between a “pre-resource mineralisation” and “inferred resources” could be difficult. Use of the term “inferred resources” would not be a sticking point for the IMM if the majority were in favour of continuing to use the term. The AusIMM, SME and CIMM definitions are alike in intention, although the wording differs.

**Reserve**

**Australasia**

An “Ore Reserve” is defined as that part of a Measured or Indicated Mineral Resource which could be mined, inclusive of dilution, and from which valuable or useful minerals could be recovered economically under conditions realistically assumed at the time of reporting. Ore Reserves are subdi-
vided into

- Probable Ore Reserves, and
- Proved Ore Reserves.

Ore Reserve estimates are derived from estimates of Mineral Resources modified by economic, mining, metallurgical, marketing, legal, environmental, social and governmental factors.

**United Kingdom**

A *mineral reserve* is that portion of a mineral resource on which technical and economic studies have been carried out to demonstrate that it can justify extraction at the time of determination and under specific economic conditions.

**Guidelines and Criteria**

The term "ore" has fallen out of use in large sections of the extractive industry and it is recommended that the term no longer be used in reserve/resource estimation.

**Definition of "ore"**

At present the Institution of Mining and Metallurgy defines ore as "a naturally occurring mineral aggregate of economic interest from which one or more valuable constituents may be recovered by treatment". The definition of ore should be considered as only of interest to the IMM, but at no time should the word "ore" be used in conjunction with "reserves" — that is, the expression "ore reserves" should not be used, the preferred term being "mineral reserves".

**United States**

A reserve is that part of the resource that meets minimum physical and chemical criteria related to the specified mining and production practices, including those for grade, quality, thickness and depth; and can be reasonably assumed to be economically and legally extracted or produced at the time of determination. The feasibility of the specified mining and production practices must have been demonstrated or can be reasonably assumed on the basis of tests and measurements. The term *reserves* need not signify that extraction facilities are in place and operative.

The term *economic* implies that profitable extraction or production under defined investment assumptions has been established or analytically demonstrated. The assumptions made must be reasonable including assumptions concerning the price and costs that will prevail during the life of the project.

The term *legally* does not imply that all permits needed for mining and processing have been obtained or that other legal issues have been completely resolved. However, for a reserve to exist, there should not be any significant uncertainty concerning issuance of these permits or resolution of legal issues.

**South Africa**

A reserve is that part of the resource that meets minimum physical and chemical criteria related to the specified mining and production practices, including those for grade, quality, thickness and depth and can be reasonably assumed to be economically and legally extracted or produced at the time of determination. The feasibility of the specified mining and production practices must have been demonstrated or can be reasonably assumed on the basis of tests and measurements. The term *reserves* need not signify that extraction facilities are in place and operative.

The term *economic* implies that profitable extraction or production under defined investment assumptions has been established or analytically demonstrated. The assumptions made must be reasonable including assumptions concerning the price and costs that will prevail during the life of the project.

The term *legally* does not imply that all permits needed for mining and processing have been obtained or that other legal issues have been completely resolved. However, for a reserve to exist, there should not be any significant uncertainty concerning issuance of these permits or resolution of legal issues.

**Canada**

Reserve is the estimated quantity and grade of all or a part of a mineralized body in a mine or undeveloped mineral deposit for which the mineralisation is sufficiently defined to form the basis of at least a preliminary mine production plan for an economically viable mining operation at long-term forecast average metal prices.

The Canadian committee believes that the degree of definition of most mineral deposits being mined or considered for mining are Probable Reserves, and that this degree of definition is adequate for production decisions.

**Comment**

The IMM recommends that the word "ore" be no longer used and prefers "Mineral reserves". The SME, GSSA and CIMM use the sole word "reserve". Australasia uses "ore reserves", but deliberately does not define "ore". The SME and GSSA definition is much more comprehensive than either the AusIMM or IMM definitions, but they use the expression "profitable extraction", which rather begs the question as to the definition of "profitable". CIMM does not mention the concept of profit but prefers "economically viable operation". The CIMM definition is not as universal as the others in that it uses the term "metal prices". The IMM regards the expression "ore reserve" as a double positive.

**Proved reserves**

**Australasia**

The term "Proved Ore Reserves" means an Ore Reserve stated in terms of mineable tonnes/volume and grade in which the corresponding Identified Mineral Resource has been defined in three dimensions by excavation or drilling (including minor extensions beyond actual openings and drill holes), and where the geological factors that limit the ore body are known with sufficient confidence that the Mineral Resource is categorised as "Measured".

**Guidelines**

The Code provides for a direct relationship between Indicated Mineral Resources and Probable Ore Reserves and between Measured Mineral Resources and Proved Ore Reserves. In other words, the level of geoscientific confidence for Probable Reserves is the same as that required for the in-situ...
determination of Indicated Resources and for Proved Reserves is the same as that required for the in-situ determination of Measured Resources.

**United Kingdom**

A **proved mineral reserve** is that portion of a **measured mineral resource** as defined on which detailed technical and economic studies have been carried out to demonstrate that it can justify extraction at the time of the determination and under specified economic conditions.

**Guidelines and Criteria**

Statements concerning a **proved mineral reserve** should be supported by a full feasibility study* or by current operating experience. It is also expected that statements concerning a probable mineral reserve will be supported by a study of the economics of working the deposit, although this does not have to be as detailed as the full feasibility study for a **proved mineral reserve**.

There is no exact correspondence between **proved mineral reserve** and **measured mineral resource** ... a measured mineral resource may not be designated as a proved mineral reserve if the scope of the economic feasibility study is insufficient to warrant **proved** status; instead it would become a **probable mineral reserve**. Thus, the distinction between proved and probable is based on a combination of geological and economic criteria, and it is up to the practitioner to use his judgment on the correct category to apply.

* Feasibility study is defined as an assessment of all aspects of a mineral project, including geological, mining, metallurgical, infrastructural, environmental, social, legislative and commercial factors, that is sufficiently detailed to support a decision on implementation.

**United States**

That part of a measured resource that satisfies the conditions to be classified as a reserve.

**South Africa**

That part of a measured resource that satisfies the conditions to be classified as a reserve.

**Declared reserve**: That part of a proven reserve which has been exposed by mining operations and can be made available for mining within a specified period. Typically this information would be required in documents published for the benefit of shareholders.

**Canada**

Proven reserve is the estimated quantity and grade of a mineralised body for which information is so well established, with respect to size, distribution of values, grade, deposit walls and thickness, that there is the highest degree of confidence as to the quantity and grade that can be mined at a profit. The term proven reserves implies the highest degree of confidence. It is retained for situations for which the information available on tonnage, grade, mining outline and other technical factors clearly demonstrates the economic viability of that part of the reserve. In general, the term proven reserve would be restricted to deposits that are being mined or have been developed in preparation for mining.

**Comment**

AusIMM definition is more comprehensive, but the IMM Guidelines and Criteria add more detail. The latter say that there is no exact correspondence between **proved mineral reserve** and **measured mineral resource**. The AusIMM code provides for a direct relationship between measured resources and proved reserves; and between indicated resources and probable reserves. The SME definition is very brief, as is that of the GSSA. The GSSA has, in addition, a classification termed declared reserve.

The IMM definition refers to "detailed technical and economic studies". The AusIMM coverage of this aspect is contained by inference in the definition of reserve. The IMM definition in this respect seems preferable. The CIMM definition is more restrictive and is similar in concept to the South African term "declared reserve".

**Probable reserve**

**Australasia**

The term "Probable Ore Reserve" means an Ore Reserve stated in terms of mineable tonnes/volume and grades where the corresponding Identified Mineral Resource has been defined by drilling, sampling or excavation (including extensions beyond actual openings and drill-holes) and where the geological factors that control the ore body are known with sufficient confidence that the Mineral Resource is categorised as "Indicated".

**United Kingdom**

A **probable mineral reserve** is that portion of a measured and/or indicated resource as defined on which sufficient technical and economic studies have been carried out to demonstrate that it can justify extraction at the time of the determination and under specified economic conditions.

**United States**

That part of an indicated resource that satisfies the conditions to be classified as a reserve.

**South Africa**

That part of an indicated resource that satisfies the conditions to be classified as a reserve.

**Canada**

Probable reserve is the estimated quantity and grade of a mineralised body for which sufficient information on continuity, extent, grade distribution, mining method, dilution, metallurgical process, mineral recovery, infrastructure, environmental considerations, operating costs and capital costs is available to form the basis of a study indicating an economically viable operation at long-term forecast average metal prices. The above could require at least a preliminary feasibility study for a future mining operation with a confidence level high enough to allow positive decisions concerning major capital expenditures.

**A Probable Reserve** is the logical progression from an **Indicated Resource** as mining, metallurgical and economic evaluation studies indicate that the resource or part of the resource is economically viable and positive decisions for mining operations can be made. A formal feasibility study for a profitable mine could serve the purpose but in...
many mines no such detailed study is needed to make the economic decision.

Comment
The SME and GSSA definition are brief, and need reference to resource definitions. The essential difference between the AusIMM and IMM definitions is that the latter refers to "sufficient technical and economic studies". The AusIMM coverage of this aspect is contained, by inference, in the definition of reserves. The IMM definition in this respect seems preferable. The CIMM proposed definition in concept appears close to the AusIMM and IMM definitions for proved reserves.

Competency Australasia
A Mineral Resource or Ore Reserves report giving technical facts, interpretations or assessments of Mineral Resources or Ore Reserves must be prepared under the direction of, and signed by, a Competent Person or Persons.

A "Competent Person" is defined as a person who is a Corporate Member of the Australasian Institute of Mining and Metallurgy and/or the Australian Institute of Geoscientists with a minimum of five years' experience in the estimation, assessment and evaluation of Mineral Resources and Ore Reserves which is relevant to the style of mineralisation under consideration.

United Kingdom
All statements based on the Definitions shall be signed by the practitioner making the assessment, who should be a competent person, as defined ... A competent person shall have a minimum of five years' relevant experience in the estimation, assessment and evaluation of mineral resources and mineral reserves.

Any statement prepared by a company or consultant that refers to reserves and/or resources must be prepared under the direction of, and signed by, a competent person.

The qualifications and experience of the competent person who signs a report shall be stated in detail. It will not be sufficient to say that the qualifications and experience are appropriate.

United States
Under Guidelines and Criteria: Qualification of Estimator(s) — Name and qualification of the person(s) preparing and reviewing the foregoing [evaluation criteria].

South Africa
Competency aspect not covered in the March 1994 draft.

Canada
Fundamental to many recommendations to the committee, and the committee's view, is that estimates are made by a competent person with an adequate background in the type of deposit under consideration and relevant estimating methods, so that the interpretation of the geology and basic data is realistic.

Comment
The AusIMM and CIMM make specific reference to the "style of mineralisation" and "type of deposit", whereas the other three standards have no such specific requirement.

Differences are not so far apart as to be incapable of satisfactory resolution.

Other matters
Some aspects have not been covered in this paper — for example, the extent of the requirements of exploration information as detailed in Table 1 of the Australasian code (Assessment Criteria) and Table 1 of the SME paper (Guidelines and criteria for evaluation of exploration information, resources and reserves). The AusIMM version is concise, whereas the SME version is comprehensive.

Both the IMM and SME definitions explicitly recognise the fact that some deposits are not metallic; the AusIMM code and the CIMM proposal have a metals bias.

The AusIMM definition of "pre-resource mineralisation" was intended to exclude reporting of tonnage and grade under this heading. If a resource has been established, it must be reported as Inferred, Indicated or Measured. The term "pre-resource" is specific — ie, no grade and no tonnage estimates. The question of whether Measured and Indicated Resources on the one hand, and Proved and Probable Ore Reserves on the other, must be reported separately may have to be addressed.

The Australasian code uses the term "Ore" for Ore Reserves to signify the economic component of the estimation and the term "Reserve" to signify the available mineral inventory aspect of Ore Reserves and to distinguish them from, the purely quantitative, in-situ "Resources".

Conclusion
It is hoped this comparison paper has identified the main areas of similarity and differences in the reporting of mineral resources and reserves. There are some significant differences in concept, but these are not so far apart as to be incapable of satisfactory resolution. For the most part the differences lie in the words rather than the concept. By eclectic selection from the five operating or proposed standards it is realistic to expect that a standard set of international definitions can be achieved in for foreseeable future.

NOTES
4. Appendix to Australasian reporting of diamond exploration results, identified mineral resources and ore reserves, October 1993.