

USGS Mineral Resources Program

The Global Mineral Resource Assessment Project

Introduction

All nations continually face decisions involving the supply and utilization of raw materials, substitution of one resource for another, competing land uses, and the environmental consequences of resource development. Global use of mineral resources will continue to increase for the foreseeable future because of the continuing increase in global population and the efforts to improve living standards worldwide. In today's global economy, a nation's economic security depends on access to adequate mineral resource supplies from a variety of domestic and international sources.

No global shortages of nonfuel mineral resources are expected in the near future; however, the growing demand for mineral resources requires continued exploration and development of as-yet-undiscovered mineral deposits. Informed planning and decisions concerning sustainable resource development require a long-term global perspective and an integrated approach to land-use, resource, and environmental management. This integrated approach, in turn, requires that unbiased information be available on the global distribution of identified and especially undiscovered mineral resources, the economic factors influencing their development, and the environmental consequences of their exploitation.



Figure 1. Bingham Canyon porphyry copper deposit, Utah. The pit is about 3 kilometers across and has produced nearly 12 million tons of copper since it opened in 1904. Photograph by Charles Cunningham, U.S. Geological Survey.

Focus of the Global Mineral Resource Assessment Project (GMRAP)

In response to the growing need for minerals information, the U.S. Geological Survey (USGS) is conducting a cooperative international project to assess the world's undiscovered nonfuel mineral resources, the Global Mineral Resource Assessment Project (GMRAP). GMRAP is a research project to develop and test methods of assessing undiscovered mineral resources on land. The primary objectives of GMRAP are to outline the principal land areas in the world that have potential for selected undiscovered mineral resources and to estimate the probable amounts of those mineral resources to a depth of 1 kilometer below the Earth's surface.

Today, more than 70 chemical elements and dozens of minerals are mined and produced from more than 100 different deposit types and geologic environments. GMRAP researchers will begin by assessing a selected subset of commodities and the most significant deposit types for world minerals supply of these commodities. This restricted focus is designed to make the assessment effort manageable. Each assessment will enable researchers to improve assessment methods, geologic models, and understanding of mineral deposit formation.

The first three commodities for which global undiscovered resources will be assessed are copper, platinum-group metals, and potash:

- **Copper** was chosen because it is important in electronics and industrial applications, it is globally distributed, and its predictive geologic occurrence and grade-tonnage models are well defined. The deposit types to be assessed are porphyry copper (fig. 1) and sediment-hosted copper deposits, which together provide about 80 percent of the world's copper.
- **Platinum-group metals** were chosen because they have critical applications as catalysts in the automobile, chemical, and petroleum industries; because their supply is limited and extracting them is expensive; because only a few deposits are known globally; and because the grade-tonnage models need to be better defined.
- **Potash** was chosen because it is one of the three indispensable fertilizer minerals required for food production, because its predictive models need further development, and because assessment methods for industrial minerals require further testing.

In all, undiscovered resources of 8 commodities will be assessed during the 8 years of GMRAP:

Metals
 copper
 gold
 lead
 nickel
 platinum-group metals
 zinc

Industrial minerals
 phosphate (phosphorus source)
 potash (potassium source)

USGS Three-Part Form of Assessment

A quantitative form of resource assessment is required to express explicitly the degree of uncertainty associated with assessments and to allow economic analysis that can translate geology-based results into a format usable in decision-support systems and cost-benefit analysis. Quantitative assessment results are essential for the effective evaluation of the consequences of alternative resource-related decisions. The USGS has developed a three-part form of quantitative mineral

resource assessment to meet these goals (fig. 2). Three-part assessments consist of the following (Singer, 1993):

1. Delineating areas permissible for undiscovered mineral resources according to the types of deposits permitted by the geology
2. Estimating the number of undiscovered deposits of each type for each delineated area
3. Estimating the amount of resources contained in the undiscovered deposits by using appropriate ore characteristics and metal contents defined by worldwide grade and tonnage models

The three-part quantitative assessment results in internally consistent quantitative estimates of undiscovered mineral resources. The assessment results can be evaluated by using economic filters, cash-flow models, and other tools for application to economic, environmental, and policy analysis (fig. 2). The USGS is improving mineral deposit models and resource assessment methods (for example, Singer and others, 2001).

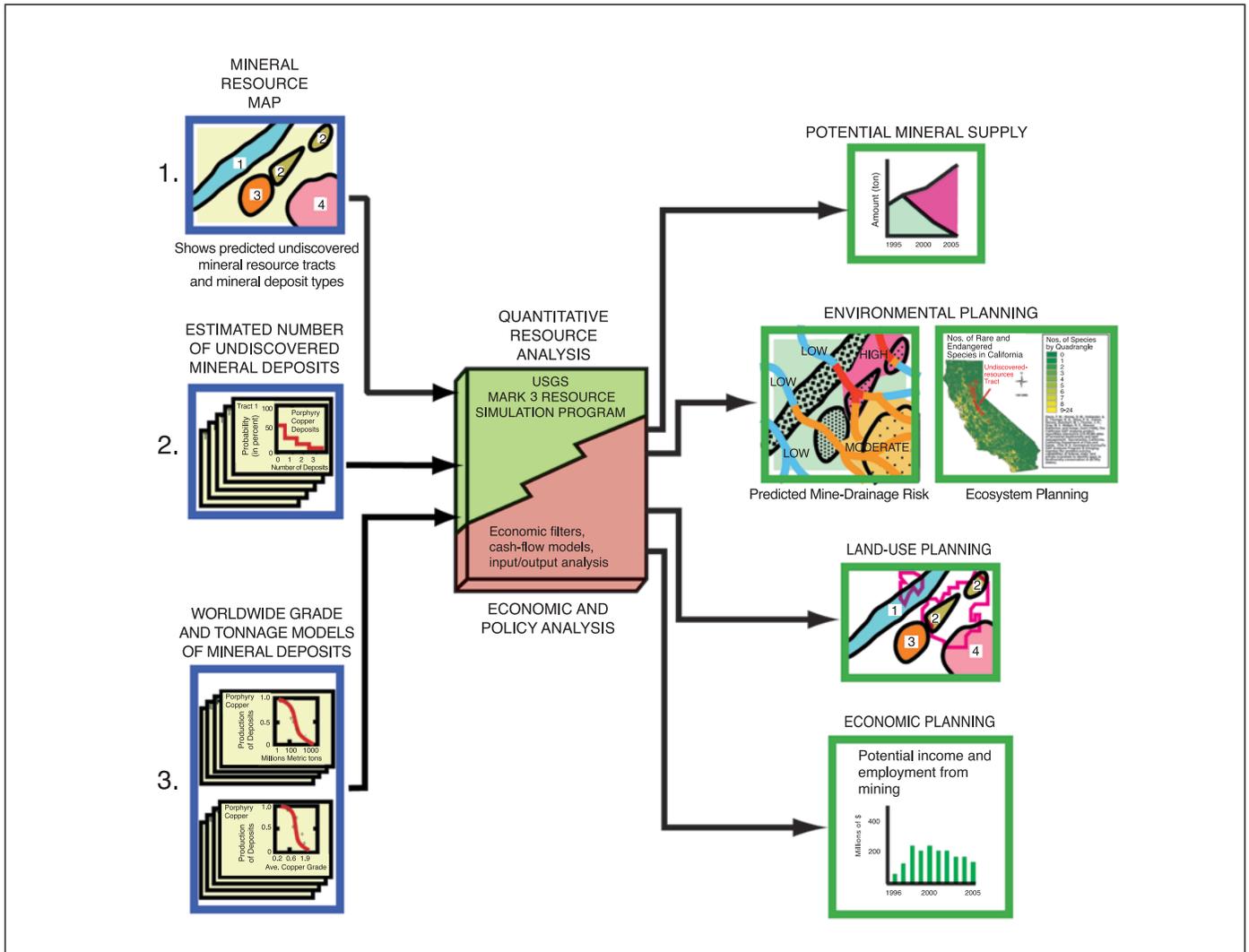


Figure 2. The U.S. Geological Survey's three-part form of quantitative mineral resource assessment. The three elements on the left show that geologic data are used to delineate areas permissible for undiscovered mineral resources, to estimate the number of undiscovered deposits, and to estimate the amount of resources that they contain. Resource, economic, and policy analysis tools are shown in the center of the figure. On the right are assessment results for the potential mineral supply and environmental, land-use, and economic planning.

Use of Global Mineral Resource Assessment Results

An example of how results from a global mineral resource assessment could be used to help evaluate trade-offs associated with minerals development is illustrated in figure 3, showing hypothetical mineral resource assessment tracts overlain on a map of global biodiversity. Mining in high latitudes, where biodiversity is low, such as in the tract in northern Canada, probably will have a smaller impact on biodiversity than mining in low latitudes where biodiversity is much greater, such as in the tract in central Africa. In addition, without mining, many of the high-latitude areas have little or no employment and infrastructure and, unlike in the tropics, subsistence farming is difficult or impossible.

On the other hand, disturbed ecosystems in high latitudes would likely require a longer time to recover from the effects of development than those at lower latitudes. Infrastructure development that follows mining into remote regions can disrupt sensitive habitats. In order to reduce habitat fragmentation in remote regions, information from

a global assessment could help efforts to encourage mineral exploration and development in identified regions of mineral potential where infrastructure already exists.

GMRAP Schedule

GMRAP is currently an 8-year project begun in 2002. The first priority for the project has been identifying and formalizing relations with cooperators from countries and multinational organizations in seven designated assessment regions (fig. 4). In addition, reports are being written containing overviews of regional geology, recent exploration, significant known mines and mineral resources, major past and current production, and supply-demand relations. GMRAP researchers aim to complete compilation of available geologic information and creation of databases of known mineral deposits and exploration history for each region by the mid-point of the project. Subsequently, assessments for undiscovered copper, gold, lead, nickel, platinum-group metals, zinc, phosphate, and potash will be completed; the results will be published for each commodity as completed in digital, Web-based, and paper formats, as appropriate.

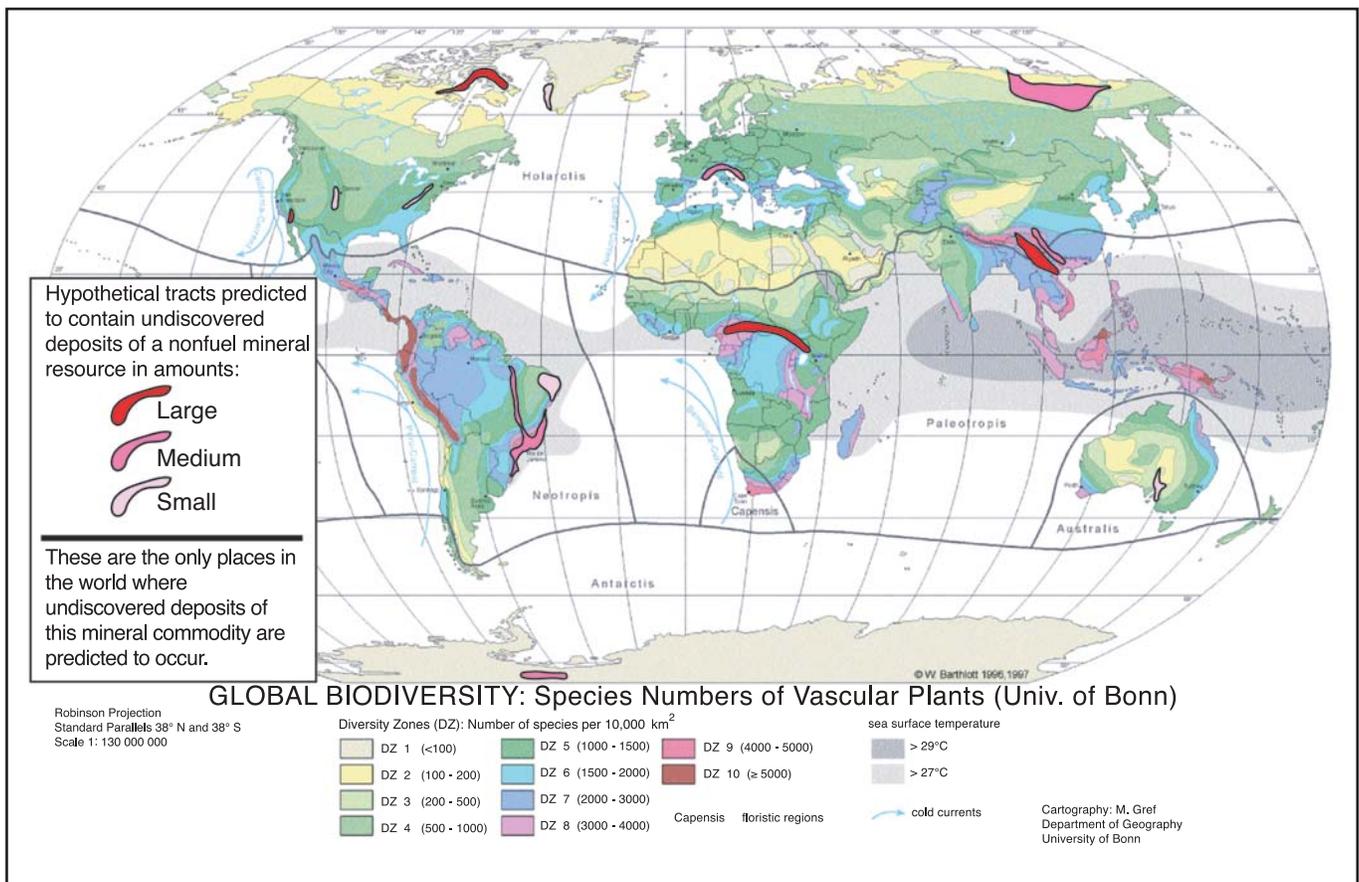


Figure 3. A conceptual global assessment in which tracts predicted to contain undiscovered deposits of a hypothetical nonfuel mineral resource are shown overlying a map of species diversity for vascular plants. The base map of biodiversity is online at <http://www.botanik.uni-bonn.de/biodiv/phytodiv.htm> and is modified from Barthlott and others (1999).

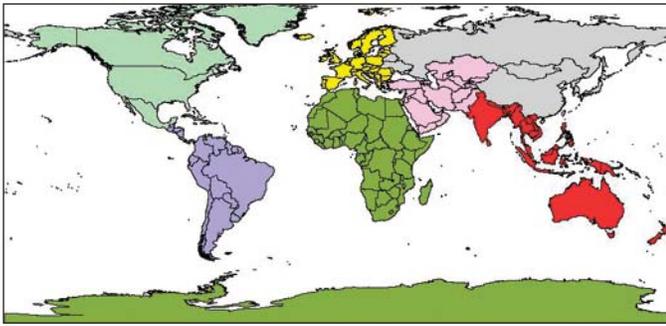


Figure 4. The seven assessment regions for the Global Mineral Resource Assessment Project (GMRAP) are shown by different colors.

A Cooperative International Project

GMRAP is being conducted on a regional, multinational basis with the cooperative participation of interested national and international geologic, mineral resource, and other institutions (see box). All assessment products will be published by the USGS in conjunction with the international cooperators.

The USGS role also includes the following:

- Coordinating the global assessment
- Facilitating workshops and working group meetings
- Compiling regional products into a global mineral resource assessment
- Analyzing assessment results with regard to regional and global resource, land-use, and environmental issues
- Leading quantitative probabilistic estimation of undiscovered nonfuel mineral deposits

The role of international cooperators includes the following:

- Providing access to and translation of existing geologic maps at appropriate assessment scales (1:1,000,000 or smaller). Emphasis will be on establishing regional consistency in geologic interpretation and on estimating the extent of buried geologic units permissive for undiscovered mineral deposits.
- Contributing to development of databases of current information on the location, sizes, and geologic types of significant known mineral deposits and occurrences
- Providing information about regional mineral exploration history
- Reviewing quantitative mineral resource assessment products
- Assisting in the analysis of assessment results

Conclusion

GMRAP will provide a consistent, comprehensive level of information and analysis of global nonfuel mineral resources based on the newest data available. The assessment results will provide all nations with a regional and global context for—

- Evaluating their known and undiscovered nonfuel mineral resources
- Designing new mineral exploration
- Planning sustainable resource development
- Anticipating environmental problems
- Making land-use decisions

Some Major GMRAP Cooperators

- Asociación de Servicios Geológicos y Mineros de Ibero América (represents geological surveys of South America)
- Bureau de Recherches Géologiques et Minières (BRGM), France
- Centre for Russian and Central Asian Mineral Studies (CERCAMS), Natural History Museum, London
- China Academy of Geological Sciences
- China Geological Survey
- Coordinating Committee for Geoscience Programmes in East and Southeast Asia (CCOP) (represents geological surveys of Cambodia, China, Indonesia, Japan, Malaysia, Papua New Guinea, The Philippines, Republic of Korea, Singapore, Thailand, Vietnam)
- General Directorate of Mineral Research and Exploration (MTA), Republic of Turkey
- Geological Institute of the Academy of Sciences, Republic of Georgia
- Geological Survey of Canada
- Geological Survey of Japan (part of the National Institute of Advanced Industrial Science and Technology, AIST)
- Institute of Geology and Mineral Resources (IGMR), Mongolian Academy of Sciences
- Instituto Geológico Minero y Metalúrgico (INGEMMET), Peru
- International Union of Geological Sciences and UNESCO Deposit Modeling Program
- Korea Institute of Geoscience and Mineral Resources
- Russian Academy of Sciences
- Servicio Nacional de Geología y Minería (SERNAGEOMIN), Chile
- Society of Economic Geologists
- University of Arizona

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