

BOARD ON EARTH SCIENCES AND RESOURCES AND ITS
ACTIVITIES

Annual Report
October 1, 1998-September 30, 1999

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THE NATIONAL ACADEMIES
Commission on Geosciences, Environment, and Resources

**BOARD ON EARTH SCIENCES AND RESOURCES
AND ITS ACTIVITIES**

Annual Technical Progress Report to the U.S. Department of Energy's National Petroleum
Technology Office, 1998-1999

This 1999 annual report of the activities of the National Research Council's (NRC) Board on Earth Sciences and Resources (BESR) begins with an introduction to the Board. The report then (1) lists activities of the Board sustained by Department of Energy support, (2) presents accomplishments of the Board, (3) describes current and proposed studies of the Board, and (4) provides a brief review of the Board's future plans.

INTRODUCTION

The BESR was established in 1988 to serve as a focal point for the solid-earth and geography communities for policy issues related to the solid earth sciences, spatial representation, and data (Table 1). In this multidisciplinary role, the Board provides counsel through its committees of volunteer professionals drawn from academia, industry, and government. Many of the activities of the Board reflect requests from the federal government for information on specific technical issues. Other activities are initiated by the Board. The purpose of self-initiated activities is to enhance the health of the earth sciences and to present new challenges to the community. The Board strives to provide accurate and timely input that can be used for wise decision-making by preparing reports and sponsoring workshops, symposia, and forums.

Table 1. Examples of Issues Addressed by the Board on Earth Sciences and Resources

- Identifying the Frontiers of Basic and Applied Research in the Geosciences
- Improving Scientific Understanding of Natural Hazards
- Assessing the Nation's Mineral and Energy Resources
- Evaluating Research Programs of Federal Agencies
- Improving Access to Scientific and Geospatial Data and Information
- Reporting on Breakthrough Technologies for Mitigating Environmental Problems
- Strengthening Multidisciplinary Programs and Integrated Approaches to Research in the Geosciences and Geography
- Enhancing Earth Science and Geography Education

The continuing committees of the Board and their areas of oversight are:

- Committee on Seismology (seismology related to research, hazards, and nuclear test ban verification);
- Geodynamics Committee (solid-earth science issues, research, and applications of geodesy);
- Committee on Geophysical and Environmental Data (national and international data policies, data and information systems, and data centers);
- Committee on Earth Resources (national energy and mineral resource issues);
- National Committee for Rock Mechanics (national and international activities in rock mechanics including geoengineering);
- Mapping Science Committee (spatial data handling and analysis issues; continued development of the National Spatial Data Infrastructure); and
- Committee on Geography (spatial representation; issues related to environmental dynamics, environmental/societal dynamics, human/social dynamics; issues related to integration in place, interdependencies between places, and interdependencies among scales).

Additional ad hoc committees and panels are formed to address specific topics. Current ad hoc activities include:

- Basic Research Opportunities in the Earth Sciences at the National Science Foundation;
- Future Roles, Challenges, and Opportunities for the U.S. Geological Survey;
- Review of the U.S. Geological Survey's Volcano Hazards Program;
- Conceptual Models of Flow and Transport in the Fractured Vadose Zone;
- To Live on a Restless Earth: The Challenge of Earthquake Science; and
- Seeing into the Earth—Noninvasive Characterization of the Shallow Subsurface for Environmental and Engineering Applications.

The Board coordinates U.S. activities for certain international activities:

- The Committee on Geography serves as the U.S. National Committee for the International Geographical Union, which operates under the International Council of Science (ICSU).
- The U.S. Geodynamics Committee serves as the U.S. National Committee to the International Lithosphere Program, which was established by ICSU.
- The U.S. National Committee for Rock Mechanics coordinates U.S. activities for the International Society for Rock Mechanics.
- The Committee on Geophysical and Environmental Data serves as the U.S. Coordination Office for the U.S. portion of the World Data Center system.

The Board also assists the NRC's Office of International Affairs with regard to three other U.S. National Committees that adhere to ICSU—International Union for Geodesy and Geophysics, International Union of Geological Sciences, and the International Union for Quaternary Research.

In addition to study and coordination functions, the Board and its standing committees serve as forums for discussions and exchange of information among scientists, engineers, and policy makers from government, universities, and industry. To facilitate discussions on specific topics, the Board works in conjunction with other organizations to organize and convene a series of forums for presidents and executive directors of geoscience societies. For example, the Board co-sponsored a forum in November 1998 to commemorate the 50th anniversary of the formation of the American Geological Institute (AGI), which was established under the auspices of the National Research Council. During the past 50 years, AGI has grown to become a federation of 32 national geoscientific and professional organizations. The forum examined the evolving role of a federation of geoscience organizations. It involved members of BESR; liaisons with federal geoscience agencies; presidents, executive directors, or representatives of geoscience societies; and other leaders of the geoscience community. More recently, the Board co-sponsored a public symposium in June 1999 on the topic of hazards and resources in the new century.

BOARD ACTIVITIES SUPPORTED BY THE DOE/NPTO

DOE/NPTO funding for the Board during the reporting period provided partial support for:

- two meetings of the Executive Committee of the Board;
- two meetings of the Board;
- two meetings of the Committee on Earth Resources;
- strategic planning, project development, oversight, and dissemination activities of the Board; and
- one forum and one symposium on topics of interest to the earth science communities.

ACCOMPLISHMENTS OF THE BOARD DURING THE REPORTING PERIOD

The Board released four reports during the reporting period. Annotated descriptions of reports published over the past year follow:

Review of NASA's Distributed Active Archive Centers

[National Academy Press, December 1998, 233 pp.]

[Committee on Geophysical and Environmental Data]

The ultimate success of NASA's Earth Observing System Data and Information System (EOSDIS) depends on the ability of scientists and other users to obtain data and information easily and in usable forms. Access to the data and information products is provided by seven Distributed Active Archive Centers (DAACs), each of which manages a different kind of scientific data and serves a unique blend of users. Review of NASA's Distributed Active Archive Centers focuses on how well the DAACs are serving their users, their readiness for launch of the Earth Observing System satellites, and NASA's overall management of the program. The report concludes that each DAAC has an essential and individual role in some part

of the scientific enterprise, with little overlap or redundancy. Given the uncertainties associated with the information system that links them, those affected by the near-term launch of the EOS AM-1 platform (a satellite with a 10:00 a.m. sun-synchronous orbit and a large number of instruments) are reasonably placed to address the challenges entailed by the launch. However, for the DAACs effectively to fulfill the expectations for them, EOSDIS will need inspired leadership to create a practical network of information centers that truly enables scientific discovery and assessment.

Meeting U.S. Energy Resource Needs: The Energy Resources Program of the U.S. Geological Survey

[National Academy Press, January 1999, 68 pp.]

[Ad hoc committee]

Adequate and reliable supplies of affordable energy, obtained in an environmentally responsible manner, are vital for economic prosperity, environmental quality, and national security. The Energy Resources Program of the U.S. Geological Survey conducts energy resource and related environmental research within the context of oil, gas, and coal investigations and assessments nationally and internationally. This research, which involves the use of digital databases and geographic information systems (GISs), is important for shaping policies about domestic and foreign energy resources, for making wise land-use decisions, and for maintaining a healthy energy industry. *Meeting U.S. Energy Resource Needs: The Energy Resources Program of the U.S. Geological Survey* provides a comprehensive evaluation of the program and recommendations for its future activities.

Distributed Geolibraries: Spatial Information Resources

[National Academy Press, May 1999, 119 pp.]

[Ad hoc committee]

Many types of information refer to specific places on the Earth's surface. They include reports about the environmental status of regions, photographs of landscapes, images of Earth from space, guidebooks to major cities, municipal plans, and even sounds and pieces of music. All of these are examples of information that has some form of geographic footprint. A geolibrary is a library filled with georeferenced information. The development of geolibraries could have a profound and lasting impact on future access to information. Information is found and retrieved by matching the area for which information is needed with the footprints of items in the library, and by matching other requirements—but the footprints always provide the primary basis of search. The report developed a vision of geolibraries for organizing information resources using spatial reference and search mechanisms, and identified the research and policy issues associated with the development of distributed geolibraries.

Hardrock Mining on Federal Lands

[National Academy Press, September 1999, 249 pp.]

[Ad Hoc Committee]

This report responds to a request by Congress that the National Research Council assess the adequacy of the regulatory framework for hardrock mining on federal lands. The regulatory framework applies to hardrock (locatable) minerals—such as gold, silver, copper, and uranium—on over 350 million acres of federal lands in the western United States. To conduct the study, the National Research Council appointed, under the auspices of the BESR, the Committee on Hardrock Mining on Federal Lands in January 1999. The charge to the Committee had three components. First, the Committee was asked to identify federal and state statutes and regulations applicable to environmental protection of federal lands in connection with mining activities. Second, the Committee was charged with considering the adequacy of statutes and regulations to prevent unnecessary or undue degradation of the federal lands. Third the Committee was asked for its recommendations to ensure environmental, increase efficiency, avoid duplication and delay, and identify the most cost-effective manner for implementation.

CURRENT AND PROPOSED STUDIES

Current and selected proposed studies of the Board and its committees are summarized below.

Standing Committees

Committee on Earth Resources

A separately appointed panel under the auspices of the Committee on Earth Resources completed a study entitled Meeting U.S. Energy Resource Needs: The Energy Resources Program of the U.S. Geological Survey (1999). The panel's report follows upon a similar program review on Mineral Resources and Society: A Review of the U.S. Geological Survey's Mineral Resource Surveys Program Plan (1996). In 1999, a panel under the auspices of the committee completed a study on Hardrock Mining on Federal Lands. The study assessed the adequacy of state and federal statutes and regulations affecting hardrock mining on federal lands that are intended to prevent unnecessary or undue degradation of federal lands. Members of the Committee on Earth Resources, who participated in a planning workshop on Material Flows of Resources, Products, and Residuals in the United States (1998), developed a prospectus for a study on material flows that is expected to be requested by the U.S. Geological Survey and supported by the Department of Energy and the Environmental Protection Agency. The committee also developed a prospectus for a study on Preserving the U.S. Geoscience Data Heritage that has been requested by the Department of Energy. Other issues that have been identified for possible study include: (1) gas hydrates; (2) carbon sequestration; (3) implications of the Kyoto Protocols on petroleum production; (4) the environmental feasibility of future domestic mining and milling operations; (5) scientific and technical issues associated with the reform of mining laws and regulations, such as an update of the 1987 NRC report of the Committee on Surface Mining and Regulation;

and (6) the appropriate federal role in research and information on mining and mineral processing.

Mapping Science Committee

The committee continues to provide a focus for discussion of nationwide mapping and spatial data issues; this involves close working relationships with the Federal Geographic Data Committee and the individual departments and agencies. The committee provides guidance on the development of a robust national spatial data infrastructure (NSDI) for making informed decisions at all levels of government and throughout society. A separately appointed panel under the auspices of the Mapping Science Committee conducted a study on Distributed Geolibraries: Spatial information Resources. A “geolibrary” is a digital library filled with georeferenced information, which is found and retrieved by matching the spatial footprints of items in the library (and other requirements). Presently, the committee is conducting a study, An Assessment of the Contribution of Federal-Community Partnerships to a Robust National Spatial Data Infrastructure. In 2000 the committee is expected to conduct an assessment of geographic information science—including education, human resources, research, and institutions.

Committee on Geophysical and Environmental Data

The Committee on Geophysical and Environmental Data (CGED) was established in 1967 to provide oversight to the U.S. portion of the World Data Center system (WDC-A). Although that function is maintained today, the committee has the broader role of providing advice to federal agencies and data centers on a wide variety of national and international data management issues and policies. In recent years, the committee has focused on the environmental data management concerns of the Data Management Working Group of the Subcommittee on Global Change Research, which operates under the federal Committee on Environment and Natural Resource within the White House Office of Science and Technology Policy. Members of the CGED are selected to represent the research areas of atmospheric, ocean, terrestrial, solid earth, and space science, but all collect, manage, or use large amounts of data. In the coming year, the CGED will undertake a study entitled What Commercialization Policies and Database Legislation Mean for Established Scientific Practices. It is also planning to review the World Data Center-A for Oceanography and the National Oceanographic Data Center. CGED staff also serves as Secretary of the Panel on World Data Centers of the International Council of Science (ICSU) and as Director of the Coordination Office of the WDC-A (United States).

Committee on Seismology

The Committee on Seismology (COS) has had the lead role in the ongoing study entitled To Live on a Restless Planet: The Challenge of Earthquake Science, which is a joint activity with the Board on Natural Disasters. This study is expected to be completed in 1999.

Geodynamics Committee

The U.S. Geodynamics Committee (USGC) fosters and encourages studies of the dynamic behavior of the Earth and continue to serve as the U.S. counterpart to the International Lithosphere Program. The committee has begun discussions of “grand challenges” in the broad field of geodynamics. These discussions are expected to lead to development of new activities.

National Committee for Rock Mechanics

The U.S. National Committee for Rock Mechanics (USNC/RM) provides for U.S. participation in international activities in rock mechanics, principally through adherence to the International Society for Rock Mechanics (ISRM). It participates in the work of ISRM commissions and plays a continuing role in a series of ISRM symposia. The USNC/RM also serves to define, initiate, and conduct sponsored studies and other activities with respect to major areas of national interest or concern in which rock mechanics problems represent critical or limiting factors. A separately appointed panel under the auspices of the USNC/RM is conducting a study on Conceptual Models of Fluid Infiltration in Fractured Media. The study will focus on the scale, complexity, and site specific conditions and processes that need to be determined in order to develop an appropriate conceptual infiltration model. It will build upon the committee's report Rock Fractures and Fluid Flow—Contemporary Understanding and Applications (1996). Other issues under consideration by the USNC/RM include: penetration of projectiles into rock masses; effects of regulations on innovation in the practice of rock mechanics related to mining, oil exploration and production, toxic waste disposal, or construction of underground facilities; carbon sequestration; and the status of hot dry rock technology in the geothermal industry.

Committee on Geography

The Committee on Geography (COG) acts as the U.S. National Committee for the International Geographical Union (IGU) and advises the President of the National Academy of Sciences on all matters relating to geography. The committee's statement of task is to undertake initiatives on behalf of U.S. geography, government agencies and programs, as well as serve the IGU. The Committee on Geography plans to make federal stakeholders aware of the existence of the committee as a source that can serve as an adviser on matters of importance pertinent to geography. Currently, it is developing studies on: (1) Learning to Think Spatially: The Incorporation of Geographic Information Science Across the K-12 Curriculum; (2) Places of Prosperity, Places of Risk: Geographical Inequalities in Livelihood Chances; (3) Identifying Data Needs for Place-Based Decision Making, and (5) A Framework for Place-Based Planning and Design. In addition, the committee plans and implements U.S. participation in the programs of the IGU. It promotes national and international cooperation in geographical activities. The next IGU Congress will take place in Seoul, South Korea, in 2000.

Examples of Studies in Progress

Future Roles, Challenges, and Opportunities for the U.S. Geological Survey

[Ad Hoc Committee]

At the request of the U.S. Geological Survey (USGS), the NRC is conducting a study on Future Roles, Challenges, and Opportunities for the U.S. Geological Survey. The USGS is at a critical juncture in its history. To better serve national needs, the USGS is arraying its programs under four major themes—environment, resources, hazards, and integrated data and information management. The consolidation of the National Biological Service and portions of the former U.S. Bureau of Mines with the USGS has created a broader and more comprehensive organization. Using the USGS Strategic Plan 1996-2005 and the science plans of the four

divisions as a starting point for its effort, the NRC will critically assess the roles that should be fulfilled by the USGS into the 21st century.

Review of the Volcano Hazards Program of the U.S. Geological Survey

[Ad Hoc Committee]

At the request of the U.S. Geological Survey, a study is being conducted to examine (1) whether activities, priorities, and expertise of the program meet appropriate scientific goals of the U.S. Geological Survey's Volcano Hazards Program (VHP), and (2) whether scientific investigations and research results throughout the program are effectively integrated and applied to achieve hazard mitigation. The broad purpose of this comprehensive review is to provide fresh perspective and guidance to the VHP about the future directions of the program.

Basic Research Opportunities in the Earth Sciences at the National Science Foundation

[Ad Hoc Committee]

At the request of the National Science Foundation (NSF), a study will be conducted to identify high priority research opportunities in the earth sciences as they relate to the responsibilities of the National Science Foundation's Division of Earth Sciences. The study will emphasize the connections between traditional solid-earth science disciplines (e.g., geophysics, geology, and geochemistry) and other disciplines (e.g., hydrology, biology, and oceanography). Research opportunities of interest to other government agencies, industry, and international partners may also be discussed, to the extent that they are germane to the responsibilities of NSF. Finally, linkages between research and societal needs will also be explored. To provide input to the study, the NRC and NSF convened symposia at the 1998 Geological Society of America and the fall American Geophysical Union meetings. In addition, the committee is soliciting comments from the broader earth science community through newsletter and bulletin board announcements.

Seeing Into the Earth: Noninvasive Characterization of the Shallow Subsurface for Environmental and Engineering Applications

[Ad Hoc Committee]

Knowledge of the nature of the subsurface is critical for a large set of environmental and engineering applications. In all cases, there is a need to "see into the earth," to determine physical, chemical, and biological properties and to detect, monitor, and predict natural and induced processes. The question addressed by this study is how can the shallow subsurface be noninvasively imaged and characterized to help decrease uncertainties about its nature. The study examines the various techniques, their applicability, and their possible improvements. The potential is high for these methods to define subsurface details with a level of accuracy, precision, economy, and safety that can exceed direct sampling. However, realizing this potential will require concerted and cooperative interdisciplinary efforts by earth scientists, geotechnologists, government agencies, and the user community.

Conceptual Models of Flow and Transport in the Fractured Vadose Zone

[National Committee for Rock Mechanics]

The purpose of the Panel is to study the process through which conceptual models of flow and transport in the fractured vadose zone are developed, tested, refined, and reviewed. The Panel will gather information by convening a two-day workshop during which specialists from the

hydrogeologic, geochemical, soil science, and related fields will present and discuss the current state of knowledge, lessons learned from field investigations, and needs for future research. The Panel will produce a consensus report of its findings and conclusions. A series of individually authored papers that were specifically prepared for and presented at the workshop will be appended to the report. The report is intended to (1) provide information on contemporary philosophies, approaches, and techniques for conceptual model building, (2) provide guidance to regulatory agencies on the review of conceptual models developed for site licensing, (3) bring together knowledge and experiences from related disciplines (for example, macropore flow in structured soils and fracture flow in rocks) so that technical communities can benefit from advances in related fields, and (4) identify future research needed to further the technical basis for developing and evaluating conceptual models of flow and transport in the fractured vadose zone.

To Live on a Restless Earth: The Challenge of Earthquake Science

[Ad Hoc Committee]

Earthquakes are agents of destruction that have stimulated human inquiry since ancient time, yet the scientific study of earthquakes is a surprisingly recent endeavor. Instrumental recordings of earthquakes were not made until the second half of the 19th century and the primary mechanism for generating seismic waves was not identified until the beginning of the twentieth. Since this late start, a range of laboratory, field, and theoretical investigations have emerged into a vigorous new discipline, the science of earthquakes. As a basic science, it seeks to provide a comprehensive understanding of earthquake behavior and related phenomena in the Earth and other terrestrial planets. As an applied science it is also of undeniable importance because it provides a knowledge base of great practical value to a global society whose infrastructure is built on the Earth's active crust. This report describes the growth and origins of earthquake science, and it identifies research and data collection efforts that will strengthen the scientific and social contributions from this new discipline.

THE EVOLUTION OF THE BOARD

In 1998-1999, the Board devoted considerable attention to its development. The Board believes that the earth sciences are at an exciting time in their evolution, and the stage may be set for the 21st century to be the century of the earth sciences. The Board, its committees, and staff are prepared to take full advantage of the challenge of an emerging earth science century by contributing more effectively to the broad concerns of science and society.

As a first step, the Board on Earth Sciences and Resources met in closed session at Woods Hole on April 18-19, 1999. The Board made the following decisions:

- Reduce the size of the board;
- Invite members of the board to resign if they fail to attend regularly;
- Formalize the liaison between the board and committees; the oversight function would kick in only when the committee gets in serious trouble;

- Merge and rename the committees on Seismology and Geodynamics. The merged committees on Seismology and Geodynamics will act as the U. S. National Committee on Geodynamics with regard to ICSU. Later this year, a statement of task will be crafted for the new committee. That statement will permit the committee to address all aspects of the dynamics of the earth, including polar issues and hazards;
- Measure the impact of studies of the board qualitatively or, better still, quantitatively;
- Endorse the continuation of the Committee on Geophysical and Environmental Data, Mapping Science Committee, Committee on Geography, Committee on Earth Resources, and U.S. Committee on Rock Mechanics as standing committees;
- Create a working group that will develop a proposal (including the identification of sources of funding) on K-21 education;
- Form a subcommittee on global change with special reference to the rock record;
- Develop a prospectus for a PIF workshop dealing with the interface between earth science and materials;
- Improve relations with the board's constituents on the Hill and in the agencies;
- Change the nature of board meetings;
- Develop a board that is much more active, much less reactive;
- Create a subcommittee for BESR strategic planning and developing terms of reference.

Most of the board meeting was devoted to the strategic planning process that will yield a strategic plan with a clear set of goals. As a result of this process, it is anticipated that the Board will become more proficient in:

- setting priorities for earth science research;
- identifying the role of the earth sciences in major policy issues; and
- supporting and assuring the quality of the science content in earth science and geography education.

By making significant progress in these areas, the BESR will help to build and sustain the earth sciences and their communities in the 21st century.

CURRENT MEMBERSHIP OF THE BOARD ON EARTH SCIENCES AND RESOURCES

J. Freeman Gilbert (Chair), University of California, San Diego
 John J. Amoroso, Amoroso Petroleum Company, Houston, Texas
 Paul B. Barton, Jr., U.S. Geological Survey (emeritus)
 Kenneth I. Daugherty, Geospatial Concepts, Inc., Falls Church, Virginia
 Barbara L. Dutrow, Louisiana State University, Baton Rouge
 Richard S. Fiske, Smithsonian Institution, Washington, D.C.
 James M. Funk, Shell Continental Companies (retired), Houston, Texas
 William L. Graf, Arizona State University, Tempe
 Raymond Jeanloz, University of California, Berkeley

Susan M. Kidwell, University of Chicago, Illinois
Susan Kieffer, Kieffer & Woo, Inc., Palgrave, Ontario
Pamela Luttrell, Mobil, Dallas, Texas
Alexandra Navrotsky, University of California, Davis
Dianne R. Nielson, Utah Department of Environmental Quality, Salt Lake City
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Edward M. Stolper, California Institute of Technology, Pasadena
John R. G. Townshend, University of Maryland, College Park
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