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ECONOMIC AND SOCIAL DEVELOPMENT NEEDS IN THE MINERAL SECTOR: REGIONAL MINERAL RESOURCE ASSESSMENT PROGRAMMES

Review of regional mineral resource assessment programmes and resource needs

Report of the Secretary-General

SUMMARY

Information about a nation's mineral resource potential is crucial in national and regional development planning. Many developing countries lack sufficient resource data despite the availability of a wide range of assessment techniques. This report, prepared in response to Economic and Social Council decision 1993/302 and the recommendation by the Committee on Natural Resources at its first session, surveys existing and planned international and regional resource assessment programmes for the use of United Nations and governmental planning officials and examines the six most utilized resource assessment methodologies. It also discusses usefulness of mineral resource information to policy makers.

* E/C.7/1994/1.

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INTRODUCTION

1. The Economic and Social Council, on the recommendation by the Committee on Natural Resources at its first session (29 March to 8 April 1993), requested the Secretary-General to submit to the Committee at its second session a summary review of regional mineral resource assessment programmes. It was to include updated information on two types of resource assessment programmes: assessment of identified resources; and assessment of resource potential, or undiscovered resources. Major mineral-producing countries of North and South America, Europe, and Africa were to be covered, as well as the many well endowed nations of the Asia/Pacific region. Information on the resource assessment activities in the former Soviet republics and other former centrally planned economies were to be included, to the extent possible. Definition of resource assessment techniques, uses, and methodologies were to be provided. The present report was prepared in response to the Council's request.

2. Contributions were provided by the Economic and Social Commission for Asia and the Pacific, the Economic Commission for Africa, and a variety of other sources identified by the Department for Development Support and Management Services of the United Nations Secretariat.

3. Section I provides background information. Section II discusses the principles of mineral resource classification, and section III presents detailed descriptions of the six major resource assessment methodologies. Sections IV and V provide information on the practical application of those techniques to regions around the world. Finally, section VI presents a brief discussion of the usefulness of mineral resource assessments in general.

I. BACKGROUND

4. Resource assessment pertains to the estimation and evaluation of minerals in the ground, both discovered and undiscovered. Attention centres on the form, concentration, and location of the minerals in order to determine whether they might be extractable under foreseeable economic and technological conditions. In practical terms, there is no such thing as an all-purpose resource assessment. Diverse groups of interested people - mineral exploration planners, economic analysts, land use planners, or policy makers - look for the aspects that are most pertinent to their particular fields and time-frames.

5. Discussions of resources have long been undermined by a vague and inconsistent use of language. For more than a century, efforts have been made to establish definitions that would be widely accepted and applied. Unfortunately, the result has been a multitude of definitions none of which has won general acceptance, largely because of differences in purpose and emphasis. Even the commonly used expressions "crustal abundance", "mineral endowment", "resources", and "reserves" convey different things to different people.

6. Estimates of resource, although necessary for decisions pertaining to future supply, are not sufficient for predicting future mineral availability. Estimates of supply flow must take into account rates of discovery, development,

and production. Estimates of resources should not be (but often are) mistaken for amounts that will be available at acceptable prices when and where needed.

II. MINERAL RESOURCE CLASSIFICATION

7. In resource assessments, the type of classification used will depend on the type of assessment. Resource assessments are of two main types: primarily geoscientific, and geoscientific/economic:

(a) Primarily geoscientific assessments aim to provide the best possible geoscientific judgements on the likely distribution and character of undiscovered mineral resources by region, for the benefit of long-range land-use planners, exploration planners, and mineral supply analysts. Mostly used in regions where there has been little or no mineral development, geoscientific assessments are qualitative only. Economic constraints imposed tend to be loose and implicit;

(b) Geoscientific/economic assessments aim to provide policy analysts with estimates of the magnitude (currently perceived) of the sources of short-range and longer-range mineral supply, so that appropriate efforts may be made to explore and develop them and technology developed to aid in their recovery. Sources of supply that can be quantified reliably are mostly those from which supplies may come within the next 15-20 years.

8. Both types of assessments require a multidisciplinary approach, which covers the degree of assurance about an estimated quantity actually being present in the earth’s crust and the degree of economic attractiveness it offers. Given these two concerns, the resources can be subdivided into four main categories: discovered and economic; discovered but sub-economic; undiscovered and economic; and undiscovered and sub-economic. These classifications are dynamic, changing with discoveries and with fluctuations in cost and price.

9. The level of assurance about the physical existence of certain tonnages of given grades can be expressed in more subtle gradations than simply "discovered" versus "undiscovered". The assurance level may cover a continuous spectrum from very high to nil, but in practice it is generally expressed in discrete gradations such as proved, measured, probable, indicated, possible, inferred, speculative, and so on. The dividing lines between such descriptive terms are difficult to define satisfactorily, so that what is "proved" to one person may be "probable" to another.

10. The distinction between economic and sub-economic is also largely judgemental. It can be made only on the basis of mining feasibility studies that consider all the details of mining methods, costs, and revenues. The explicit criterion used for economic subdivisions is generally one of the following: price; cost; cost/price ratio; or probability of becoming economically mineable within a given time period. For some metals, economic subdivision is complicated by association with other metals in the same deposits, which may enhance the economics of exploitation.

11. Detailed knowledge about discovered and economic reserves - and about past production - is invaluable as a basis for extrapolation in resource assessment. However, the cost of upgrading knowledge about the exact tonnage of new discoveries to the "reasonable assurance" level of reserves is high. So is the cost of economic analysis. Therefore, the drilling and analysis necessary to establish reserves is normally undertaken only to the extent needed for production planning.

12. Especially imprecise is the outer limit of resources determined by foreseeable technology and economics, concepts that respond closely to one another. Some of the technological improvements that would extend the economic limit of resources are techniques for locating deposits at greater depths and methods for better extraction of ores and recovery of the mineral commodities from them. These represent changes in the technology of raw material production. The economic limit of the resources of a commodity can also be affected by the technology of material use, which, for example, might lower the demand for that commodity (and thus its price) through the use of another material in its place.

III. MAJOR RESOURCE ASSESSMENT METHODOLOGIES

13. Resource assessment activities may begin with an evaluation of identified deposits and their reserves in a region or country and may or may not proceed to an estimation of undiscovered resources by analogy. Many different estimation procedures can be used for evaluating reserves, each dependent on the physical characteristics of the deposit and geological data available. Reserve estimation methodologies make quantified estimates available, but they require many data that are frequently unavailable. The methodologies used in computing reserves may be conventional or geostatistical.

14. One of the differences between the reserves and the undiscovered mineral resources of a country is a function of quantity. In both developed and developing countries, undiscovered mineral resources may be many times larger than the known deposits. Because of the need for assessments of undiscovered mineral resources, various estimation methodologies have been developed and are utilized internationally. In general, there are six of them, plus a multitude of techniques based on their fundamental concepts. The six are based on areal value, crustal abundance, volumetric analysis, deposit, Delphi surveys, and integrated synthesis. They are described below along with the analytical procedures required to implement them. Cost and data requirements, the product’s strengths and weaknesses, and country applications of the methodologies are summarized in table 1.

Table 1. Characteristics of major resource assessment methodologies

Methodology	Estimation procedures	Data requirements	Products
Areal value estimation	Extrapolation of estimated mean unit value of well-explored developed area to similar, less explored, underdeveloped region of interest	Data on rock types and production data by year and commodity for both study area and analog area	National, regional, or provincial estimate of resource potential for known and unknown deposits on a commodity-by-commodity basis
Crustal abundance	Estimation of the amount of recoverable resource from a representative mean abundance, normally through an empirical function	Data on rock types and geochemical values	Regional, local, or specific estimates on an elemental basis. Empirical estimation of production capability, and recoverable resources formulas
Volumetric estimation	Extrapolation of representative estimated or determined mean concentration of a known unit volume to the volume of interest	Data on quantity and size of prospects, stratigraphy porosity/permeability, yield, areas, and thickness	Estimate of resources on a regional, local, or specific geologic unit, based on analogy
Deposit modelling	Estimation of resources in a specific geologic environment based on an analysis of known deposits in geologically similar environments	Geologic, geochemical, geophysical, mineral occurrence, and remote-sensing data. Also, genetic information and results of previous exploration	Area-specific or local estimate of tonnage and grade distribution by deposit type and commodity at .05, .5, and .9 confidence levels
Delphi estimation	Resource estimation based on a collection of opinions from expert geologists. Such opinions are based on analysis of all available data and individual experience	No specific data requirements except knowledge of the geology of the area of interest	Subjective estimation by area of deposit type. May estimate tonnage, grade, and deposit size distribution
Integrated synthesis	Estimation of resource potential based on a combination or integration, or both, of some or all of the above methods	Data from all of the above methodologies and, in some cases, data files of estimates produced as basic inputs to other methodologies	Specific resource estimation by deposit, commodity, tonnage, grade, and area (highly disaggregated). Estimates can be used by national econometric models

Methodology	Strengths	Weaknesses	Selected country applications
Areal value estimation	Relatively simple to use for mineral resource planning; universally applicable to developed and developing countries; low cost; short evaluation time	Basic assumption that geologically similar areas contain similar mineral resources; requires a reliable geological map of area of interest; dependent on availability and accuracy of commodity data	Australia, Canada, China (in preparation), Mexico, New Zealand, Papua New Guinea, United States, Zimbabwe
Crustal abundance	Quick and moderately reliable for resource planning; can be easily updated with new data and relies on fairly accurate analytical inputs	Estimates are subject to wide range of error, very data-dependent; totally dependent on availability of good geological maps; assumes close genetic relationship between rock types and associated mineral deposits	Canada, China, Soviet Union (former), Turkey, United States
Volumetric estimation	Relatively simple to use and requires minimum amount of data; a standard method for petroleum and natural gas basin estimation; excellent for deposits with simple and uniform geometry	Paucity of information used is not apparent to the uninitiated; misleading to use volumetric estimates to guide major economic or national policy decisions; assumes geologic similarity between regions	Canada, Indonesia, United States (Alaska)
Deposit modelling	Incorporates all available data and permits the incorporation of geological concepts; resource estimates reflect the quality of the data used; delineates exploration targets	Data for deposit model construction is limited and can lead to misapplication of specific models; very data-dependent; basically used for well-known deposit types	Bolivia, Canada, Colombia, Costa Rica, Cyprus, Finland, Norway, Papua New Guinea, United States
Delphi estimation	Rapid and low cost; applicable anywhere in the world, provided geological experts are available; provides disaggregated estimate	Very easy to introduce bias either intentionally or accidentally; resource estimates tend towards group mean; totally dependent on knowledge and experience of geological experts	Canada, Costa Rica, Mexico, Papua New Guinea, United States
Integrated synthesis	Incorporates all available data, concepts and geological experts, provides disaggregated, commodity specific estimates; useful on delineation of exploration targets and mineral resource planning	Quite expensive and time consuming; requires substantial amount of data, hence limited to local application; requires complex mixture of skilled personnel	Bolivia, Canada, China, Colombia, Costa Rica, Papua New Guinea, Puerto Rico, Scandinavia, United States, Venezuela

Source: A. L. Clark, "The importance of data banks for resource assessment", in New Paths to Mineral Exploration. Proceedings of the Third International Symposium (Hannover, Federal Republic of Germany, 27-79 October 1982), F. Bender, ed., pp. 97-98.

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A. Areal value estimation

15. Resource assessment by areal value estimation involves the extrapolation of a representative estimated mean unit value of the resources in a known area to the region under study. Such extrapolation is normally based on geologic analogy between some well-defined region and a geologically similar area of interest. An example of a well-defined area would be a United States state where data on mineral production and reserves are available from published sources. Such data are measured in terms of amount and value for comparative analysis with resources of other geologically similar regions. Areal value estimation can indicate the types and quantities of mineral resources likely to exist in a geologically comparable region of interest. In addition, resource assessments based on areal value estimation provide an idea of how much more of the mineral commodities already being produced may be obtained in the future.

16. Areal value estimation can be accomplished through use of the unit regional production value (URPV) mineral assessment technique. This technique represents a revised version of the original unit regional value (URV) assessment technique, developed more than two decades ago at Pennsylvania State University (United States). The URV and URPV techniques are based on the assumption that geologically similar regions contain equal values of mineral resources and that comparable production will be achieved under similar levels of exploration and development. For the URPV method, data on historical mineral production and reserve amounts from well-explored or developed areas are used to estimate mineral resources in less explored or underdeveloped regions. Unit regional production values are obtained by

(a) Summing historical minerals production in an area;

(b) Adding economic reserve amounts to the sum;

(c) Valuing the aggregate sum of historical production plus economic reserves;

(d) Prorating that value over the area (km^2) of the region being considered.

Once these estimates are calculated for developed regions, such as a United States state, they can be used to estimate the mineral resources in geologically similar, underdeveloped regions.

17. Two countries that have been assessed by the URPV technique are Papua New Guinea and China. For both studies, unit regional production values from United States states were used to estimate the quantity and value of mineral resources that were likely to exist in geologically similar provinces of Papua New Guinea and China.

B. Crustal abundance

18. This methodology assumes that the larger the crustal abundance of an element per unit of rock type, region, or geological province, the greater the

likelihood of that element's concentration into a resource. Consequently, the idea is to establish a relationship between crustal abundance and resources using a crustal abundance model. To establish such a model, geochemical data from a known region are complied for purposes of determining crustal abundances. Once the crustal abundance estimates for the known area are determined, resource tonnage estimates of the known area are acquired. Then, tonnage is plotted against abundance, establishing, in general, a linear relationship known as a crustal abundance model. This model is then used to estimate the resource endowment of specified minerals in a geologically similar area of interest.

19. The problems encountered with crustal abundance estimation centre on the difficulty in establishing the relationship between tonnage of resource and crustal abundance. Although in general it is linear when expressed in logarithms, this does not hold true in all environments. Thus, extrapolation (of a non-linear model) may be unreliable. Another problem is the difficulty of judging the crustal abundance of a specified mineral or mineral group. For this reason, the methodology provides only preliminary estimates which cannot be applied with the same degree of confidence as more data-dependent methodologies.

20. The principal strength of resource estimation based on crustal abundance is that, in a relatively short period of time, an inexpensive resource assessment can be conducted. Such estimates provide an indication of the potential for selected minerals in an area. Geologists and mineral economists can use crustal abundance estimates to judge whether mineral production in a region is high or low, based on its possible resources, which, in turn, are taken to be related to crustal abundance.

C. Volumetric estimation

21. The volumetric approach approximates total resources in a region by multiplying the mean mineral content of a unit volume of the earth's crust by the total volume of an area of interest. In such estimation, a representative estimated mean concentration of a known unit volume is extrapolated to the volume of an area of interest. As with the areal value and crustal abundance estimation procedures, the known unit volume is normally extrapolated from a well-explored region to a geologically similar, less explored area. The preliminary evaluation of petroleum and natural gas resources in the Alaskan North Slope serves as one example of resource estimation based on volumetric analysis.

22. To implement the volumetric estimation procedure, sufficient geological information on the known area must be available in order to determine the mean content of a unit crustal volume. For some mineral commodities the information required to determine the mean concentration is minimal; other commodities require substantial data.

23. A hypothetical example of volumetric estimation would be an assessment of a chromium-bearing beach deposit by extrapolation of the mean chromite concentration of the beach deposit of some known area, such as the northern coast of Papua New Guinea, to an unknown region. Along the Papua New Guinea coast, the chromium-bearing beach deposit has been assessed as containing an

estimated 3.3 million tons of 1.8 per cent grade Cr_2O_3. If a geologically similar deposit were to be discovered elsewhere, a volumetric estimate of the chromite resource could be obtained by multiplying the volume of the newly found chromium-bearing beach deposit by the mean chromite concentration of the deposit on the northern Papua New Guinea coast.

D. Deposit modelling

24. In an area recognized as being geologically favourable, the deposit model estimation procedure is used to evaluate mineral resources based on knowledge of known deposits in geologically similar environments. A deposit model is essentially a characterization of a particular mineral deposit type. The character description primarily includes the geological attributes of the deposit, including tonnage, grade, and deposit distribution. Deposit modelling is a relatively objective assessment methodology, in the sense that the assessment is based primarily on a model and not on the experience of geologists.

25. The fundamental concept behind deposit modelling is to compare the characteristics of a selected model to the characteristics of the region of interest. The deposit model should be based on information from as many relevant deposits as feasible, in order to ensure that all possible geological characteristics are being used for comparison. Once the geology of the appraisal area has been studied, geologists and mineral economists can select the relevant deposit model. The geological characteristics of this model are essentially extrapolated to the region of interest, and modified according to the specific geology of the area. Thus, deposit models are relevant to specific geological environments, although they usually need to be modified according to the particular characteristics of a region.

E. Delphi surveys

26. The Delphi method of estimation uses the professional intuition and knowledge of geological experts to provide probabilistic estimates of mineral resources. Geological experts familiar with the mineral occurrences of a selected area are brought together, individually and collectively to estimate resource potential. Individual opinions are voiced among the experts, who have the opportunity to modify their opinions according to the responses of the others. The ultimate goal for the group is to express its collective opinion in the form of a single quantitative resource estimate. Such an estimate tends to be biased around the group mean; hence, a probability range around the estimate based upon the variation of the group’s opinion is usually established.

27. This methodology is very widely used for resource assessment because it is quick, efficient, and can be done at low cost. If the geological experts are available, Delphi estimation can be used in any part of the world. Although an understanding of the basic geology of the area under study is needed by the experts, no specific data are required for use of the methodology. Therefore, Delphi estimation is especially useful for areas where few, if any, exploration data are available. If a preliminary resource assessment has been conducted in

a region, the results could bias the opinions of the geological experts. In general, the less information available, the greater the appeal of using the Delphi method. Delphi estimation is probably most applicable to regional or reconnaissance-type assessments. A recent Delphi survey, using the expert opinion of five senior geologists, was conducted on the San Juan Basin (New Mexico, United States) to estimate the uranium endowment, based on existing geological data and ignoring previously made estimates.

F. Integrated syntheses

28. If sufficient time, personnel, and funds are available to conduct a complete and detailed resource assessment, the integrated syntheses approach could be used. It leads to resource estimates based upon a combination or integration of some or all of the previously discussed methodologies. All existing geological, geochemical, and geophysical data, combined with the labour of skilled personnel, are required to develop such estimates. In many cases, data and resource estimates generated from the other five major methodologies are needed for an integrated synthesis analysis.

29. A recent example of integrated synthesis analysis is the estimation of the mineral potential of the Altay Mountain region of Xinjiang, China. The major assessment techniques of reserve estimation, compilation of mineral inventory, deposit modelling, and Delphi estimation were all employed.

30. Resource estimation by integrated synthesis is generally disaggregated and commodity-specific. A selected mineral of economic interest may be evaluated by deposit or deposit area in terms of tonnage and grade. Since such estimates are fairly detailed in scope, they can be used to delineate exploration targets and guide resource policy decisions. Moreover, highly disaggregated resource estimates (that is, by deposit) can be used for national econometric models evaluating resource supply and cost.

IV. APPLICATIONS OF RESOURCE ASSESSMENT METHODOLOGIES

31. Resource assessments are conducted in order to evaluate both known and unknown mineral resources. Known deposits are generally assessed by undertaking a national inventory of mines and of deposits considered or prepared for mining, and by validating the reserves of each mine. The tonnage estimates of reserves provide a quantitative basis for policy makers to formulate regional or national development objectives.

32. The estimation of undiscovered mineral resources, by one or more of the six major resource assessment methodologies just described, serves as a basis not only for the development of future mineral exploration programmes but also for intermediate-to-long-term policy planning. Unfortunately, the usefulness of an assessment of undiscovered mineral resources is poorly understood and generally underestimated by most governmental planners. For the most part this can be attributed to the idea that undiscovered resources are "invisible" to the policy maker and, as such, do not require immediate attention. Regardless of the "invisible" characterization of undiscovered mineral resources, their estimates

have been historically an accurate predictor of future resources and discovery potential. The usefulness of resource assessment data to Governments can be improved if the information is presented in economic, rather than geologic, terms since policy makers tend to have little skills in the geological sciences.

33. The selection of a specific resource assessment methodology is an important and sometimes difficult task. The first step is to decide on the type of information needed from a particular resource assessment activity. If a broad-based resource assessment is desired, the areal value, crustal abundance, or volumetric estimation procedures may be adequate for the purpose. If a more detailed characterization is needed, the deposit modelling procedure may be more appropriate. Cost, time, and personnel requirements, the availability of geological, geochemical, and geophysical data, and the acceptability of biases and inaccuracies in the assessment must all be considered in the selection.

V. MAJOR REGIONAL/NATIONAL RESOURCE ASSESSMENT PROGRAMMES

A. Circum-Pacific Map Project

34. The Circum-Pacific Map Project is a collaborative global effort to compile and publish geologic, geophysical, and resources maps of the Pacific Basin and surrounding continental areas. A series of more than 60 maps has been designed, and about two thirds have been published by the United States Geological Survey. Maps are designed to illustrate the relationship of known energy and mineral resources to the geology, tectonics, and crustal dynamics of the Pacific region. Geologic, geophysical, mineral, and energy data are being compiled at a scale of 1:10,000,000 on equal-area map projections. Where possible, available data are complemented by new, project-developed data sets such as magnetic lineations, earthquake first-motion solutions, lithospheric stress, seafloor mineral deposits, and seafloor sediments. Geologists and earth scientists from throughout the Asia/Pacific region are participating in this work.

35. Covering more than half of the earth’s surface, the project area extends from the Indian Ocean (lat 90°E) eastward across the Pacific to include most of North and South America (lat 50°W). It also includes the Arctic Ocean and the entire continent of Antarctica. Six overlapping regional maps at a scale of 1:10,000,000 form the cartographic base for the project. In most of the eight map series there is also a Pacific basin map at 1:17 million scale for depicting basin-wide data. These maps cover 220° of latitude, more than half of the earth’s surface. Maps are compiled on a Lambert azimuthal equal area projection to minimize distortion. Base map series include geographic and base maps, the latter with 2° grids for plotting data. The thematic map series include plate-tectonic, geologic, geodynamic, energy resources, mineral resources, and tectonic maps.

36. The Circum-Pacific Map Project is currently organized under six panels of geoscientists representing national earth-science organizations, universities and natural-resource companies. Forty-one map sheets were published as of 1992. Four map series have now been issued: geographic, base, plate-tectonic, and geodynamic. Publication of the geologic map series began in 1983 and is scheduled for completion in 1994. The first map in the mineral resource series

was published in 1984. The first map of the energy resources series was published in 1986. The first map of the tectonic series was published in 1991 (table 2).

Table 2. Circum-Pacific maps, by year of publication

Year	Map
1977	Northeast Geographic
	Northwest Geographic
	Northeast Base
	Northwest Base
1978	Southwest Geographic
	Southeast Geographic
	Antarctica Geographic
	Southwest Base
	Southeast Base
	Antarctica Base
	Pacific Basin Geographic
	Pacific Basin Base
1981	Northeast Plate Tectonic (revised and reprinted 1982, 1986)
	Northwest Plate Tectonic (revised and reprinted 1982, 1987)
	Southeast Plate Tectonic (revised and reprinted 1982)
	Southwest Plate Tectonic (revised and reprinted 1982, 1986)
	Antarctica Plate Tectonic (revised and reprinted 1983)
1982	Pacific Basin Plate Tectonic (revised and reprinted 1983, 1985)
1983	Northeast Geologic
1984	Southeast Geodynamic
	Southwest Geodynamic
	Tectonostratigraphic Terranes
	Pacific Basin Manganese Nodule/Sediment
	Northwest Geodynamic
	Antarctica Geodynamic
	Pacific Basin Geodynamic
	Southeast Geologic
1985	Southeast Geodynamic
	Southwest Geodynamic
	Tectonostratigraphic Terranes
	Pacific Basin Manganese Nodule/Sediment
	Northwest Geodynamic
	Antarctica Geodynamic
	Pacific Basin Geodynamic
	Southeast Geologic

Year	Map
1986	Northeast Energy Resources
1988	Northwest Geologic Southwest Geologic Antarctica Geologic
1989	Arctic Base
1990	Arctic Geographic Arctic Geodynamic Pacific Basin Natural Hazard (revised and reprinted 1992)
1991	Southeast Energy Resources Southwest Tectonic
1992	Northwest Energy Resources

37. Preparation of eight 1:2,000,000 scale base maps for a basin evaluation/resources assessment study of South-east Asia was initiated in late 1983 in cooperation with the International Union of Geological Sciences (IUGS) and the Committee for Coordination of Joint Prospecting for Mineral Resources in Asian Offshore Areas (CCOP). Other regional mapping projects in Central and South America are in the planning stage.

38. Prior to 1990 all maps were published by the American Association of Petroleum Geologists. All maps are now published by the United States Geological Survey. Current status reports are available on request from Project headquarters. 1/

B. International Strategic Minerals Inventory (ISMI)

39. Earth-science and mineral-resource agencies from several countries started the International Strategic Minerals Inventory (ISMI) in 1981 in order cooperatively to gather information about major sources of strategic mineral raw materials. Officials of the Governments of Canada, Germany and the United States have participated in the programme since its inception; they were subsequently joined by officials from Australia, South Africa and the United Kingdom.

40. ISMI reports make publicly available, in convenient form, non-proprietary data and characteristics of major deposits of strategic mineral commodities for policy considerations in regard to short-term, medium-term and long-term world supply. (Because a mineral that is strategic to one country may not necessarily be strategic to another, no definitive list of strategic minerals can be prepared.) They provide summary statements of the data compiled and overviews

of supply aspects in a format designed to benefit policy analysts and geologists.

41. ISMI decided to begin with commodity studies on chromium, manganese, nickel, and phosphate. These studies, plus others on platinum-group metals, cobalt, titanium, graphite, lithium, tin, vanadium, and zirconium, have now been published. Additional studies on niobium (columbium) and tantalum, tungsten, and rare-earth oxides and yttrium have subsequently been undertaken. A regional survey of the strategic minerals of sub-Equatorial Africa has been published, and a survey on eastern Europe is under way.

42. Earth science agencies which have participated in ISMI's resource inventory compilation include the Bureau of Mines and the Geological Survey of the United States Department of the Interior; the Geological Survey of Canada and the Mineral Policy Sector of the Canadian Department of Energy, Mines and Resources; and the British Geological Survey, a component of the Natural Environment Research Council. Other ISMI participants include the Bureau of Resource Sciences of the Australian Department of Primary Industries and Energy; the Institute for Geosciences and Natural Resources of Germany; and the Geological Survey and Minerals Bureau of the Department of Mineral and Energy Affairs of South Africa.

C. United States Geological Survey (USGS)

43. The resource assessment activities undertaken by USGS assess the distribution, quantity, and quality of the mineral resources of the United States, particularly those on public lands, by studying the geology of known mineral occurrences and potentially mineralized areas; by developing and improving exploration techniques and mineral-occurrence models necessary in the continuing search for new deposits; and by enhancing knowledge and understanding of domestic and world resources of non-fuel minerals. Particular emphasis is placed on strategic and critical minerals, minerals that are largely or entirely imported and those that are necessary to the economy of the United States.

44. In recent years USGS conducted two national/regional mineral resource assessment programmes: the Alaska Mineral Resource Assessment Project (AMRAP), and the Conterminous United States Mineral Resource Assessment Project (CUSMAP). The objectives of these programmes are to provide a comprehensive modern assessment of identified and undiscovered mineral resources of the conterminous United States, Alaska, and United States territories in order to determine those areas that have significant mineral potential; to provide mineral resource information for planning the use of public lands; and to provide information on how resource-management decisions, land-use policy, Congressional actions, and state and local government planning will affect the country's total resource base. These objectives are met by a broad range of investigations that include compilation and synthesis of published mineral resource information on a statewide or multistate basis; specific topical or areal studies designed to satisfy statutory requirements related to wilderness suitability decisions or to aid in determining the siting and character of mineral resources; and multidisciplinary field studies by teams of geologists, geophysicists,

geochemists, and mineral economists to produce quantitative probabilistic mineral resource assessments on a regional basis.

45. In 1993 the Office of Mineral Resources (OMR) of USGS proposed to undertake a probabilistic quantitative assessment of the non-fuel mineral resources of the United States and its public lands. For the first time, a consistent, usable, minimum level of current mineral-resource information, together with estimates of total undiscovered mineral endowment, will be provided for the entire United States.

46. USGS proposes a seven-year plan to provide quantitative probabilistic estimates of the undiscovered non-fuel mineral resources of the United States and its public lands. This proposed assessment will provide an affordable, consistent, usable, minimum level of current mineral-resource information for the country as a whole.

47. The plan calls for a two-year preliminary national assessment, followed by an iterative national assessment recurring about every five years. The two-year preliminary assessment, serving as a springboard, will consider a limited number of types of deposit based on existing data. The report of this preliminary effort will include maps showing the outlines of tracts that are permissive for the types of deposits considered and a broad description of the basis for the delineation of the tracts. Tables will list the deposit types assessed, the identified resources, estimates of numbers of undiscovered deposits, and a summary of quantities of estimated undiscovered mineral resources. Maps will be provided to land-management agencies and resource-planning organizations in paper and digital formats at whatever scales they request for use in land- and resource-planning and decision-making. USGS scientists will visit these users to identify their future planning needs.

48. The proposed plan also will focus on the following important mineral-resource issues:

(a) First-time mineral-resource assessments of terranes favourable for the occurrence of concealed mineral deposits, in part through expansion of existing USGS activities for developing specialized geochemical and geophysical exploration technologies and concepts;

(b) Completion, testing, and preliminary application of technology that will permit quantitative probabilistic assessments of industrial mineral resources within two years;

(c) New emphasis on assessment of terranes favourable for the occurrence of unconventional mineral deposits only recently discovered in geological formations traditionally thought to have little or no value for minerals.

49. The methodology for conducting a national mineral-resource assessment is complementary and similar to the play-analysis methodology recently used to conduct the national petroleum assessment. Both national assessments will be closely coordinated and share collection responsibilities for data common to their activities.

50. The technology and the methodology for conducting quantitative, probabilistic mineral-resource assessments have, for the most part, been developed by USGS. The proposed seven-year plan will apply those techniques and methods systematically for the first time to a national mineral-resource assessment. The methodology consists of a highly integrated, systematic procedure that relies on descriptive geological occurrence models and grade-tonnage models assembled by USGS for a large number of types of mineral deposits world wide. Geologists who possess firsthand knowledge of the geology of an area estimate the number of undiscovered deposits of each identified type of deposit within that area. The simulation programme, called MARK3, combines the estimates of the number of undiscovered deposits with the historical grades and tonnages of the deposits represented by the grade-tonnage models developed for each type of deposit to produce a probability distribution of the quantities of contained mineral commodities. In generating the probability distributions, particular attention is given to the dependencies between grades and tonnages of deposits and among grades of different mineral commodities in the same type of deposit. In this way, geologists' knowledge is made available to economists and decision makers in a form readily adaptable to further analysis.

1. Alaska Mineral Resource Assessment Programme (AMRAP)

51. AMRAP studies are conducted at four progressively more detailed levels to produce comprehensive assessments of the mineral and energy resources of the state of Alaska, United States. Level-I studies are state-wide in scope, and published maps are generally at a scale of 1:2,500,000. No level-I studies are being pursued at this time.

52. Level-II studies address large parts of the state, and the resultant maps are generally published at a scale of 1:1,000,000. Level-II studies of geology and mineral resource potential are ongoing on the Alaska Peninsula and in the eastern Alaska Range.

53. Level-III studies consist of multidisciplinary evaluations involving team studies of selected 1:250,000-scale quadrangles; these continue to be the primary focus of AMRAP.

54. Level-IV studies consist of detailed mapping (1:63,360 or larger scale) and sampling of individual mineral deposits or mining districts and related research. Ongoing Level-IV activities in Alaska include geochemical studies of massive sulfide deposits in mafic volcanic rocks of the Chugach and Prince William terranes, a study of turbidite-hosted lode gold in the Seldovia quadrangle, and metamorphic and structural studies in the central and western Brooks Range.

55. Major reports published recently as a result of AMRAP and related mineral resource projects include a comprehensive study of the gold placers of the Circle District; lithologic and tectonic controls on mercury mineralization in the Bethel quadrangle; and undiscovered mineral resources of the Tongass National Forest, in south-east Alaska.

56. The results of field and laboratory studies during 1990 on mineral and energy resources and the geology of Alaska have been published by USGS.

D. Canada

57. In Canada a comprehensive Mineral and Energy Resource Assessment (MERA) programme has been in place since 1980 as a mechanism for implementing the federal governmental policy on the non-renewable natural resource potential of areas in the Yukon and Northwest Territories prior to their formal establishment as new national parks. The programme's objectives include:

(a) Ensuring that the economic and strategic significance of mineral resource potential is duly considered in the national park establishment process in the Yukon and Northwest Territories;

(b) Ensuring that, in making recommendations regarding the withdrawal of land for parks purposes, the Minister of Indian Affairs and Northern Development is advised on the balance between the values of the land with respect to park establishment criteria and the potential for the exploration, development and use of mineral and energy resources which the land may possess;

(c) Preparing an assessment of the mineral-resource potential of areas in the Yukon and Northwest Territories which are being considered for administration by Canada as a national park.

58. The reasons for mineral-resource assessments have been varied, but most assessments have been in response to outside requests from other governmental agencies. Areally limited resource assessments in Canada north of latitude 60° have most frequently been related to requirements for the land claim negotiations of native peoples and to the proposed establishment of northern national parks. Less frequently, the motivations stem from the development of other northern policies, including guidelines for exploration, wilderness assessment, and pipeline and transportation development. Future requests may arise more frequently as a result of land settlements of native peoples.

59. The principal method of resource assessment used for the MERA programme is integrated synthesis. It consists of two phases of activity over a time-frame of 18-30 months. The phase-1 activity (6-12 months) consists primarily of an analysis of the existing data including definition of the study area; establishment of geologic domains; compilation of geology from existing sources and inventory and appraisal of mineral and energy resources within the study area, using the available information base, with emphasis on metallic commodities and hydrocarbons; and application of conceptual deposit models to the study area followed by a qualitative assessment of resource potential.

60. Phase 2 can be more varied than phase 1, incorporating one or more additional aspects. New information can be collected by means of new bedrock mapping, new surficial mapping, geobotanical studies, remote-sensing studies, paleontological studies, stratigraphic studies, and exploration geochemical studies. Phase 1 can be combined with phase 2 if time is short or if the existing database is extremely limited.

61. The MERA programme recognizes and accommodates the need for continuing reassessments of areas evaluated. Mineral resource assessment studies cover what is known about the geologic framework of the area being assessed (synthesis of available geologic data) and knowledge of deposit models. The more that is known about the geology of the area being assessed, the greater the confidence in the resulting synthesis. The geologic synthesis, in turn, places constraints on the variety of types of deposit that might be expected to occur in the area under study. Because large parts of northern Canada have received only reconnaissance-level geologic investigation, only low-confidence geologic syntheses are available for several areas requiring resource assessment statements. Statements of resource potential are, in turn, qualified by considerable uncertainty.

62. Future geologic mapping programmes in northern Canada will raise the level of the geologic database, and the confidence levels of the syntheses will, in turn, be raised. Future resource assessment studies in northern Canada thus should produce more confident statements of resource potential.

E. China

63. With its complex geology and huge land area (China ranks second after the Russian Federation in area), China is well-endowed in most major metallic, non-metallic and mineral fuel resources. However, with a population of more than 1,100 million, China’s mineral and energy allotment per capita is less than that of most other resource-rich countries. In addition, many of the deposits of non-fuel minerals are of poor quality or in remote locations, making them very costly and sometimes difficult to exploit.

64. All the mineral exploration activities in China are organized by the State, including airborne geophysical, geochemical and regional geological surveys, prospecting, detailed surveys, and exploration of solid-state minerals, petroleum, natural gas and groundwater, of different scales both on land and offshore. Financial support comes mainly from the State. Of the 1.1 million people engaged in geological exploration in China at present, nearly 400,000 belong to the Ministry of Geology and Mineral Resources (38.2 per cent of the total), and the rest belong to other, related ministries. There are more than 900 field geological exploration teams in the country, reporting to the Ministry of Geology and Mineral Resources (51.9 per cent), the Ministry of Energy Resources (21.8 per cent), the Ministry of Metallurgical Industry (8.6 per cent), China Nonferrous Metals Industry Corporation (12.0 per cent), the Ministry of Chemical Industry (2.6 per cent), the State Bureau of Building Materials Industry (2.8 per cent) and the Ministry of Light Industry (0.2 per cent).

65. There are different degrees of intensity of geological investigation in China. It was not until the end of 1985 that the Chinese Government undertook the first detailed and comprehensive nationwide survey of mineral and energy resources and mines. Experimental and small-scale studies were also conducted in 1984 and 1980. The 1985 survey was supervised by the State and involved such organs as the Ministry of Geology and Mineral Resources. It examined the number of mines and mineral and energy resources discovered in China, and the national

production, consumption, and employment levels. According to it and other surveys since, geologists in China have discovered more than 160 types of mineral and energy resources and have verified reserves of most types. These include five types of ferrous minerals, 20 types of non-ferrous and precious metallic minerals, 76 types of non-metallic and geothermal and groundwater minerals, and six types of mineral fuels. Mineral ores in China are found in over 200,000 locations, although distribution is fairly uneven due to the complicated and varied geological conditions.

66. The reserves of many types of mineral and energy resources in China are the largest in the world, and several minerals, including rare earths and tungsten, occur in an abundance that not only satisfies domestic demand but also allows for exports. China's mineral reserves can be considered relatively small in chromite, platinum-group metals, titanium (rutile), and zirconium. 2/

67. On average, there are more than 7,000 geological exploration projects in China every year. By the end of 1990, regional geological surveying at a scale of 1:1,000,000 was completed on land; that at a scale of 1:200,000 was completed on two thirds of the territory. The first round of nationwide mineral prospecting was completed. More than 200,000 deposits (occurrences) of various varieties of minerals were found, with 15,000 of them having proved reserves. More than 40,000 geological reports have been submitted, and the drilling of nearly 300 million metres has been completed (table 3).

Table 3. Major geologic maps and atlases of China, published 1989-1992 a/, b/

Title	Scale	Date	Remarks
Mineral Resources Map of China	1:5,000,000	1992	Set of 3 maps
Map Series of Geology and Geophysics of China Seas and Adjacent Areas	1:5,000,000	1992	Set of 9 maps
Landsat Images of China	1:6,000,000	1992	1 sheet
	1:4,000,000	1992	2 sheets
	1:2,500,000	1992	6 sheets
	1:500,000	1992	15 sheets
Progress in Geology of China	..	1992	93 papers
Mineral Deposits of China	..	1992	Volume 2
	..	1990	Volume 1
Stratigraphy and Paleontology of China	..	1991	Volume 1
Land Use Map of China	1:1,000,000	1991	Set of 64 maps

/...

Title	Scale	Date	Remarks
Atlas of Landsat Imagery of Main Active Fault Zones in China	..	1990	135 pages
Geological Map of China	1:5,000,000	1991	With explanatory text
Geological Hazard Type Map of China	1:5,000,000	1991	With explanatory text
Quarternary Geologic Map of China and Adjacent Sea Areas	1:2,500,000	1990	9 sheets with explanatory text
Quaternary Geology and Environment in China	..	1991	Volume 1
Loess Plateau	..	1991	374 colour plates and 19 maps
Geomorphologic Map of Huang-Huai-Hai Plain (North China Plain) in China	1:1,000,000	1990	1 map
Quaternary Map of Huang-Huai-Hai Plain in China Quaternary Lithofacies Paleogeographic Map of Huang-Huai-Hai Plain	1:1,000,000 and 1:2,000,000	1990	2 maps
Geological Map of Shenzhen	1:500,000	1989	1 map
Geological Map of Qinghai-Xizang (Tibet) Plateau and Adjacent Areas	1:1,500,000	1989	1 map
Plate Tectonic-Lithofacies Map of Xizang (Tibet)	1:1,500,000	1989	1 map

N/A Not applicable.

a/ Not necessarily complete.

b/ Maps and atlases are generally available and distributed by GEOCARTO International Centre, G.P.O. Box 4122, Hong Kong, Telephone: (852) 546-4262, Fax: (852) 559-3419.

68. Prospecting for mineral resources in Xinjiang Autonomous Region was one of 76 national major research projects during China's seventh five-year plan (1986-1990) and the biggest geological research effort in China to that date. After four years of prospecting, 25 non-ferrous mineralized belts were discovered in the northern part of Xinjiang. They contain gold, copper, nickel, lead, zinc, mercury, antimony and tin. There are also another 132 areas which are thought to have deposits of gold, copper, nickel, lead, aluminium, tin, mercury, antimony and other nonferrous metals. These deposits are located mainly to the south of the Altay and Tianshan mountains and in the Junggar basin.

69. China's eighth five-year plan promotes accelerating the pace of geological prospecting so as to ensure sufficient mineral reserves to facilitate continued economic growth. The recently announced 12-year exploration programme by China's Ministry of Geology and Mineral Resources emphasized that future prospecting activities will be shifted to the western part of the country since major energy and mineral resources in eastern and central China have already been mapped and are being mined. The massive 12-year geological exploration programme was initiated in 1989 by several Chinese governmental bodies and approved by the State Planning Commission. The 1989-2000 study is a joint effort by the Ministry of Metallurgical Industry, China National Nonferrous Metals Industry Corporation, the Ministry of Geology and Mineral Resources, and five other state agencies. The emphasis will be on a search for ores of aluminium, chromium, iron, lead and zinc, and manganese, and locating new deposits in the interior and western provinces of China. Exploration activities for industrial minerals required by China's chemical and construction industries will include phosphate, potash and soda ash.

70. As part of China's expanding efforts to search for and discover new mineral deposits, the Metal Mining Agency of Japan has recently signed an agreement with the China National Nonferrous Metal Industry Corporation to begin a six-year base and rare metals exploration and development project in south central China. The focus will be on the Western Yangtze Para Platform area, and the survey will cover some 150,000 km^2 in the Mian-Lue-Ning area of Shanxi Province and the Lu-Wa area of Yunnan. The potential for copper, lead, zinc, nickel and cobalt minerals is thought to be particularly promising. The survey began in September by examining existing data. Geological mapping, geophysical and geochemical surveying, drilling and underground exploration will be implemented in the subsequent years of the programme.

F. Former Soviet Union

71. As a means of attracting foreign investment into its mining industry, in 1989 the Government of the USSR released a list of 120 mineral deposits found throughout the country suitable for overseas investment. To coincide with the opening of the industry to foreign investors, the Government improved its geological information base by hiring the Robertson Group of the United Kingdom to undertake a joint cooperation project to produce a paleogeographic geological atlas of the shelf regions of Eurasia. The terms of the agreement were that the Geological Institute of the USSR Academy of Sciences (GINAS) would provide the company with geological maps and supporting technical data of the offshore and

adjacent onshore area of the Soviet Union. Those maps, compiled by a team of more than 100 Soviet geologists over the past seven years, are now being made available to the West for the first time.

72. Between 1990 and 1992, the Group used digital production techniques to prepare high quality colour maps and also assisted the Soviets in preparing a technical report to accompany the atlas. To complete the coastline coverage, GINAS gathered information from counterpart organizations in countries outside the USSR which border the Eurasia landmass, stretching from Japan, China and Viet Nam through India and the Mediterranean region. The project was valued at nearly $US 750,000, financed by oil and mining companies. The maps contain petroleum- and mineral-oriented geological information which can be used to identify which offshore and adjacent coastal areas are the most promising for development.

73. In 1991, following an agreement with the Soviet Ministry of Geology, the Robertson Group acquired for sale and distribution limited quantities of current geological and mineral maps of the Soviet Union, previously unavailable in the West. The maps have an English legend. Commodities shown include oil and gas, metallic minerals, industrial minerals, diamonds and gold.

74. With the dissolution of the Soviet Union in 1991, the business relationship between the British contractor and the Soviet Government disintegrated. Today, the Russian Committee on Ecology and Rational Use of Natural Resources has assumed much of the role of the former Soviet Ministry of Geology and, as such, has access to current geological maps of the former Soviet Union.

75. Since the former Soviet Government was anxious to improve its geological information base before the country dissolved, it began cooperating with geological surveys throughout Asia, notably with China. A 1991/92 memorandum of understanding on priorities in Sino-Soviet cooperation in the fields of geology and mineral resources was signed in Beijing in April 1991 between the geology ministries of the two countries. According to the document, China and the Soviet Union would begin geological cooperation in the border areas, exchanging scientific and technological information and new technology and materials.

76. Chinese oceanologists started working with Soviet geologists in 1991 in studies ranging from marine physics and geology to information exchange and instrument development. A five-year contract, the result of a bilateral agreement signed in September 1990 in Moscow, was drawn up. This Sino-Soviet cooperation was based on mutual interest in the study of the western part of the north Pacific, which both countries border in the east, and of the Kuroshio, a northward-moving warm current originating near the tropics. It had been separately reported that the former Soviet Union had planned to exploit manganese nodules on the Pacific Ocean floor to a depth of about 5 km.

77. Today, the Russian Federation is the largest country in the new Commonwealth of Independent States (CIS). Geologically complex, much of the former Soviet Union’s mineral abundance is to be found in Russia, and the newly independent State contains the largest mining industry in the world. In 1992, Russia was a major world producer of a variety of mineral and energy resources,

including aluminium, cement, copper, coal, diamonds, gold, iron ore, lead, manganese ore, natural gas, petroleum, tin, and zinc.

78. Explored, developed and assessed reserves of major minerals in Russia are estimated (using world prices) to be worth about $28.5 trillion. Altogether the figure is speculative, Russian leaders realize the importance of the country's mineral industry to long-term economic growth. A draft federal programme, released in 1993, outlines Russia's intention to ensure a reliable mineral resource base to the year 2000 and beyond. The basic principles for forming a reliable base are:

(a) Promoting accelerated development by applying advanced technologies to production and processing;

(b) Accelerating investment in the discovery and development of deposits;

(c) Quantifying and acknowledging the potential economic contribution of Russia's mineral industry in the year 2000 and 2010;

(d) Disassembling the State monopoly in geology and promoting the development of subsurface resources through a licensing procedure;

(e) Privatizing enterprises and reorganizing them into stock companies specializing in geological and geophysical services.

79. Clearly, the Geological Survey of Russia will face tremendous difficulties in promoting the discovery and development of mineral resources in the country during the next few years. The State budget is in disarray, and legal issues such as ownership rights are still uncertain. Regardless of these problems, however, the Russian Government will continue trying to attract foreign investment to assist in geological surveying activities and project development.

G. South Pacific Applied Geoscience Commission (SOPAC)

80. SOPAC is an independent, intergovernmental regional organization through which 12 island member countries have access to modern equipment and experienced marine scientists. SOPAC's work programme is determined by member country requests, with an emphasis on collecting information to assist with the management and development of the non-living resources of their coastal and offshore areas. The work programme is carried out by a technical secretariat based in Suva, Fiji, with a staff of about 50.

81. SOPAC was established in 1972 as the Committee for Coordination of Joint Prospecting for Mineral Resources in South Pacific Offshore Areas. In 1984, it changed its legal status to become an independent regional organization, changing its name to South Pacific Applied Geoscience Commission in 1989. Member countries are currently Australia, Cook Islands, Federated States of Micronesia, Fiji, Guam, Kiribati, Marshall Islands, New Caledonia (Associate), New Zealand, Papua New Guinea, Solomon Islands, Tonga, Tuvalu, Vanuatu, and Western Samoa. The Commission meets annually to review work completed and to plan future work projects requested by members.

82. SOPAC undertakes coastal surveys of geological processes and hazards; resource studies for environmental management and coastal development; assessment of hydrocarbon, wave-energy and marine mineral potential; coastal and seabed mapping; and training in geoscience. The work programme for a particular year depends on member country requests and the funding and expertise available to the secretariat at the time.

83. SOPAC is organized along programme lines, including the Coastal Programme (minerals, mapping, management, energy, and field support), Hydrocarbon and Offshore Programme (hydrocarbons, deepsea minerals, seabed mapping, and computer services), Onshore Programme (water resources and onshore geology), Training Programme, Information Programme, and Management Programme. Mineral resource assessment activities take place primarily within the Onshore Programme, which assists member countries with onshore geoscience investigations, including the assessment of geological hazards. According to SOPAC's 1992-1995 corporate plan, some of the Onshore Programme's action strategies will be to:

(a) Assist in geological mapping of urban centres in island member countries;

(b) Encourage and assist in the development of regional onshore mineral databases;

(c) Promote the mineral potential of onshore areas to industry;

(d) Assess sources of onshore aggregate resources;

(e) Develop Geographic Information System (GIS) capability at the secretariat.

84. Success in these action strategies will be measured according to the following performance indicators:

(a) Requests for assistance in geological mapping of urban centres in island member countries;

(b) Value and use of regional onshore mineral databases;

(c) Publication of promotional brochures on onshore mineral potential;

(d) Level of commercial interest in mineral potential;

(e) Increase in mineral exploration activities;

(f) Issuance of mining licenses;

(g) Identification of onshore aggregate resources;

(h) GIS capability developed at the secretariat.

85. According to the draft 1994 SOPAC work programme, the Onshore Programme will concentrate its efforts in 1994 on water resources and not on onshore

geological assessments. An estimated $315,000 will be spent for water resource activities in the 1993/94 fiscal year for preparation of a forward plan, technical assistance and establishment of a water resources unit at the SOPAC secretariat, transfer of technical skills to national staff to assist them in water resources assessment, and drilling workshops.

86. Key tasks in the 1993/94 onshore geology subprogramme of SOPAC include a regional hazard assessment and planning workshop and post-disaster mapping of the effects on the physical environment of natural disasters and advise on appropriate action, in response to special requests from member countries.

87. SOPAC's medium-term plan for 1995-1999 desegregates activities by nine "core programmes":

(a) Coastal protection and management;

(b) Economic minerals, aggregates and water development;

(c) Ocean energy resource development;

(d) Deep sea mineral resources;

(e) Petroleum resource assessments;

(f) Ocean mapping and monitoring;

(g) Human resource development;

(h) Data management resource;

(i) Information.

88. The economic minerals, aggregate and water core programme will account for nearly half of SOPAC's 1995-1999 budget. During the medium-term its primary goals will be to assist member countries to manage and develop their mineral, aggregate and water resources. SOPAC assesses precious and industrial mineral and water resources of the coastal zone of member countries. Systematic assessment of mineral resources is an important requirement for the region's future development. Currently, exploration for placer gold is under way on many of the volcanic islands in the region. During the next five years, gold, titanium-bearing minerals, chromium, and strategic minerals will be assessed.

89. Due to the construction of wharves, jetties, seawalls, buildings, airports, and landfill projects, tremendous pressure is already being placed on traditional sources of sand and aggregate such as beaches, reef-flats, and storm deposits. SOPAC will continue to assist each country to assess resource availability and requirements.

90. The economic minerals core programme will include four major projects:

(a) Project 1. Resource evaluation and investigation. The objectives will be to conduct regional and site-specific geoscientific field studies and economic evaluations to assess the resource potential; to promote the development of a regional capacity to conduct field investigations; to collect and maintain a usable database of mineral, aggregate and water resources; and to monitor international research and development relevant to mineral exploration and development. The results will be the identification and assessment of mineral, aggregate and water resources; production of bathymetry, seismic, geomorphology, resource maps and seabed profiles, high resolution aerial photographs, and interpretation of satellite images; advice on sustainable use of construction materials and water resources; promotion of mineral and aggregate resources to industry; and a usable database that will facilitate planning and coordination for the region;

(b) Project 2. Field support and equipment;

(c) Project 3. Legislation and policy;

(d) Project 4. Human resource development.

H. Economic and Social Commission for Asia and the Pacific (ESCAP)

91. ESCAP has been actively involved in the promotion of regional cooperation in mineral resources development and management and the activities during the biennium 1991-1993 focused on planned mineral resource exploration and development and responsible land-use, through training, exchange of information, technical advice and the strengthening of relevant national and regional institutions, and the preparation of reviews, studies and maps on geology and land-use, mineral resources and potential, mineral economics and trade; and advisory services in the formulation of national policies, strategies and programmes for the development of mineral resources and land-use, including the review of mining codes and related legislation and the promotion of foreign investment. The secretariat provided technical backstopping to intergovernmental organizations within the region such as CCOP/SOPAC, South-East Asia Tin Research Centre (SEATRAD), and the Indian Ocean Marine Affairs Cooperation (IOMAC). United Nations inter-agency coordination in the field of mineral resources is actively pursued. 3/

92. The systematic collection of regional knowledge on mineral resources has been one of the primary goals of the ESCAP secretariat. To that end the secretariat has assisted member countries since 1985 in the compilation of national atlases of mineral resources, and the countries covered so far are Bhutan, Lao People’s Democratic Republic, Malaysia, New Zealand, Nepal, Republic of Korea, Solomon Islands, Sri Lanka, and Viet Nam. Each atlas consists of an explanatory brochure in English with two atlas sheets - a geological map and a mineral resources map. The atlases provide an essential overview to international mining companies for assessing the geological potential for detailed exploration and investment in mining.

93. ESCAP initiated action in 1992 to establish a mineral information system under a regional project funded by the United Nations Development Programme (UNDP) on economic restructuring and international trade in the mineral

commodities, sector (RAS/89/027). The database was specifically designed for use by earth scientists, mining engineers and governmental policy makers. Collaboration with United Nations Conference on Trade and Development (UNCTAD) made possible incorporation of relevant sections of the UNCTAD Micas System, a computer-based commodity analysis and information system for world-wide distribution, now under development. The ESCAP database is now functional in six countries - namely, Bhutan, Nepal, Philippines, Sri Lanka, Thailand and Viet Nam - after two consultants installed the ESCAP-donated hardware and software and provided training to national staff in the use of the system.

94. To ensure the widest distribution of the ESCAP mineral information system, a workshop was held in Colombo, Sri Lanka, at the Institute of Computer Technology in July 1992. It was attended by representatives from Afghanistan, Bangladesh, Bhutan, China, India, Indonesia, Lao People’s Democratic Republic, Malaysia, Mongolia, Myanmar, Nepal, Pakistan, Papua New Guinea, Philippines, Sri Lanka, Thailand and Viet Nam.

95. The assessment of offshore minerals and construction materials within the maritime States of the Asia/Pacific region has also been given consideration. The secretariat strives to promote regional cooperation and provides assistance in training in the assessment, evaluation, development and management of offshore mineral resources. Assistance to member States in implementing the new regime of the sea established under the 1982 United Nations Convention on the Law of the Sea is being provided by the secretariat.

96. ESCAP has also initiated a project for digital compilation of geological and related thematic maps covering east and south-east Asia in collaboration with CCOP and the Geological Survey of Japan. The main objective of the project is to impart the technological state of the art and to integrate the geoscientific information system into an effective GIS system for storage and retrieval of relevant data. The project will involve a comprehensive compilation of multidisciplinary geoscientific data - both on-shore and offshore - and its systematic analysis and will be beneficial to regional geoscientists and investors on mineral resources development who have advanced information systems.

I. South America (Bolivia/Venezuela/USGS)

97. The United States Geological Survey (USGS) and the Bolivian Ministry of Mines and Metallurgy are currently running two cooperative projects to investigate mineral deposits in the high Bolivian Andes. USGS and the Ministry have also proposed a new cooperative investigation to evaluate, map, and spur the development of Bolivia’s abundant alluvial-gold deposits and their bedrock sources. USGS is also assisting Venezuela in its efforts to investigate and gain access to the mineral resource potential of that country.

1. Bolivia: mineral-resource assessment of the altiplano

98. The USGS, working cooperatively with the Ministry’s Servicio Geologico de Bolivia (GEOBOL), initiated in January 1990 a two-year assessment of the mineral

resources of the Bolivian altiplano and its western cordillera. The high Andean plateau area contains some of the world's most important deposits of gold, silver, and tin, and may yield rare, strategic and critical minerals.

99. The cooperative mineral-resource assessment will provide:

(a) Mineral-occurrence maps of both metallic and non-metallic minerals;

(b) Detailed geologic information on selected mineral deposits resulting from USGS field investigations. The information will include geologic maps, geochemistry, and geophysics;

(c) Assignment of the altiplano and western cordillera mineral occurrences to world mineral-deposit models. These will include geologic and grade and tonnage characteristics of the deposits;

(d) Estimates of the number of undiscovered mineral deposits within identified mineral domains.

100. The United States Bureau of Mines is assisting with a sensitivity analysis of the economics of the mining of the undiscovered mineral deposits, funded as follows: $1.35 million from the United States Trade and Development Program; $0.50 million from the United States Agency for International Development; and $0.15 million from the World Bank.

2. Venezuela: Mineral-resource investigation of the Guayana Shield

101. Since 1987 USGS has been assisting Mining Technics (TECMIN), the mineral exploration arm of the Venezuelan Corporation for the Development of Guayana (CVG), in its continuing cooperative exploration of south-eastern Venezuela's mineral resources.

102. USGS is assisting TECMIN in the reconnaissance geologic mapping and mineral-resource assessment of south-eastern Venezuela's rugged Guayana Shield. That largely unexplored jungle and river area - with tens of flat-summited mesas (tepuis) and hundreds of waterfalls (including Angel Falls, the world's highest) cascading from their tops - contains important deposits of gold, platinum, and diamonds and may yield rare and strategic minerals. The Government of Venezuela asked USGS to aid CVG in its search for potential undiscovered mineral deposits which might be leased for exploration and development. Two USGS mineral-resource geologists are stationed at CVG TECMIN offices in Venezuela. They are joined periodically by other USGS specialists who visit for several weeks to assist in the geologic mapping and mineral-resource assessment of the difficult and dangerous terrain and to strengthen CVG's technical capabilities through on-the-job and short-course staff training and facilities enhancement.

VI. USEFULNESS OF RESOURCE ASSESSMENT PROGRAMMES

103. An important concern of development planners (generally economists, rarely geologists) is deciding how much money to spend on gathering information on mineral resources. Most geologists will argue that more information is better; however, from an economic perspective, more information is not always better. Expenditures for obtaining resource information should continue as long as an additional unit of expenditure is expected to generate one or more units of benefits (benefits and costs discounted to the present).

104. One practical solution to the costs versus benefits dilemma is to link most mineral-resource assessment activities to policy issues in which decisions can be influenced by assessment data. This allows Governments to select resource assessment programmes that can provide the required level and quality of information at minimum cost. Ten policy issues that are influenced by resource assessment data are:

(a) Ranking resource projects;

(b) Regional development planning;

(c) Diversification of regional economic and political power;

(d) Attracting investment;

(e) Establishing the terms of development of mineral deposits;

(f) Reservation of land areas;

(g) Designing resource processing plants;

(h) Diversification of commodity exports;

(i) Depletion rate of resources;

(j) Efficiency in resource development.

105. Another problem is that the current understanding of the geologic parameters controlling the size, grade, and distribution of mineral resources is incomplete. No model can be constructed to predict these physical characteristics accurately. Therefore, resource estimates for undiscovered mineral resources are subject to a relatively wide margin of error. To be effective in development planning, the degree of uncertainty associated with estimates must be considered.

106. Resource assessment information, gathered without consideration of the specific policy decisions that might be influenced by the data, may not be used, regardless of the quality of the assessment. This may partially explain why so much of the mineral resource information gathered in developing countries is never used to make any substantive policy decisions. Despite the inherent errors in resource assessment methodologies, planners and policy makers can more effectively establish long-term development strategies for a country by

considering estimates of the economic potential of discovered and undiscovered mineral resources.

107. The Department for Development Support and Management Services of the United Nations Secretariat has not hitherto engaged in the sort of regional resource assessment work described in this report. However, in the course of its technical assistance activities, the Department has participated in the creation of a number of national mineral inventories and geo-databases. The information and expertise developed during the execution of these projects could readily be applied to a coherent mineral-resource assessment programme managed by the United Nations and designed to unite and standardize current independent and regional initiatives, and thereby assist international trade and planning.

Notes

1/ 345 Middlefield Road, Menlo Park, CA 94025, United States of America.

2/ Mineral reserves in China are classified according to criteria which were drawn up by the National Mineral Reserves Committee in 1959. According to the scheme, mineral reserves are "industrial" or "non-industrial", or "prospective".

3/ Technical cooperation activities in the mining sector are described in E/C.7/1994/3.
