UNITED NATIONS
ECONOMIC
AND
SOCIAL COUNCIL

Distr.
GENERAL

E/C.7/104
23 March 1979

ORIGINAL: ENGLISH

COMMITTEE ON NATURAL RESOURCES
Sixth session
Turkey, 5-15 June 1979
Item 9 of the provisional agenda. Other issues: (c) Standardization of definitions and terminology; report of the Group of Experts

# THE INTERNATIONAL CLASSIFICATION OF MINERAL RESOURCES

## Report of the Group of Experts on Definitions and Terminology for Mineral Resources

SUMMARY

The Expert Group on Definitions and Terminology for Mineral Resources, convened by the Secretary-General and organized by the Centre for Natural Resources, Energy and Transport at United Nations Headquarters on 29 January-2 February 1979, has recommended an international classification system for mineral resources. Three basic resource categories, R-1, R-2 and R-3, are distinguished according to the level of geological assurance. Each of these categories can further be subdivided into those considered to be exploitable under the prevailing socio-economic conditions (subcategory E) and other resources (subcategory S). These categories can either refer to in situ quantities of metals or minerals or to recoverable metal or mineral.

The Group of Experts recommends the adoption of this classification system. It further recommends that the system be adapted to the needs of individual commodities; that the classification system, if adopted, be reviewed periodically and that the system be employed not only for further work by the United Nations but also to encourage the expansion of and internal improvement in resource estimation by individual countries.

CONTENTS

## INTRODUCTORY NOTE

In accordance with Economic and Social Council resolution 1954 B (LIX) of 25 July 1975, the Secretary-General submits herewith the report of the Group of Experts on Definitions and Terminology for Mineral Resources. Attached also are a bibliography, a graphical presentation of the major classification categories (annex I) and a background paper reviewing mineral classification terms and definitions (annex II). The annexes contain information without which the report of the Expert Group would be difficult to understand in all its implications. Annex II is a shortened and adapted version of the background paper made available to the experts during their meeting. It summarizes the results of the review of present definitions and terminology requested in Council resolution 1954 B (LIX).

The Council also requested the Centre for Natural Resources, Energy and Transport to review definitions and terminology for production and consumption that are being used in the mineral resources field; however, it proved not practical to include these definitions in the present report because very different expertise is required for those fields. The Committee on Natural Resources may wish to request that work continue on this subject and that definitions and terminology for production and consumption be dealt with at a future time.

# I. TERMS OF REFERENCE OF THE GROUP OF EXPERTS

1. In recognition of the difficulties encountered in the interpretation of mineral resource data, the Committee on Natural Resources, at its fourth session held in Tokyo from 24 March to 4 April 1975, recommended to the Economic and Social Council the adoption of a draft resolution, in response to a proposal submitted by Canada, concerning the need for a common set of definitions and terms that might be used by the United Nations in its work on mineral resources.

2. The resolution was adopted by the Council at its 1975th meeting on 25 July 1975, as part B of resolution 1954 (LIX) entitled "Problems of availability and supply of natural resources":

> "The Economic and Social Council,
>
> "Recognizing the need to find agreement on terminology used in categorizing mineral resources so that there should be comparable and generally agreed statistics,
>
> "Having due regard to the work of the International Geological Correlation Programme and the Committee on Storage and Automatic Retrieval of Geological Data of the International Union of Geological Sciences,
>
> "1. Requests:
>
> (a) The Centre for Natural Resources, Energy and Transport to review present definitions and terminology for reserves, production and consumption that are being used in the mineral resources field;
>
> (b) The Secretary-General to convene afterwards a group of experts selected on an equitable geographical basis to prepare a report recommending a common set of definitions and terminology which might be used internationally for the purpose of reporting to the United Nations on mineral resources;
>
> "2. Also requests the Secretary-General to submit the report of the group of experts referred to in paragraph 1 (b) above to the Committee on Natural Resources at its sixth session."

3. The adoption of this resolution followed recognition that there is increasing interest in resource assessment and that there is difficulty in understanding the meaning of the terms and definitions used to classify and describe mineral resources. This leads to difficulties in preparing information that is comparable from one country to another.

4. The Group of Experts referred to above met at United Nations Headquarters from 29 January to 2 February 1979 to review present definitions and terminology for mineral resources and recommend a common set of definitions and terminology. It comprised the following experts and observers:

Members

| | |
|---|---|
| Alan A. Archer | Institute of Geological Science, London<br>United Kingdom<br>(Chairman) |
| Octavio Barbosa | Companhia de Pesquisa de Recursos Minerais, Rio de Janeiro<br>Brazil |
| François Callot | Bureau de Documentation Minière, Paris<br>France |
| Günter B. Fettweis | Institute of Mining, Montanuniversität, Leoben<br>Austria |
| Kirill P. Kavun | All-Union Institute of Economics of Mineral Reserves and Geological Prospecting, Moscow<br>Union of Soviet Socialist Republics |
| Rabi N. Mishra | Geological Survey of India, Bangalore<br>India |
| John J. Schanz, Jr. | Resources for the Future, Washington, DC<br>United States of America<br>(Rapporteur) |
| Jan Zwartendyk | Department of Energy, Mines and Resources, Ottawa<br>Canada |

Observers

| | |
|---|---|
| K. E. Koch | Federal Institute for Geosciences and Natural Resources, Hannover<br>Federal Republic of Germany |
| Vladimir Rogoznikov | Ministry of Higher and Secondary Specialized Education, Moscow<br>Union of Soviet Socialist Republics |
| Maurice V. Hansen | International Atomic Energy Agency |
| Noriko Iwase | Ocean Economics and Technology Office, International Economic and Social Affairs, United Nations Secretariat |
| Wolfgang Gluschke | Centre for Natural Resources, Energy and Transport, Technical Co-operation for Development, United Nations Secretariat<br>(Secretary) |

5. Preparation for the meeting was carried out by the Centre for Natural Resources, Energy and Transport, Department of Technical Co-operation for Development of the United Nations Secretariat. The experts expressed their appreciation to the Director of the Centre for Natural Resources, Energy and Transport for his introductory statement at their first meeting.

6. The Group recognized the advantages that might follow international acceptance of a system of resource classification, including definitions and terminology, particularly as the basis for the compilation of world-wide information (the details of which lie outside its terms of reference). It also recognized, however, that any system should be used with caution. This report, therefore, not only includes a recommendation for a system but also draws the attention of the Committee on Natural Resources to some of the difficulties that may be associated with its use.

7. The Group based its work on a background paper prepared by J. J. Schanz, Jr., on request from and in co-operation with the Centre for Natural Resources, Energy and Transport, which drew on other papers, notably those by I. Bondarenko and J. Zwartendyk. Other documentation is included in the bibliography.

## II. GENERAL GUIDELINES

8. The Group sought a classification system that used terms, definitions and resource categories that would be compatible to the maximum extent possible with those already in use and with current assessment techniques. It also thought it important that the system be simple enough to make possible its use in all countries.

9. After discussing general principles, the Group agreed that the classification system should:

(a) Facilitate the international exchange of data, particularly by enhancing their comparability. This might be a step towards better world-wide understanding of mineral resource issues;

(b) Ideally, be suitable for all mineral resources, or readily adaptable to the specific needs of particular mineral commodities. For practical reasons, the Group considered oil and gas only to the extent necessary to ensure universal applicability;

(c) Take account of measurement and collection procedures to the extent necessary to ensure that the system will be of practical value;

(d) Provide for the inclusion of estimates concerning all mineral resources that are known or surmised to exist with varying degrees of assurance, as well as resources that are as yet undiscovered;

(e) Make provision for both <u>in situ</u> and recoverable resources;

(f) Allow separate estimates of economic and subeconomic resources within those categories where such subdivision is feasible; and

(g) Be primarily concerned with estimates of resources that are of economic interest over the foreseeable period of the next few decades. However, provision should be made for recognition of estimates or descriptions of mineral occurrences that fall outside of the major resource categories as defined.

10. The Group reviewed present basic terminology, as instructed. The terms "resources" and "reserves" give rise to confusion because in a number of languages, among them English, French and Spanish, they have general as well as technical meanings. In some languages only one term is available, while in Russian both terms have virtually the same meaning. Furthermore, it is not uncommon for the terms to be used interchangeably, as synonyms, by non-specialists. For example, the Economic and Social Council refers in its resolution to "reserves" where, in line with the established technical definitions in many English-speaking countries, "resources" would have been more appropriate. The Expert Group therefore recommends that the term "resources" be used exclusively for general classification purposes.

11. The Group emphasizes the need to understand that the extent of mineral resources is a dynamic concept, but estimates for each mineral commodity and for each country must be made at a fixed point in time. All estimates are, therefore, static representations of a dynamic picture; prospecting, technical improvements and changes in market prices serve to alter them.

12. While all countries find it useful to gather information about their short-term mineral supply potential, the Expert Group questions the value of estimating the total amount of mineral commodities that will ultimately become available from the earth's crust for mankind's use. To try to estimate very long-term resource potentials in detail would be an expensive process of limited usefulness.

13. The Group was aware that, even with ideal definitions for the different categories of resources, the information received from countries cannot be expected to be fully homogeneous. The basic information available to any resources estimator is not exhaustive, varies in detail, and interpretation for most categories involves subjective judgement. Thus, the ability to assemble resources estimates and store them in a computer could create a false impression that the computer output will provide definitive answers to mineral policy issues. Even with the best resource information, policy-making must rely upon the continuing participation of specialists familiar with each commodity. They are able to interpret as well as recognize the limit of original or processed data, to correct for any apparent over- or underestimation, to make assumptions or adjustments to provide for the ever-present gaps in the data base, to account for future price trends, and to draw conclusions as to the amount of each commodity that appears likely to be available within stated limits of error.

14. Furthermore, although each category described in the simplified classification system recommended in this report is defined as clearly as possible, some countries will probably have difficulty applying the definitions to their specific

circumstances. For example, it must be recognized that even if a reporting system is agreed upon as desirable, some countries will not provide data for some categories or will find it necessary to aggregate the data for two or more categories. These aggregations may then hide differences in the accuracy and reliability of the individual components used to derive the aggregate data. 1/

15. Thus, the adoption of a satisfactory classification system for international use cannot, by itself, solve all problems of compilation and evaluation. Non-specialists, including planners and decision makers, should be made aware of the pitfalls inherent in the application of the resulting data to purposes for which they are not suitable.

## III. RESOURCE CATEGORIES

16. The Group proposes that for the international classification of mineral resources, three basic categories of resources should be provided, identified as R-1, R-2 and R-3. These categories are differentiated according to the level of geological assurance that can be assigned to each category. They include all of the in situ mineral resources that might be of economic interest over the foreseeable period of the next few decades. 2/

17. Category R-1 encompasses the in situ resources in deposits that have been examined in sufficient detail to establish their mode of occurrence, size and essential qualities within individual ore bodies. The major characteristics relevant to mining and processing, such as the distribution or ore grade, the physical properties that affect mining, the mineralogy and deleterious constituents, are known mainly by direct physical penetration and measurement of the ore body combined with limited extrapolation of geological, geophysical and geochemical data.

18. Quantities have been estimated at a relatively high level of assurance, although in some deposits the estimation error may be as high as 50 per cent. The primary relevance of such estimates is in the planning of mining activities.

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1/ The subjective nature and varying reliability of resource estimates suggest that it may eventually prove useful to request countries to provide broad regional or world estimates in addition to their own national data. Not only would this provide an interesting cross-section of judgements about total resource availability, it would establish bench-marks for identifying variations in outlook or assessment methodologies among countries that are also reflected in their national data.

2/ For the present purpose, foreseeable economic and technical conditions are limited to the next two or three decades. This will vary to some extent according to the commodity being estimated. The limit of economic interest may be further established by the use of various economic or physical criteria suitable for that individual mineral commodity.

19. Category R-2 provides for estimates of in situ resources that are directly associated with discovered mineral deposits but, unlike the resources included in Category R-1, the estimates are preliminary and based largely upon broad geological knowledge supported by measurements at some points. The mode of occurrence, size and shape are inferred by analogy with nearby deposits included in R-1, by general geological and structural considerations, and by analysis of direct or indirect indications of mineral deposition. Less reliance can be placed on estimates of quantities in this category than on those in R-1; estimation errors may be greater than 50 per cent. The estimates in R-2 are relevant mostly for planning further exploration with an expectation of eventual reclassification to Category R-1.

20. Category R-3 resources are undiscovered but are thought to exist in discoverable deposits of generally recognized types. Estimates of in situ quantities are made mostly on the basis of geological extrapolation, geophysical or geochemical indications, or statistical analogy. The existence and size of any deposits in this category are necessarily speculative. They may or may not actually be discovered within the next few decades. Estimates for R-3 suggest the extent of exploration opportunities and the somewhat longer-range prospects for raw material supply. Their low degree of reliability should be reflected by reporting in ranges.

21. Any additional material with a lower economic potential, estimates of which would fall outside the boundaries of "resources" as here defined, should be referred to as "occurrences" and should be reported separately along with some clarification as to the derivation and meaning of the estimates.

22. Each of the categories can be further subdivided as follows:

E - Those in situ resources that are considered to be exploitable in a particular country or region under the prevailing socio-economic conditions with available technology;

S - The balance of the in situ resources that is not considered of current interest but may become of interest as a result of foreseeable economic or technologic changes.

23. The subclassifications "E" and "S" are particularly useful for subdividing resource category R-1 and perhaps category R-2, but the Group does not expect that R-3 will generally be subdivided in practice.

24. Some countries may wish to further subdivide "S" to provide for an estimate of resources, "M", that may become exploitable in the more immediate future as a result of normal or anticipated changes in economic or technical circumstances.

25. The categories and subcategories described above are all specified as referring to estimates of in situ quantities of metals or minerals. The Group was fully aware that resource estimates for some minerals, such as oil and gas or uranium, are more commonly reported as estimates of recoverable metal or mineral. In the Group's judgement, in situ estimates are important but the recoverable

content of metal or mineral more closely approximates the quantity that may appear as mineral supply.

26. Therefore, the Group recommends the establishment of a parallel set of categories and definitions for recoverable quantities in addition to the above categories and subclassifications. This will provide for the opportunity of using either one or both sets depending on what is most suitable. To distinguish between the two sets of parallel data, it is proposed that R-1, R-2 and R-3 should be used for the in situ categories, while the recoverable quantities should be shown as r-1, r-2 and r-3. The subclassification notations E, S and M can be used for both (annex I illustrates these categories). However, there can be no general definition of recoverability, or of the point in the mining and processing sequence at which it should be measured. These must be established for each commodity.

27. The letter-number combinations have been chosen to be different from any now in use in the better known national classification systems. The Expert Group strongly recommends that they be used rather than descriptive terms. The use of word identifiers was rejected because of the tendency of the user to assume, often incorrectly, that the desired definition would be identical to his own. The Group's strategy is apparent: if the categories bear no name or commonly used letter-number combination, both the estimator and the user of these data will be required to read the definitions. An added advantage is that the relationship of letters and numbers to one another is simpler to recall than words that do not have such an orderly arrangement.

28. The Group was aware that there will still be an inclination to equate the proposed categories with familiar terms. Despite the risk of violating its own caveat, the Group lists below some of the more common terms that, to varying degree, have been used for the proposed categories:

R-1 - established, demonstrated, reasonably assured, explored

R-2 - inferred, estimated additional, possible

R-3 - potential, undiscovered, hypothetical, speculative, prognostic

E - economic

S - subeconomic

M - marginal

## IV. FURTHER RECOMMENDATIONS

29. It is recommended that expert assistance be sought to design individual questionnaires. If the classification system proposed here is placed into common use for international reporting of resource information, it will be only the first step towards general harmonization of resource classification. The collection, aggregation and dissemination of resource estimations on a world-wide scale are at present only carried out regularly by the International Atomic Energy Agency for uranium and the World Energy Conference for other energy resources. If it is to

be used for a reporting system, this classification system will have to be adapted to the specific requirements of individual commodities. For example, levels of assurance may have to be defined and recovery levels established. It is also recommended that both the definitions and the questionnaires to be used for individual commodities be tested carefully before actual use.

30. If a set of standard definitions and classifications is adopted for general use throughout the United Nations or as a part of a reporting system, then it is recommended that provision be made for periodic review of the classification system.

31. It is recommended that the classification system be employed not only to further the work of the United Nations on resources but also to provide a means of encouraging the expansion of and internal improvement in resource estimation by individual countries, both for their internal use and for international purposes.

32. The Expert Group notes that it did not address the problems of production and consumption data classification, definition and terminology. It recommends that an intergovernmental group, selected for its particular expertise in this kind of terminology, be convened to complete the work specified by Economic and Social Council resolution 1954 B (LIX).

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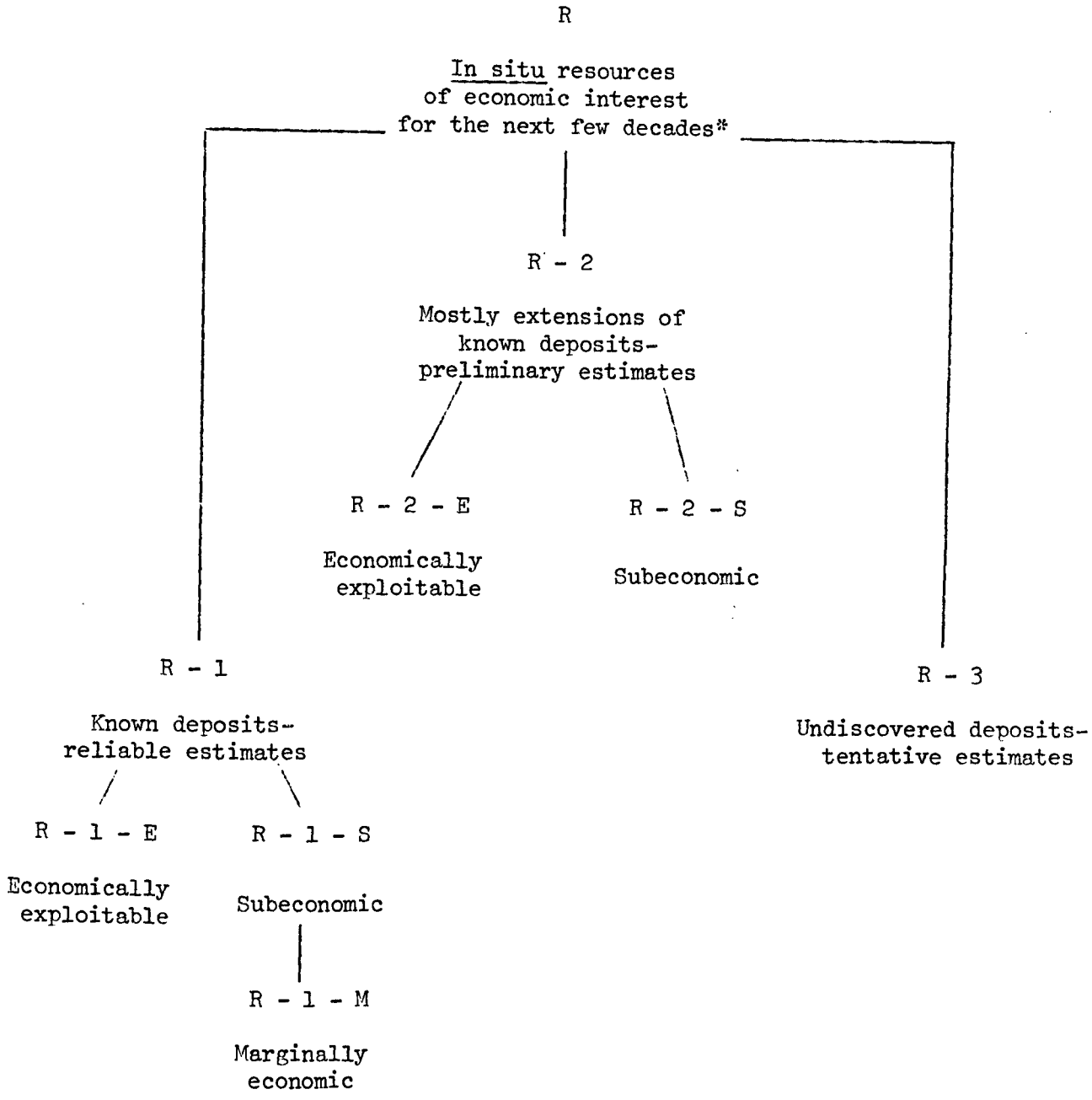
Annex I

CLASSIFICATION CATEGORIES




* While the capital "R" denotes resources in situ, the lower-case "r" would express the corresponding recoverable resources for each category and subcategory, such as r-1-E.

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# Annex II

## REVIEW OF MINERAL CLASSIFICATION TERMS AND DEFINITIONS

This annex summarizes the basic characteristics of the systems most commonly employed at the present time throughout the world for measuring and reporting on mineral resources. This is drawn primarily from the contemporary literature and information obtained from inquiries of various countries consulted by the Centre for Natural Resources, Energy and Transport, United Nations Secretariat. Special attention is paid to the USSR and North American approaches because their systems have been adopted by many other countries.

### A. Review of terms and definitions currently in use

A review of the resources literature of the past several decades, as well as the responses to the inquiry by the Centre for Natural Resources, Energy and Transport concerning classification systems used by the mineral-producing countries of the world, indicates two things rather quickly. One, most countries devote much of their attention to the classification of resources from specific known deposits ranked according to the degree of information possessed and the expected accuracy of the estimate. Two, despite separation of the world into many autonomous States and the disappearance of colonial relationships, linguistic ties still remain between the countries that over the years have provided a preponderance of mining technology and those countries that are currently producing minerals.

As a consequence, the most commonly used classification systems and their terms and definitions originate from a relatively limited number of sources. Primarily these have been Eastern Europe and the USSR, the French- and German-speaking countries of Western Europe, the United Kingdom and North America. Not surprisingly, many of the professionals who write about the problems of resource classification and terminology are found in these same regions. The topic is highly specialized and the basic literature on resource classification and terminology is not voluminous. Only a handful of authors appear to have written on the subject over the past decade. Two fairly recent publications direct considerable attention to what has been said about the topic and who has said it over the years. a/

At first glance the various classification schemes that have been adopted in Europe or North America (and by the countries influenced by their mining traditions)

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a/ G. B. Fettweis, Weltkohlenvorräte, Series Bergbau, Rohstoffe, Energie (Essen, Federal Republic of Germany, Verlag Glückauf, 1976), 435 pp.; an English translation is being published; and J. J. Schanz, Resource Terminology, Electric Power Research Institute, Report 336 (Palo Alto, California, 1975), 116 pp.

seem to vary extensively. Further examination reveals that the conceptual differences are not as great as the diagrammatic presentations, choice of identifiers and the necessities of definition would seem to indicate. All of the systems in some way distinguish between estimates concerning the developed portions of deposits and what lies beyond the actual workings. Similarly, the boundary between what is feasible to mine and what is not, and whether or not to report on a recoverable or an in-place basis, is addressed and dealt with in some way. Though approaches that have been taken in the classification of resources differ, there are in reality many similar characteristics hidden by the physical dissimilarities in presentation.

There are two core efforts in classification. One is the system employed in the USSR and adopted in 1960 by the Council for Mutual Economic Assistance (CMEA). The other is the terminology formally recognized by the United States of America Department of the Interior and built upon the earlier work of geologists McKelvey and Blondel and Lasky. This system is used in modified form by Canada and a number of other countries (see the bibliography).

The basic characteristics of these systems are explored in some detail in the following sections.

## B. The USSR resource classification system for hard minerals b/

The planned economy of the USSR has established strict requirements for the classification of resources of solid minerals. In 1960, the State Commission for Resources approved a new classification system for solid minerals (metallic and non-metallic) as well as oil, gas and underground water, depending on the degree of exploration, knowledge of the physical properties of the raw material, quality (grade, minor constituents, impurities etc.) and mining conditions of a deposit etc., and consisting of four categories designated by the symbols A, B, $C_1$ and $C_2$.

A-category resources are those considered suitable for production planning and capacity projection; B-category resources are used for estimating mining investment requirements and for planning the development of deposits; $C_1$-category resources are taken into account in formulating long-term development plans for the industry and in projecting exploration needs in detail; and $C_2$ resources are used for planning further exploration.

The classification of reserves into different categories is based on three main factors: (1) reliability of the estimates; (2) knowledge of the technological properties of the mineral; and (3) knowledge of the mining conditions and hydrogeological features of the deposit.

In some cases, when the percentage recoverable needs to be determined, this is resolved subsequently in the course of the determination of the mining methods for each deposit; but the resources included in the State Balance of Resources are calculated in situ.

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b/ This section is based on a report by I. Bondarenko (see the bibliography).

The requirements for establishing the different categories of solid minerals provided in the official instructions are as follows:

Category A includes resources sufficiently explored (through drilling or mining openings) and studied to permit full evaluation of the type of occurrence, shape and structure of mineral bodies; precise determination of natural types and commercial grades of mineral products, their ratio and dimensional position; segregation and delineation of barren and non-standard blocks inside the mineral bodies; evaluation of the quality, technological properties of the mineral and natural factors (hydrogeological, engineering-geological etc.);

Category B includes the resources sufficiently explored and studied to permit evaluation of the main features of the mode of occurrence, shape and character of the mineral bodies; ascertaining of natural types and commercial grades of mineral products, and regularity of their distribution; and other factors. The contour of mineral reserves is determined by exploration openings (pits, trenches, bore holes, tunnels) including limited extrapolation when the shape of the mineral body is regular and its quality consistent;

Category $C_1$ includes the resources sufficiently explored and studied to permit the rough evaluation of the mode of occurrence, shape and structure of mineral bodies, their natural type, commercial grades, quality, technological properties and other factors, based on openings and extrapolation according to geological and geophysical data;

Category $C_2$ includes resources only preliminarily evaluated; the mode of occurrence, shape and distribution of mineral bodies are determined on the basis of geological and geophysical data proved by measurement at certain points, or by analogy with the studied areas. The quality of the mineral is determined by individual samples and specimens or according to the data of adjacent explored areas. The reserves in this category are calculated by means of extrapolation along the strike and dip for ore bodies under exploration, and for unstudied ore bodies by the method of analogy.

In addition to mineral resources in categories A, B, $C_1$ and $C_2$ calculated for individual deposits, the "predicted" c/ resources are determined on the basis of general geological knowledge. These are unproved resources of minerals which are thought to exist on the basis of the natural factors governing the formation and distribution of mineral deposits, on the basis of studies of the geological structure of the area being assessed and the history of its geological evolution. They serve as a basis for possible expansions of the mineral base of the appropriate sector of the economy and for planning geological research and exploration. Predicted resources are distinguished from resources of the $C_2$ category by the fact that they are assessed on the basis of data relating to the geological environment and the special structural features of the area in question.

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c/ The Russian term прогнозные can also be translated as "prognostic" or "hypothetical".

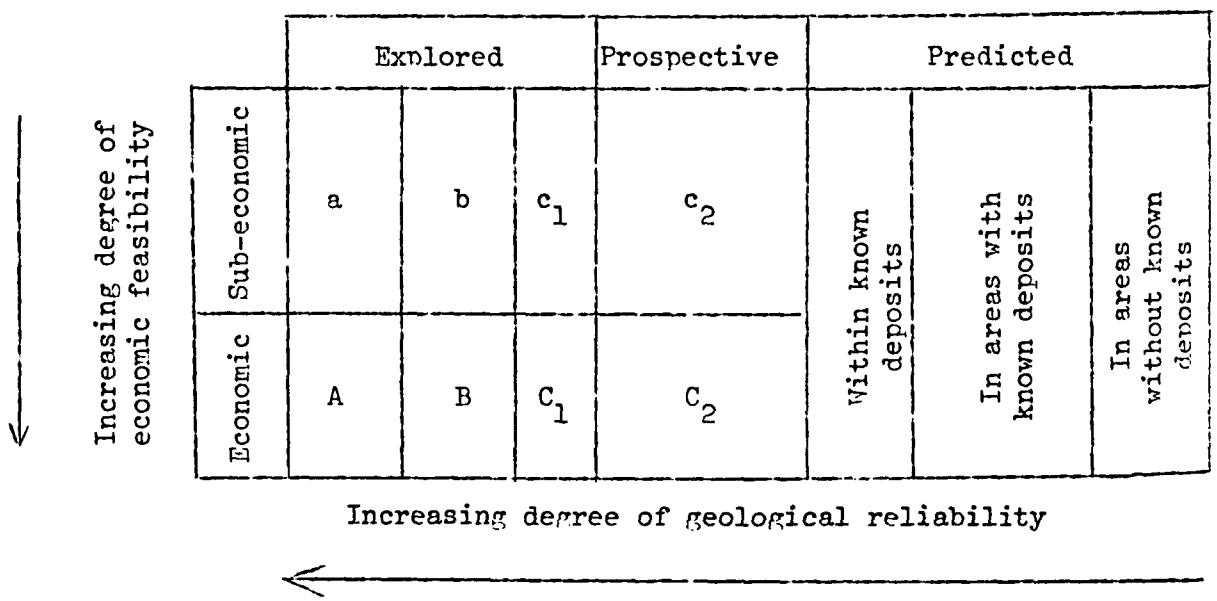
Three categories of predicted resources are distinguished:

(a) Additional resources of deposits which are being exploited or which have been or are now being explored and which are outside the limits of those of the $C_2$ category;

(b) Deposits which may be discovered in areas with proven economic deposits; and

(c) Deposits in areas where geological evidence suggests that ore deposits could be discovered.

The classification of mineral resources, adopted in the USSR and in other member countries of CMEA, can be presented schematically as follows:




A mineral deposit is not only a geological notion but also an economic one. As science and technology change and develop, the quality aspects of raw material requirements and the concept and assessment of economic importance of deposits also change. This dynamic aspect is reflected in the USSR classification: categories A, B, $C_1$ and $C_2$ are divided into two subgroups, namely, economic and subeconomic. d/ Economic (БАЛАНСОВЫЕ) resources are those for which the development is economically expedient with present mining techniques under current economic conditions. Subeconomic (ЗАБАЛАНСОВЫЕ) resources are those which may become economic as a result of changes in economic and/or technological conditions.

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d/ In geological and mining literature translated from Russian into English, a reader may also find the terms "industrial" and "non-industrial" or "balance" and "out of balance" resources, meaning economic and subeconomic resources, respectively.

C. The United States of America Department of the Interior resources classification system e/

To serve the planning purposes of the Department of Interior, total resources are classified both in terms of economic feasibility and the degree of geological assurance. General guides for the use of this classification system are:

(a) Resource categories and definitions should be applicable to all naturally occurring concentrations of metals, non-metals, and fossil fuels. The categories may be subdivided for special purposes;

(b) Definitions may be amplified, where necessary, to make them more precise and conformable with accepted usage for particular commodities or types of resource evaluations; and

(c) Quantities and qualities may be expressed in a variety of terms and units to suit different purposes, but must be clearly stated and defined.

The following terms are used (see also figure I):

Resources - A concentration of naturally occurring solid, liquid or gaseous materials in or on the earth's crust in such form that economic extraction of a commodity is currently or potentially feasible;

Identified resources - Specific bodies of mineral-bearing material whose location, quality and quantity are known from geological evidence supported by engineering measurements with respect to the demonstrated category;

Undiscovered resources - Unspecified bodies of mineral-bearing material surmised to exist on the basis of broad geological knowledge and theory;

Reserves - That portion of the identified resources from which a usable mineral and energy commodity can be economically and legally extracted at the time of determination;

Measured - Reserves or resources for which tonnage is computed from dimensions revealed in outcrops, trenches, workings and drill holes and for which the grade is computed from the results of detailed sampling. The sites for inspection, sampling and measurement are spaced so closely, and the geological character is so well defined, that size, shape and mineral content are well established. The computed tonnage and grade are judged to be accurate within limits which are stated, and no such limit is judged to be different from the computed tonnage or grade by more than 20 per cent;

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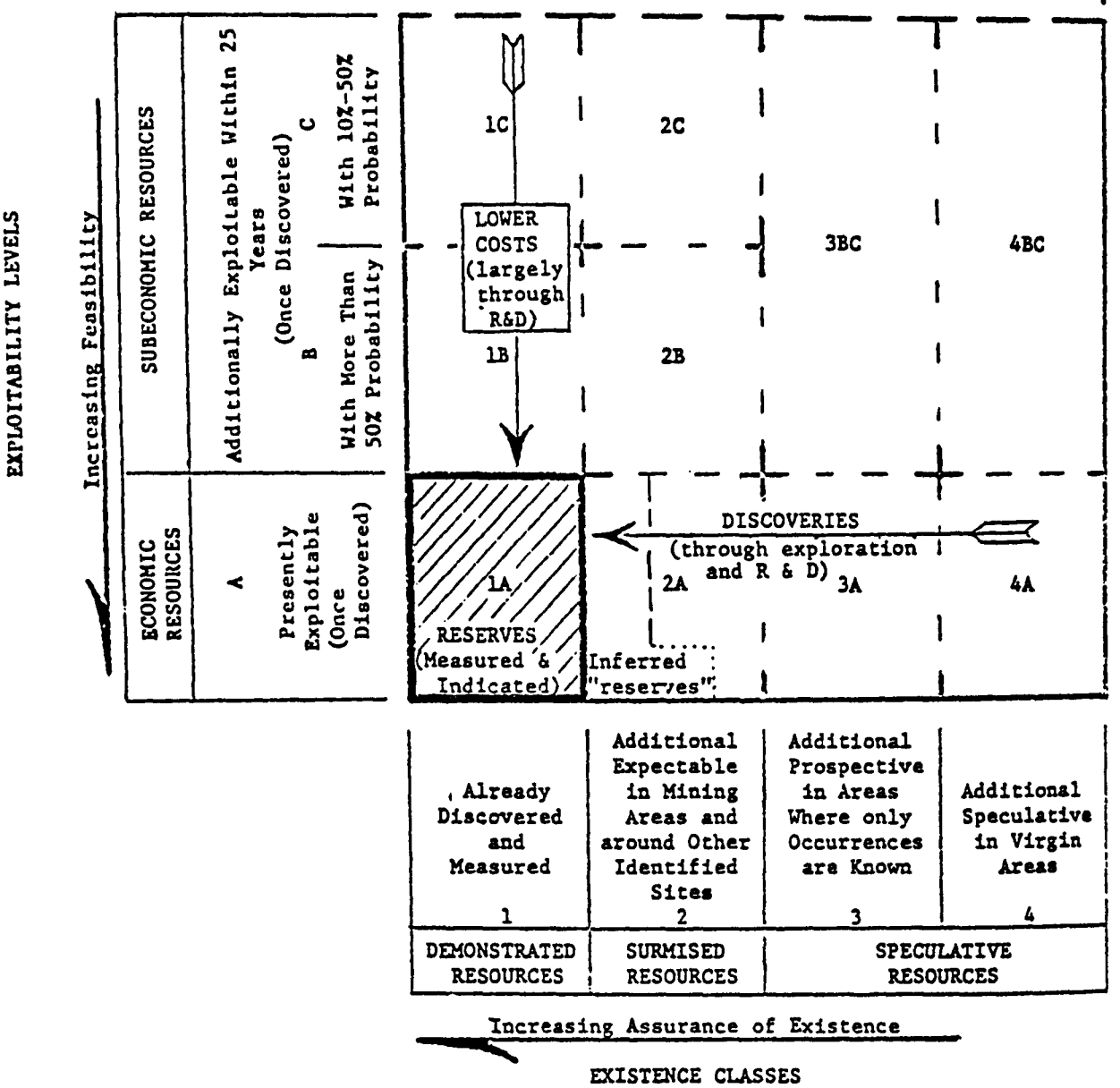
e/ Based upon United States of America, Department of Interior, Geological Survey Bulletin 1450-A (Government Printing Office, 1976), 5 pp.

FIG. 2

DEPARTMENTAL RESOURCE CLASSIFICATION SCHEME




RESERVES (measured & indicated) = 1A (i.e. demonstrated economic resources)
RESOURCES = RESERVES + all other numbered areas
RESOURCE BASE = RESOURCES + indefinite area beyond top of diagram

Note: It has been found impossible in practice to make distinctions between 3B and 3C, and between 4B and 4C.

Indicated - Reserves or resources for which tonnage and grade are computed partly from specific measurements, samples or production data and partly from projection for a reasonable distance on geological evidence. The sites available for inspection, measurement and sampling are too widely or otherwise inappropriately spaced to permit the mineral bodies to be outlined completely, or the grade established throughout;

Demonstrated - A collective term for the sum of measured and indicated reserves or resources;

Inferred - Reserves or resources for which quantitative estimates are based largely on broad knowledge of the geological character of the deposit and for which there are few, if any, samples or measurements. The estimates are based on an assumed continuity or repetition, of which there is geological evidence; this evidence may include comparison with deposits of similar type;

Paramarginal - The portion of subeconomic resources that (a) borders on being economically producible or (b) is not commercially available solely because of legal or political circumstances;

Submarginal - The portion of subeconomic resources which would require a substantially higher price (more than 1.5 times the price at the time of determination) or a major cost-reducing advance in technology;

Hypothetical resources - Undiscovered resources that may reasonably be expected to exist in a known mining district under known geological conditions;

Speculative resources - Undiscovered resources that may occur either in known types of deposits in a favourable geological setting where no discoveries have been made, or in as yet unknown types of deposits that remain to be recognized.

## D. Canadian modification of the system of the United States of America

Unlike the United States of America Department of the Interior, the Canadian Government f/ recognizes that there is a "resource base" beyond resources (figure II). However, this is not included in the scheme for quantification purposes because measurement would be of dubious value.

In another departure from the approach of the United States of America the distinction between economic and subeconomic resources is not based on a cost/price ratio. Instead, the Canadian system identifies Category 1B as subeconomic resources that have a greater than 50 per cent probability of becoming exploitable within 25 years if discovered. Category 1C are resources with a 10 to 50 per cent chance of being exploitable within 25 years. The intent is to permit multidisciplinary appraisal groups to make subjective judgements as to the probable course of market and technological events over the next 25 years.

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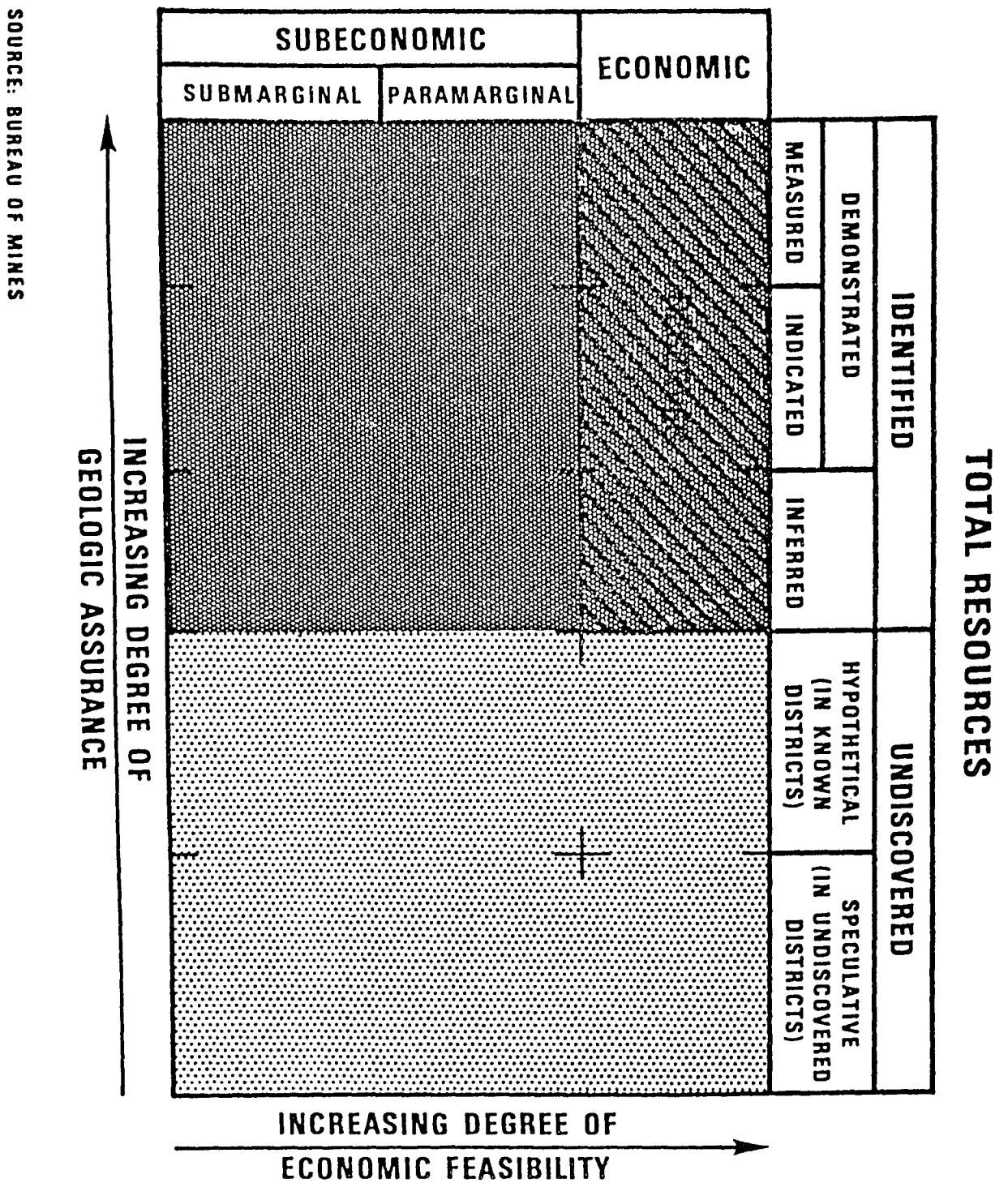
f/ Based upon Canada, Department of Energy, Mines and Resources, Interim Document (Ottawa, 1975), 36 pp. (see bibliography).




SOURCE: BUREAU OF MINES

The other important difference is found in the geological dimension. A Category 2A "surmised resources" has been introduced. These are partially inferred resources as well as other extensions which are not sufficiently known to be classed as discovered or identified.

## E. Analysis of the classification problem

A number of authors have attempted at various times to examine the different systems and through careful examination align the different categories in a matrix so that one can get a visual impression of how they coincide, overlap or diverge. This is not always successful, nor do the various authors interpret the definitions identically. As one example, a comparison between the classification systems of the USSR and the United States Department of Interior is attempted below.

| United States of America | USSR |
|---|---|
| Measured | A + B partly $C_1$, and a, b, and c |
| Indicated | $C_1$ + partly $C_2$, and $c_1$ and partly $c_2$ |
| Inferred | $C_2$ and $c_2$ + predicted within known deposits |
| Hypothetical | Predicted in areas with known deposits |
| Speculative | Predicted in areas without known deposits |
| Identified | A + B + $C_1$ + $C_2$ and a, b, c, and $c_2$ + predicted within known deposits |
| Undiscovered | Predicted beyond known deposits |
| Economic | A, B, C, $C_1$ |
| Subeconomic | a, b, c, $c_1$ |
| Paramarginal) Submarginal ) | Undefined |

At some point in time, all resource-producing countries which desired to inventory their mineral stocks have had to come to grips with the problem of what actually has been discovered and how it can be measured. The differences that appear in various national systems revolve about the details of how many

classes of discovered resources there are in the system, what are the expected accuracies in measurement, what are reasonable standards and practices for the extrapolation of geological information beyond the limits of actual observation and development, and so on. Thus the problem in international statistics is one of disparities in definition of these subclasses, differences in standards of measurement, and variations in the quality of the statistics and the data-processing systems, rather than a major conflict in fundamentals.

One basic difficulty appears to be in drawing the line between what has been discovered and what has not. However, this is not solely a problem between countries but also an internal difficulty. It should be recognized that many present or potential mineral-producing countries at this stage of their resource development have little interest, funds, work force or experience for appraising their undiscovered resources. None the less, this in itself is not a barrier to the creation of an international classification system that can accommodate estimates of undiscovered resources. For the present, those countries that primarily deal in discovered, economically producible resource data are implicitly recognizing the limit between discovered and undiscovered resources. The primary need is to determine if that line is being observed in practice and not just in principle. If it is not, then efforts should be made to encourage tightening of standards of measurement and methods of statistical reporting, according to a classification system which might be accepted internationally.

Perhaps a more difficult task in providing clarity in international resource communication and purity of statistical aggregation is the question of dealing with known resources that are below contemporary standards of usability. Regardless of their economic or political system, most countries know of mineral resources for which they feel the application of manpower, equipment and transport is not justifiable under present circumstances. Whether these resources are identified as "out of balance", "subeconomic", "non-commercial", "not marketable", or by any other term, the key consideration is, given the purview of the decision makers in that particular country, what portion of known deposits is not currently exploitable by the present mineral resource recovery system. In concept, these quantities are not a part of what most resource analysts would classify as currently known and pruducible mineral resources. The international classification problem does not arise solely from the presumed existence of such a line of demarcation of what is currently producible under contemporary technical and economic conditions, but rather whether or not that line is observed in the measurement and reporting of resources. Another question is that of subdividing undiscovered resources into usable and unusable categories. It is quite rational to take the position that undiscovered mineral deposits should only be considered in terms of the costs and usable technology that will be relevant at the time they are discovered and a decision is made to develop or not develop. Thus, to apply current technology and economic perspectives to prognostic resources is somewhat of a fiction that contributes little to our perception of future resource opportunities. Yet there are those who feel that to forecast a future improvement in technology is too expansive a view of prognostic resources and that the practice of identifying only that portion of the undiscovered resources that could now be produced provides a more acceptable and conservative view of the magnitude of what remains to be discovered.

As a final point in the basic structure of mineral resource classification, there is the necessity to establish a lower limit to what is considered to encompass economic and subeconomic mineral resources. In essence, this is the requirement to restrict classification and quantification of the resources to those mineral materials that are perceived to have some present or future usefulness as separate from "country rock". This is bound to be an arbitrary setting of spatial and geological and mineralogical limits. Obviously, these standards should be established commodity by commodity and country by country in a fashion that has already begun for coal and uranium.

## F. Difficulties in implementation

One major issue is the question of the percentage extracted by mining and recovered by processing. For the high-grade metallic ore deposits this has never been a problem because the deposits tend to be clearly delineated and the percentage loss during removal from the earth has tended to be less than the variation in the accuracy of measurements. This may not be the case with the disseminated ores, extensive bedded deposits, some industrial minerals, coal and petroleum and natural gas. In these cases, the recovery of the in-place material may be as little as 10 per cent. After mining, there is the further question of whether or not the losses in processing to meet market specifications or to keep costs low enough should also be accounted for. In addition, recoverability is intimately involved in the consideration of the feasibility of extraction.

The practice in many countries appears to be classification relying upon in-place resources. This, however, does not negate the necessity of having to calculate and present the recoverable proportions of the total resources in some fashion. To do otherwise would leave the data user with numbers that bear little relationship to the actual resource quantities that would currently be produced from these in-place quantities. Several approaches suggest themselves. One, a classification system for those minerals for which recoverability is important, which would present resource data in two categories - in-place and recoverable. Two, resource data could be presented only on an in-place basis with recovery ranges merely noted. Calculations could be made by any analyst, as required, outside of the classification system under whatever assumptions he would care to make. Three, only currently discovered and usable mineral resources would be presented on a recoverable basis, whereas non-usable and undiscovered resources not subject to current practice would be in-place. In this system, the non-recovered portions of the discovered and usable resources could still be accounted for by placing the quantities left in-place after mining in the subeconomic or non-resource categories.

Another area of difficulty is that most national systems subdivide resources, particularly in the discovered, usable category. These subclasses vary in number, definition and standards of measurement. How far the resources data may depend upon geological extrapolation, how interpolation is to be practised, and how accuracy is specified in estimation or the use of probability limits varies widely in practice.

Some analysts, disturbed by the proliferation of subcategories, and the inexactness of definitions and identification of these categories, have suggested that classification would be improved through qualification of estimates in terms of probability of occurrence, discovery or of becoming economically usable. This could perhaps lead to the abandonment of terms and definitions altogether. Although appealing to the mathematically inclined, total reliance on probabilities ignores the facts that many users of resources data find it difficult to interpret data presented in this fashion, that preparation of estimates would become more difficult and expensive, and the appearance of mathematical precision or sophistication may be deceiving.

## G. Adaptation to individual commodities

Although the Economic and Social Council resolution does not specifically charge the panel of experts to include coal and uranium, the particular problems of appraising their resources have to be taken into account. In the case of coal, this requires not only that the resource classification systems be compatible with the recommended basic system. Coal resources have a long history of international exchange of resource data and there are deeply ingrained legal and other institutional patterns of classification within many countries.

The particular problem of recoverability is an important issue in the case of coal. Coal recoverability varies widely among countries and between mining methods and also reflects mining conditions. Also, the meaning of in-place coal resources requires sharp clarification. For example, does this mean all of the coal or are there standard exclusions for coal that cannot be mined due to haulage ways, surface activities and so forth? Does recoverability mean the proportion that is brought to the mine portal versus what was in place or are losses in surface washing and preparation of the coal for utilization also included? These standards must be adopted for the other mineral resources and it is important that a similar definitional posture be taken with respect to coal.

A major effort is now under way under the auspices of the International Energy Agency (IEA). Data will be submitted through a central clearing-house by member countries on their coal resources including technical and market information. To this will be added as much information as is available to the Agency on coal resources in other countries and the world. Since this information will originate from a variety of sources, there is a necessity to be able to translate these data for both storage in the data bank and use by the member countries after retrieval.

Uranium, like coal, offers special problems of adaptation to the general system. Recoverability from the deposit and, in addition, the separation of fissionable material through post-mining processing are important considerations.

Uranium, as an energy resource, has attracted considerable attention from international groups and from industry. As a consequence, resource terminology and definitions have already been discussed on an international scale, with the International Atomic Energy Agency (IAEA) being the most important organization with respect to the development of a uranium classification system.

Perhaps the most unique characteristic of uranium resource classification has been the introduction of the concept of cost. Although to date this has not been an attempt to measure the full cost of uranium resources or to provide a true supply schedule, it is unusual that resource data are regularly assembled in terms of cost.

Another characteristic of past resource estimates made for uranium has been the concentration on the resources in known deposits. The effort expended in consideration of the potential of areas not currently being mined has been modest. As a result, the Advisory Group on Evaluation of Uranium Resources has proposed to the NEA/IAEA the adoption of a new category, "Estimated Additional Resources II". This will provide for the use of geological extrapolation to estimate resources which may occur in as yet undiscovered deposits discoverable with existing exploration techniques. All uranium resource categories will continue to be reported in standard cost ranges, taking into account the finding cost.

Although standard international classification of uranium resources has categories similar to those used for other mineral resources, there are some difficulties to be overcome in matching a general classification system with one that may emerge from the recommendations currently being presented by other organizations. None the less, in the interest of uniformity and public understanding, it is essential that any disparities between individual commodity practices or between individual countries be eventually resolved.

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