Geologic Mapping in the U.S. Geological Survey (1987)

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Preface

As a part of its continuing function of advising the Director and Chief Geologist, the Committee Advisory to the U.S. Geological Survey (USGS), at its meeting of January 10-11, 1985, created a Subcommittee on Geologic Mapping. The decision to form the subcommittee grew from the perceptions of the committee, based on program reviews, that there appeared to be no well-defined geologic mapping program direction in the USGS and that the rate and amount of geologic mapping appeared to be declining.

The subcommittee was charged to determine the status and extent of the geologic mapping program and activities in the USGS and to report back to the committee with a summary of findings and recommendations.

Dr. M. E. Ostrom (chairman), Dr. Priscilla Grew, and Professor Leon T. Silver served on the subcommittee. The subcommittee is grateful to Professor Allan Cox who filled in when Dr. Grew was unable to attend Regional meetings in Denver and Menlo Park. The full committee is responsible for the contents of this report.

Three meetings—in Reston, Denver, and Menlo Park—were held with representatives of the USGS offices of Regional Geology; Mineral Resources; Energy and Marine Geology; and Earthquakes, Volcanoes, and Engineering. Programs covered in these discussions included the following:

Office of Regional Geology
- Geologic Framework and Synthesis
- COGEOMAP
- Eastern, Central, and Western Geology Branch Programs
- Isotope Geology Program

Office of Mineral Resources
- Wilderness
- CUSMAP, AMRAP
- Strategic and Critical Minerals
- BLM Lands
- Eastern, Central, Western, and Alaskan Branch Programs

Office of Energy and Marine Geology
- Coal Resources
- Marine Geology, Pacific and Atlantic
- Oil & Gas Resources
- Energy and Minerals

Office of Earthquakes, Volcanoes, and Engineering
- Volcanic Hazards and Geothermal
- Engineering Seismology and Geology
- Engineering Geology and Tectonism
- Igneous and Geothermal Processes

The subcommittee sincerely appreciates the cooperation of the USGS, the Director and his staff, and particularly Drs. Eugene Roseboom, Benjamin Morgan, and Fred Miller who helped to coordinate the agenda and the various staff inputs. We quickly recognized that we are allies in our concern for the character and prospects for geologic mapping in the U.S. Geological Survey.

INTRODUCTION

A principal concern of the Committee Advisory to the U.S. Geological Survey (USGS) was that the activity that lends its name to both federal and state geological surveys appears to be declining in the federal survey. This is particularly disturbing because it is the committee's perception that the need for a vigorous geologic mapping program is great, although the extent of need has not been determined. In the most fundamental terms, the federal and state surveys were created to conduct geological surveys and to prepare maps and reports based on their findings. The initial objective was assessment of mineral resource potential. Today geologic maps—the fundamental geologic information—serve a significantly expanded role and are a principal guide to most human interactions with the Earth, including the environment, land use, energy and mineral resources, natural hazards, and water resources. However, less than 20 percent of the nation is mapped at the standard 1:24,000 scale.

Because of the constant acquisition of new information, changing concepts, changing technology, and evolving needs, geology is an unending subject of research; and geologic maps are subject to constant review and periodic revision.

For the purposes of program analysis, the committee defines geologic mapping as the preparation of a map from field surveys and other sources of information on which is recorded geologic information such as the distribution, nature and age of rock units, and the occurrence of structural features, mineral deposits, and fossil localities. As such, geologic maps present carefully and competently compiled and well organized geologic information of a basic and/or interpretive nature.

A geologic mapping program should be responsive to society's needs. Given that these needs have changed and will continue to change, it seems equally apparent that those responsible for geologic mapping should recognize the changing character of this "need" and that it be periodically reexamined and redefined. An NRC committee surveyed the mapping needs of the general geologic community; the final report is in preparation.

The principal elements of a geologic mapping program follow logically from a need and should include a clearly defined statement of mission and objectives, a listing of priorities, and a plan.

Insofar as was possible, the committee sought to determine the extent to which these already exist within the USGS.

FINDINGS AND RECOMMENDATIONS

The committee has identified certain key concerns that bear on geologic mapping activities in the USGS. These follow in an unprioritized order.

Finding 1

The committee found that no separate, single, national geologic mapping program exists in the USGS. Although much of the geologic mapping done by the USGS is done in the Geologic Framework and Synthesis Program, a large amount is also done within the context of the missions and objectives of the various other branches and programs. There is no overriding guidance or management that regularly assesses and coordinates the many different geologic mapping efforts and products in the USGS. The committee believes that coordination of these many activities as part of a well-defined national geologic mapping program would serve the prospective needs of the USGS and the nation.

Recommendation 1

The USGS should develop and adopt a long-term, stable, and evolving national program to coordinate its geologic mapping activities and the preparation of geologic maps among its branches and programs. Such a program should include a clear statement of long-term geologic mapping mission and objectives, a definition of methods, assignment of responsibility for coordination of activities, a process for setting priorities, and a mechanism for annual assessment of progress. In addition, there must be more cooperation between the USGS and state surveys and universities who are involved in geologic mapping.

Finding 2

Geologic maps provide basic information that is critical to solving problems and making decisions in an increasingly complex world concerned with the occurrence and abundance of natural

resources and with environmental, economic, and social issues. In spite of this need, geologic mapping is on the wane in the USGS and has been decreasing (see Figures 1 and 2) for some map types since 1963. The decrease is most notable for all maps since about 1978. The previous rate of mapping was inadequate to satisfy map needs for purposes of mineral resource evaluation/assessment, identification of geologic hazards, construction siting, utility routing, waste disposal, or pollution assessment, to name only some of the applications. The reduced rate of mapping since 1963 has amplified the problem.

Recommendation 2

The USGS should review and augment their geologic mapping program(s) within the context of the general need for geologic maps, and should fashion budget requests to reflect the need for these maps as essential tools for solving resource and environmental problems, as, for example, with mandated programs that require geologic maps.

Finding 3

The incentives for geologic mapping among USGS personnel are minimal, given the slower rates of accomplishing field studies, publication, and promotion. Thus, geologic mapping tends to be viewed as less rewarding than other activities in the USGS and is not approached with the same enthusiasm as other activities and assignments. This attitude reflects on both staff and management and affects programs to the extent that geologic mapping tends to be deemphasized. Many experienced geologic mapping specialists have retired recently and few younger geologists have been hired to take their places.

Recommendation 3

The USGS should emphasize the importance of geologic mapping to its programs and to the national welfare by adopting an incentives and rewards policy for this activity. Publication of maps and scientific papers from geologic mapping programs should receive recognition equal to that enjoyed by scientific papers from other USGS program activities.

Finding 4

The USGS, with the exception of mandated programs, tends to internalize area and problem identification, prioritizing, budgeting, and staffing decisions on geologic mapping. A notable exception is the USGS request to the National Research Council to create the committee Advisory to the USGS. This internalization does not take advantage of a wealth of knowledge and support available in state surveys and educational institutions that could be used in support of a geologic mapping program.

Recommendation 4

There should be a standing subcommittee on geologic mapping established under the auspices of the Committee Advisory to the USGS. The purpose of the subcommittee would be to provide support for long-term program consistency and intellectual continuity; to review and provide advice and assistance on program priorities; to review program goals and objectives for possible duplication of effort; and to provide greater national visibility by highlighting the importance of geologic mapping to the nation as well as to the success of other USGS programs.

It is further recommended that the structure of the subcommittee be comparable to that of the Subcommittee on Earthquake Research. It should consist of representatives from industry, state surveys, and academia, appointed on staggered terms. Three of the members, one from each constituency, should be drawn from the parent committee and one of these should be appointed chairperson. This would assure continuity and consistency with the parent committee. To gain a nationwide perspective, the subcommittee should, at least initially, consider meeting in each of the three regional USGS facilities once each year. At the conclusion of each meeting, the subcommittee would submit a letter report of their findings and recommendations to the USGS. The chief geologist, in turn, would provide a response to the subcommittee prior to the next meeting.

Finding 5

The USGS has no well-defined program to involve universities in geologic mapping activities. A significant amount of high-quality mapping is being conducted by and supported by colleges

and universities. Such activities, if coordinated with and at least partially supported by the USGS, could enhance a national mapping program by utilizing an untapped reservoir of competent and willing talent. If done within the context of the USGS mission and programs, the rate of national mapping at USGS standards would be increased. In addition, the pool of students would provide a well evaluated source of professional manpower.

Recommendation 5

The USGS should establish a competitive grants program to colleges and universities for the purpose of supporting geologic mapping and related research within the context of the USGS Geologic Mapping Program. The program should be modeled after the university component of the USGS Earthquake Program, which embodies the following elements: (1) grants to be awarded on the basis of competitive peer review; (2) budget for university program to be set at a fixed fraction of the budget of the USGS program; (3) on the basis of availability, USGS facilities to be made available to aid with the mapping performed under terms of the grant; and (4) Faculty Principal Investigator and his or her university to assume responsibility for completing the program of the grant. In addition, it is recommended that because of the need to coordinate geologic mapping with state surveys, mapping under this program should be coordinated by the USGS with the state surveys.

Finding 6

The USGS formerly operated under a mentor program, which provided for the training of new employees under the direction of senior staff. With severe staff reductions and the added burden of mandated programs, the mentor program has declined and nearly disappeared except for the Alaskan Branch. A mentor program provides for continuity of contacts and programs, for consistency of methods, and for on-the-job training under the direction of experienced senior staff. All of these factors dictate that the program should be encouraged.

Recommendation 6

The USGS should strive to use the mentor process for training new employees wherever time and staffing permit.

Finding 7

There are very significant delays of 36 or more months in the time between approval of a map for publication and actual publication. Such a delay is unnecessary and unwarranted, and poorly serves the national need.

Recommendation 7

The USGS should take whatever steps are necessary to reduce the time required for publication of geologic maps including the broader use of computer technology such as is being used in the Central Region for individual projects and in the Western Region in the Hazards Program.

Finding 8

Most state geological surveys have ongoing geologic mapping programs designed to respond to individual state needs. Many of these programs are substantial in terms of budget and personnel commitments, and, taken in toto, would rival and possibly exceed that of the USGS. In addition, most state programs, and thereby federal programs, could benefit substantially by closer cooperation in geologic mapping activities to achieve maximum benefit from available budgets, personnel, facilities, and capabilities. The USGS has recently initiated the Cooperative Geologic Mapping Program (COGEOMAP) to support projects of mutual federal and state interest. Although COGEOMAP is conceptually significant, it suffers from a lack of adequate funding and is a minor part of the total commitment of USGS program funding and personnel to geologic mapping.

In the past, coordination of USGS geologic mapping activities with those of state geological surveys tended to be after the fact. The USGS has taken steps to improve communication and coordination by means of direct notification and by conferences such as Cluster meetings. This process of early notification has tended to improve coordination to the extent that if problems occur they

can usually be attributed to oversight. It would be much more useful and constructive to both the state and federal surveys if discussion were held prior to project approval, and preferably at the conceptual state in project development, for greater assurance of coordination.

Recommendation 8

The USGS should increase its efforts under its policy of informing the state geological surveys of program and project initiatives and intentions during the formative stages of their development. A positive step in response to the committee's concern over this issue is the recent action taken by the USGS to assure early contact with states by including a check-off on project approval forms to indicate contact has been made with the appropriate state survey(s).

Coordination implies that state surveys will take equal measures to inform the USGS of their intentions. A clear statement by the USGS to indicate their commitment to improve coordination, and what they are doing to assure coordination, could provide the catalyst to elicit reciprocal participation on the part of state surveys.

PROGRESS TOWARDS A NATIONAL GEOLOGIC MAPPING PROGRAM

In 1985, in response to concern expressed by the committee and by users and makers of geologic maps, and through interaction with the subcommittee, the USGS took a very positive step toward addressing the issue of the need for a national geologic mapping program. This step consisted of preparation of a draft program proposal that defined goals, objectives, and long-range plans; the proposal was issued in 1987 as USGS Circular 1020.

The program has the following three main goals:

1. Meet national needs for geologic maps.
2. Improve coordination among all federal, state, and university producers of geologic maps to encourage cooperative efforts and avoid unnecessary duplications.
3. Adopt new technologies and innovative methods for improving the geologic map production process and combining general geologic data with other earth-science and geographic data

bases to make derivative maps to address specific earth-science questions.

The major components of the program include the following:

1. A federal program for geologic data acquisition.
2. A greatly expanded cooperative effort with state geological surveys through COGEOMAP.
3. A grants program to universities to utilize academic capabilities and aid in training graduate students in field mapping projects.
4. The development of new techniques for data acquisition, presentation, and publication.

Preparation of this program proposal is a clear indication that the USGS recognizes the need for a coordinated national geologic mapping program and that coordination is needed within and between their programs as well as outside their programs. The committee applauds this effort to move quickly to establish a much needed, coordinated national geologic mapping program.

THE ROLE OF GENERAL GEOLOGIC MAPPING IN GEOLOGIC DIVISION PROGRAMS

Geologic mapping is a critical element in building a long-term national data base. Inherent in building this data base is the identification and recognition of the need for geologic information for solving problems and making decisions in an increasingly complex world concerned with the occurrence and abundance of natural resources and with environmental, social, and economic issues. With the exception of the Alaskan Branch and the Pacific Regional Geology Branch, the committee could not identify elsewhere in the the USGS a long-term program commitment or sense of mission expressing the importance of geologic mapping to the accumulation of a national data base. In the opinion of the committee, geologic mapping is a critical element in building a long-term data base, and it is the most efficient way to develop this data base. In addition, geologic maps are the most useful data mode for industry and government because of the variety of data that can be integrated into maps. Without a long-term commitment to geologic mapping, the committee fears that the rate at which information is being developed will not meet the future demand for its use.

Having conducted preliminary program reviews, the committee suspected that there is no single well-defined geologic mapping program in the USGS. This suspicion was confirmed by subcommittee interviews with USGS personnel: there is at present no central planned or managed program of geologic mapping in the USGS. The committee suspects there is a tendency for the various offices and the 20 or more programs to operate independently. The method and process of communication, data coordination, and compilation, and related activities, are not being monitored in any coordinated way out of any particular office or by any particular individual. In addition, the various programs are not necessarily coordinated with each other, but are conducted in response to needs that are reflected in the separate program objectives and priorities. The principal programs were discussed separately; geologic mapping done in programs of the Water Resources Division was not discussed. The published program (USGS Circular 1020) is the end product of these discussions.

Geologic Division appropriations over the period FY 1976 through 1986 indicate dollar increases in most key programs that conduct geologic mapping. The difficulty is in determining how many dollars under each program were committed to geologic mapping and of what kind. This could not be determined with certainty, which indicates once again that there is no single geologic mapping program, but rather that geologic mapping is spread over several programs and is not necessarily coordinated.

One means of maintaining a strong mapping capability is to provide continuity of personnel and programs in specific geologic provinces. The USGS has had, we believe by design rather than chance, a tradition for maintaining its expertise on both a regional and commodity basis. Thus, there developed a cadre of recognized regional experts who provided the USGS a broad base of geologic expertise on a national scale. These individuals served as mentors to younger generations, passing on their knowledge, techniques, and contacts, and providing continuity to the nation's resource of geologic knowledge and expertise. It appears that, with the exception of the Branch of Alaskan Geology, this practice, one which the committee sees as vital to the nation's and the USGS's well-being, has been curtailed. We suspect that the mentor process may be a victim of the shift in emphasis away from geologic mapping and towards theoretical and laboratory research and to mandated programs. What appears to be the case is that the

mentors are an aging resource in danger of vanishing. As evidence of this it should be noted that the mean age of professionals assigned to Regional Geology is 51, 21 percent are over 60, and only 3 percent are younger than 35.

The fact that geologic mapping requires a long apprenticeship carries with it severe implications for the USGS's long-range geologic mapping capabilities. As a part of this equation, it was pointed out that past investigators had more freedom. Constraints imposed by mandated programs have strongly affected the mentor program. Today, projects and areas change location and character rapidly in response to rapidly evolving needs. Thus, an individual may have several mentors and work in several areas. Nonetheless, there is not necessarily a conscious effort to sustain the mentor process, and demands on the organization argue against the process. The committee believes the mentor system is one method for maintaining the regional capabilities of the USGS. In sum, it appears the mentor system is used in some cases; however, there appears to be little deliberate effort to coordinate the mentor system with geography and geology on a national scale such as has been done with mineral commodities.

Office of Regional Geology

The mission of the Office of Regional Geology is to determine the geologic framework of the United States and to provide a basis for assessing the land as a resource. In the Office of Regional Geology, the principal program that conducts geologic mapping is Geologic Framework and Synthesis. The Geologic Framework and Synthesis (GFS) Program is one of three subdivisions under the Land Resources Surveys subactivity. Geologic mapping in this program is done under three categories—basic mapping, mapping related to process studies, and regional framework problems. The principal product of the basic mapping category is geologic maps. Ten to 12 maps at scales from 1:24,000 to 1:250,000 have been produced in the past several years. The rate of production is variable with time. These maps may be followed up by topical mapping and/or research.

In the category of mapping related to process studies, emphasis is on volcanic, metamorphic, sedimentary, plutonic, glacial, and

other processes. The regional framework problems category emphasizes multidisciplinary and integrated studies. These generally start with a mapping effort.

There is no explicit set of criteria for selection of projects in the GFS program. It is the committee's impression that projects are not selected on the basis of a long-term plan, but rather are determined using a "ground-up" approach whereby staff make recommendations that are subject to approval at branch or office levels. The subcommittee inferred from a number of discussions that little "top-down" planning is involved in the project selection process. Coordination between divisions, offices, and branches, and programs tends to suffer from this process.

Geologic mapping priorities are set by the branch chiefs who are responsible for organizing programs in their areas of responsibility. Within the realm of the GFS program, mapping is done as part of regional, process, geochronological, and deep crustal studies, and COGEOMAP. The branch chiefs can program studies under any of these categories. The philosophy behind this approach is that the need for framework studies can be generated in any of the regional branches. The office chief, who oversees the branches, is the constraining/coordinating force and administers under the constraints of budget, missions, and direction from above. In truth, it was stated that within GFS, geologic mapping tends to get residual support after the requirements for principal mission and other activities are satisfied. Thus, GFS funds tend to be diverted to support mandated programs as needed.

The GFS program is popular even though, or maybe because, it lacks specific mission orientation, project deadlines, and constraints, and it affords the branch chiefs more flexibility. In consequence, it is widely dispersed and oversubscribed. The program is designed according to a management concept. Whereas projects are developed and organized in discussions between the branch chiefs and the project chiefs, ultimate approval is with the office chief. However, it was clearly stated that the process is not part of a comprehensive USGS national geologic mapping plan.

The diversion of funds from GFS projects to mandated and other programs and projects disrupts GFS program continuity. There are significant delays (up to 5 years) in the publication of geologic quadrangles. The commitment to GFS projects and programs appears to be less than that given to mandated and other programs.

COGEOMAP is administered under the GFS program. It is a federal/state cooperative initiative begun in 1985. The primary goals of COGEOMAP are publication of new geologic maps of high quality at scales from 1:24,000 to 1:100,000 and generation of new geologic mapping that fills gaps in state map programs. Specifically, the tasks of COGEOMAP are as follows:

1. Intermediate and large-scale (>1:100,000) mapping in areas of high hazard and/or resource potential.
2. Assisting in the planning and preparation of state geologic maps.
3. Mapping projects to clarify relations of geophysical features to basement/cover geology.
4. Promoting state geophysical maps utilizing digital data base.
5. Supporting studies contributing to relative and absolute chronologies of rock units within COGEOMAP project areas.

The program was funded in the amount of $1,000,000 for FY 1985. The USGS allocated $200,000 for state digital geophysical map projects, $400,000 in funds, and $400,000 in in-kind services; state geological surveys matched these offerings with $200,000 in funds and $800,000 in in-kind services.

In FY 1985, state requests for funding exceeded available funds by $1,200,000. There were 48 proposals from 35 states; funds were allocated to 23 projects in 18 states. Fourteen of the projects will continue into FY 1986; thus, there was only a modest opportunity for new starts in FY 1987. The $200,000 for state digital geophysical mapping was allocated to projects in 8 states—including 4 not included in the geologic mapping program.

The COGEOMAP program is rated the second priority behind toxic waste by the Geology Division. It is well-intentioned but severely underfunded. The USGS is working toward a $2,000,000 increase in the program in FY 1987.

COGEOMAP priorities are determined by the branch chiefs within the context of their programs. However, final decisions are subject to review and approval by the program coordinator. As with other programs, there is no overall management effort within the context of a specific USGS geologic mapping core program. However, COGEOMAP is the one program within the USGS that is clearly defined as being committed to the production of geologic maps in cooperation with state surveys. The response from

state surveys has been supportive and enthusiastic based upon the number of project proposals submitted.

Office of Energy and Marine Geology

The Office of Energy and Marine Geology has responsibility for both onshore and offshore minerals and consists of five branches: Onshore Coal Resources, Energy and Minerals, Oil and Gas Resources, Offshore Atlantic Marine Geology, and Pacific Marine Geology. The office is charged with determining the origin, size, and distribution of energy resources excepting geothermal but including sedimentary minerals. The philosophy of the Office towards geologic mapping of offshore areas is dictated by the desire of the Executive Office to bring the Exclusive Economic Zone (EEZ) into development and for other areas by geologic process studies, which extend beyond land areas. In offshore areas, the office addresses a wide range of geologic issues such as topography, geomorphology, mineral resources, and hazards. Geologic mapping of onshore areas is done principally where more detail is required for assessment and interpretive purposes.

The amount and detail of geologic mapping completed depends on program/project requirements. In the offshore branches, reconnaissance geologic mapping of the EEZ is done at scales from 1:50,000 to 1:500,000. One-half of the marine budget ($8 million) is committed to mapping of the EEZ. Mapping by the onshore branches (some of which is done in wilderness areas) is budgeted at less than $1.5 million.

Onshore mapping is described as general purpose geologic mapping. Mapping of coal, uranium, and thorium is very limited; oil and gas mapping is principally in the subsurface. Although funding for mapping of coal resources has terminated, the USGS will complete projects in process (51 of original 80 coal folios will be completed). All those to be completed are in the west; none of the eastern folios will reach publication.

The budget commitment of approximately $30 million to energy programs rose by 52 percent from 1976 through 1982; since then, it has decreased 22 percent. Executive Office, congressional, and Department of the Interior support for certain energy programs, such as coal and oil shale, has waned. To counter this shift, the USGS in 1985 created the Evolution of Sedimentary Basins (ESB) Program, which is in a sense a multidisciplinary/integrated

approach to basin analysis with special emphasis on energy resources. It is intended to avoid the "boom-bust" problem associated with the coal, uranium, and oil-shale programs. It can be looked on as part of the USGS's attempt to construct a core program.

In the ESB program, areas selected for study are determined by a management process. Teams are formed for specific basin studies, i.e., to look at the broad aspects of geology in a given basin. Such basin analysis is comparable to industry's approach to exploration. The USGS intends to put out a comparable product. It sees the program as responsive to national needs. Of the ESB budget, 5 to 10 percent ($5M to $10M) goes toward geologic mapping that is mostly surficial, but with some subsurface.

Office of Mineral Resources

The Office of Mineral Resources (OMR) program has the following goals (USGS Circular 949, p. 58):

- To assess the mineral resource potential of specific areas in the United States (particularly federal lands) for resource management and Congressional action.
- To identify new areas for exploration and develop new concepts of ore formation and distribution to increase our known mineral resources, particularly the strategic and critical minerals.
- To improve current methodology and develop new techniques for identifying and evaluating mineral resources and analyzing resource data more efficiently and more precisely.

Geologic mapping in the OMR is done for specific purposes rather than as part of a broader program of geologic mapping. The principal reason for geologic mapping in the OMR is to provide a base of geologic understanding. Mapping is also done to prepare multipurpose maps that can be used with specialized geophysical or geochemical maps to achieve a specific objective. The boundaries of geologic maps prepared by OMR are determined by geology and do not coincide with political or quadrangle boundaries. The emphasis of OMR programs is to map features that are relevant to understanding and defining mineral resources.

The OMR is divided into five funding programs as shown in Table 1. About 50 to 70 percent of geologic mapping in the AMRAP, CUSMAP, and MRPL is directed toward mineral resources

TABLE 1 Funding Programs in the Office of Mineral Resources

	Office Level	Geologic Mapping
AMRAP (Alaska Mineral Resource Assessment Program)	$6.9M	$3.0M
CUSMAP (Conterminous U.S. Mineral Assessment Program)	$4.1M	$1.7M
MRPL (Mineral Resources on Public Lands)	$6.2M	$2.1M
SCM (Strategic/Critical Minerals Program)	$6.8M	$1.0M
DAT (Development of Assessment Techniques Program)	$8.6M	$1.0M

assessments. The emphasis is on all commodities in a given geographic area.

A principal purpose for the existence of geological surveys is to develop basic geologic data and to prepare maps and reports on the findings. The information produced in OMR mapping programs is basic to the eventual construction of traditional geologic maps. The data are important to the future and they should be recorded and preserved. However, it is not clear whether the maps and data developed in OMR are incorporated into a comprehensive plan for geologic mapping in the USGS. The subcommittee suspects that mapping in the OMR is done within the confines of its specific mission and objectives and that it is not considered in a planned context as an integral part of a "core" or framework geologic mapping program.

Office of Earthquakes, Volcanoes, and Engineering

The Office of Earthquakes, Volcanoes, and Engineering, the newest, is described as perhaps the most topical major unit within the USGS. By virtue of its subject area, it is and must be responsive to the demands of the public and of Congress. It is strongly mission oriented to the extent that essentially all its work is done within the context of its specific mission mandates (refer to USGS Circular 1000).

Geologic mapping in this office is done principally to define the character, extent, and risk of geologic hazards. Geologic hazards surveys "are conducted to acquire data useful in delineating and predicting hazards from earthquakes and volcanoes and to identify

engineering problems related to nuclear reactor siting and landslide hazards" (USGS Circular 1000, p. 15). Mapping is special purpose rather than general geological mapping in that it records structures, landslides, earthquakes, and similar features. The map products are regarded as special purpose and include derivative maps designed to satisfy specific needs.

Expenditures in geologic hazards programs are monitored by watch-dog congressional oversight committees. For a sense of budget commitment to geologic mapping in these programs, it is useful to note that of the $36.5 million allocated to the study of earthquake hazards in 1985 about 16 percent was directed to geologic studies and 3 percent to general geologic mapping. In the volcano program about 5 percent ($600,000) is committed to geologic mapping.

The activities of the hazards program are dedicated to specific missions; solving problems is their principal objective. This posture imposes strict real time/staff/resource constraints on the degree and character of mapping that can be done. It is recognized by the USGS that geologic mapping is fundamental to the objectives of the hazards program. However, they have great difficulty convincing those responsible for funding that this is the case.

The landslides program has shifted away from basic mapping and towards investigating processes that can be used to predict landslide potential. The committee stresses the need for basic geologic mapping to understand processes and that it should start with bedrock mapping. The USGS recognizes this need, but is convinced that the need is enormous and far beyond their capability to address. The success of the program depends on a sufficient multidisciplinary mapping capability.

The committee noted that geologic mapping in Geologic Hazards Programs is done quite strictly within the context of the mission and objectives of these programs. There does not appear to be coordination with other geologic mapping activities of the USGS in the sense that it is a part of a "core" program or a broader geologic mapping program. For this reason, it is not clear how and if the data developed in the Hazards Program is coordinated with or incorporated in other programs. The Hazards Programs rely quite heavily on geologic mapping. By the same token, the products of hazards studies can contribute to the eventual construction of regional geologic maps. What appears to be missing is an overall management strategy that sets the broader USGS objectives

and goals that should include a coordinated program of geologic mapping.

Coordination with State Geologic Surveys

Coordination with state geological surveys is carried out by several means. One means is that the USGS provides state geologists with copies of project proposals/descriptions once they have been finally approved by the USGS. It was acknowledged that although some states provide the USGS with copies of their project descriptions, it would be most helpful if all states reciprocated. One problem with this process is that coordination of information after the fact does not allow much opportunity for cooperation and mutual planning. The USGS intends to add a space on their project description form to indicate that contact has been made with state surveys. However, it would be much more useful and constructive if the federal and state surveys could be brought together at the conceptual stage in project development. In this way both could take advantage of the potential for cooperation and coordination; conflict, disagreement, and duplication of effort could be avoided.

Another means of coordination with state surveys is the Cluster Meetings, which are sponsored annually in each region by the USGS. The Clusters are intended to provide the opportunity for discussion of issues of mutual concern and to provide the opening for cooperation. The Clusters are successful only insofar as the states are involved in their planning and to the extent the states are willing to participate. The level of success is somewhat uneven, but in general the Clusters are considered a useful means for communication on major issues such as program emphasis and potentials for cooperation including geologic mapping.

Coordination with state surveys is also done through semiannual meetings with the Association of American State Geologists' Liaison Committee and the Interagency Coordinating Committee. These meetings provide a means for coordination and communication at the policy and program level, which can affect geologic mapping done by both the federal and state surveys.

Another means of coordination is field visitation wherein USGS project staff visit the state surveys to describe and discuss their programs and to learn something of related state survey

programs and projects. The purpose of these visits is for both information exchange and coordination.

In the opinion of the committee, coordination with state surveys could be improved if contact were made in the formative stage of project and program development rather than after a project has been approved. However, the committee believes it is equally imperative for the state surveys to keep the USGS informed of their geologic mapping projects at an equivalent stage in development. It is only through open discussion of programs and projects in their formative stages that the potential for cooperation can be fully realized.

Coordination with Universities

The committee determined that the USGS has no well-defined program to involve colleges and universities in geologic mapping activities. What support has been provided to universities for mapping and related research has been sporadic and subject to the vagaries of changing USGS budgets, priorities, and mandates, as interpreted at district levels. The support has generally been in the form of temporary appointments for students or faculty and rarely in the form of research grants to faculty comparable with those given on a competitive basis by the NSF and by the USGS Earthquake Program. Nonetheless, a significant amount of geologic mapping is being done through colleges and universities. Such activity, if coordinated with and supported by the USGS, could enhance USGS programs by utilizing an untapped reservoir of competent and willing talent pool.

STATUS OF GEOLOGIC MAPPING IN THE UNITED STATES

The USGS has a program called GEODAT, the outgrowth of GEOINDEX, which is intended to indicate what areas of the United States have been mapped, the scales of published geologic maps for individual regions, map quality and content, and outstanding problems. GEOINDEX is strictly bibliographic and, thus, not so useful. The GEODAT files are available on floppy discs for purchase.

GEODAT has the disadvantage that it does not provide a sense of the rate of geologic mapping or whether mapping being

completed is responsive to the elusive "need" factor. A National Research Council committee surveyed the mapping needs of the general geologic community; the final report is in preparation. The survey assessed needs on the basis of opinions and perceptions, but not in relationship to specific problems or issues, i.e., the question of "why?" was not answered. The basic unanswered questions are still who needs what kind of mapping, where, for what purpose, what are the priorities, and how are they determined?

There is a very definite shift to production of integrated maps incorporating the third dimension as is represented by the Continental Drilling Program. In addition, digital techniques are being applied to integrate various maps for the production of derivative maps. While all of these activities are recognized, there is no coherent management that defines how they are or should be interrelated and coordinated.

Time Required for Map Production

A major problem raised in discussion of the status of geologic mapping is the length of time required for completion and publication of a map. Limitations of cost, staff, product printing, quality, and editing are given as factors that seriously affect this timing. For example, the average time required for a map to reach the editor in the Bureau of Technical Review (BTR) is 9 months. The current backlog of geologic maps, based on when a map is assigned to an editor, is on average not more than 3 months. The flow of maps is uneven on a monthly basis and depends on how many maps are submitted. Once a map is approved, 14 to 22 months are required for final preparation in the National Mapping Division (NMD). The major problem with timing is related to limitations of funds and manpower. The options for decreasing the time are to speed up the NMD or to shift the responsibility to the Geologic Division.

The committee expressed concerns about the potential loss of information in the open-file system of issuing reports. Only 10 percent of open-file reports are eventually published. One reason for open-filing a report is to make it available at the earliest possible moment and to short-circuit the 2- to 3-year delay required for publication. The decision to open-file is left to the author. Authors of geologic maps tend to elect the open-file option because it leads to quicker release of results and to early recognition for

purposes of promotion. The committee believes the entire process should be reviewed with the purpose of expediting the publication of geologic maps.

New technology is leading to increased operational and production efficiency in the National Mapping Division, which should decrease the length of time required for publication.

Is Geologic Mapping Declining?

The committee expressed a concern at its January 1985 meeting that geologic mapping appears to be declining. In response to this concern, the USGS initiated a preliminary review to determine if the concern is justified. The report, prepared by Fred Miller, is preliminary and statistically based, and it strongly supports the committee's concern. According to the review, publication of geologic maps has declined in all USGS publications series (Figures 1 and 2). The USGS agrees that the review findings definitely indicate a problem. The reasons for decline in geologic mapping include, among others, redirection of base program dollars to newly mandated programs; geologic mapping being crowded out by mandated programs; small science being crowded out by high technology new starts; severe Geologic Division staff reductions from approximately 3800 down to 2900 in the past five years; an internal tendency in the USGS to deemphasize geologic mapping in favor of what are perceived to be more popular or scientifically more challenging projects; and a lack of incentives related to slower promotion rates for geologic mappers than for colleagues working on non-mapping projects. The situation tends to be exacerbated by positive feedback, i.e., geologic maps needed for short-term studies are not available, thus any new short-term studies divert manpower needed to produce geologic maps. The need for a strong systematic geologic mapping program is felt by many USGS researchers to the extent that they bootleg geologic mapping under other projects where monetary rewards tend to be greater.

There is some indication that while geologic mapping has decreased in the USGS, there has been an increase among state surveys. Whether this is true and to what extent is unknown.

There is a fundamental question behind the emphasis given to geologic mapping. What is the extent to which there is a need for geologic maps? It seems obvious to geologists working with the public, industry, and government that there is and will continue to

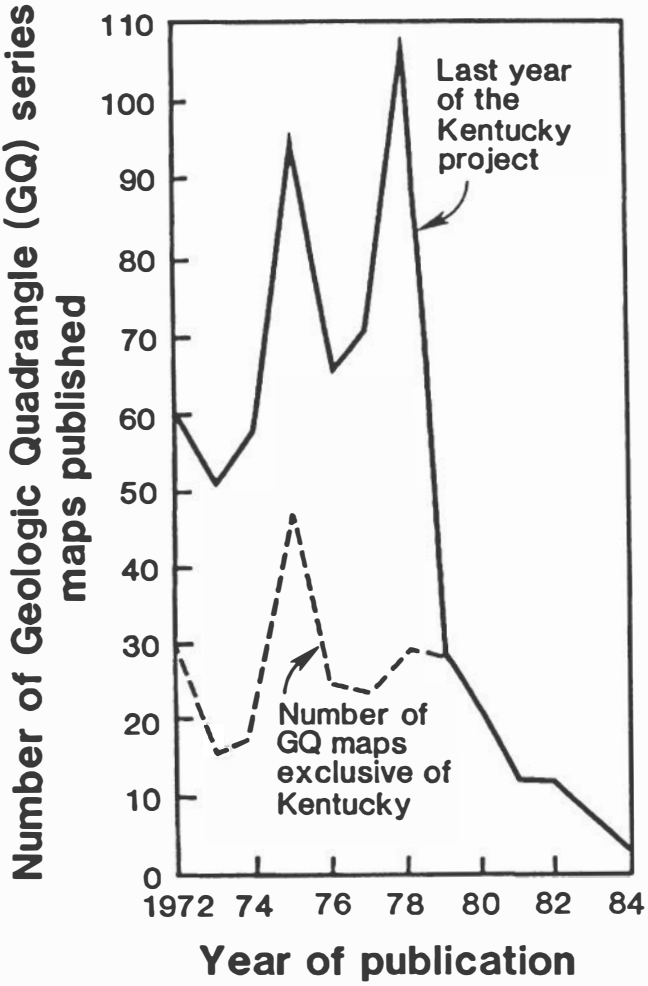

FIGURE 1 Number of square miles mapped by geologists during each of the past five decades. Only maps at scales of 1 mile to the inch or larger are included. From USGS Circular 1020.

be an increasing need for geologic maps to respond to problems of mineral resources, water availability, pollution, construction siting, utility routing, waste disposal, material storage, and others. If this is true, then there is reason to be concerned that apparently the geologic mapping effort/capability of the USGS is not keeping pace with the national need for geologic maps. The COGEOMAP

GEOLOGIC MAPS AT SCALES MILE-TO-THE-INCH AND LARGER

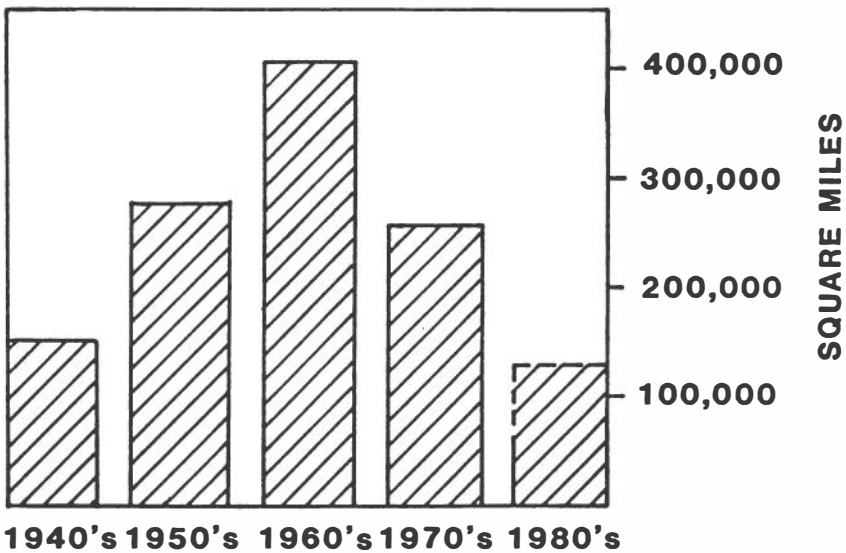

FIGURE 2 Number of Geologic Quadrangle (GQ) maps published between 1972 and 1984. From USGS Circular 1020.

program reflects a concern for this situation; namely, in an attempt to rectify the situation the USGS initiated a program to recruit the cooperation of state surveys. The level of state commitment and concern is not known, but on the basis of response to COGEOMAP, one gets the sense that states are placing more emphasis on geologic mapping than does the federal survey. It is apparent that more needs to be learned of the federal and state survey commitment to geologic mapping. If the roles of the USGS and state surveys are changing, emphasis is changing, or programs are expanding, it is important to determine what impact these shifts will have on any long-term national program of geologic mapping.