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H.R. 1528, THE NATIONAL GEOLOGIC MAPPING REAUTHORIZATION ACT OF 1999, TO REAUTHORIZE AND AMEND THE NATIONAL GEOLOGIC MAPPING ACT OF 1992

HEARING

BEFORE THE

SUBCOMMITTEE ON ENERGY
AND MINERAL RESOURCES

OF THE

COMMITTEE ON RESOURCES
HOUSE OF REPRESENTATIVES

ONE HUNDRED SIXTH CONGRESS

SECOND SESSION

JUNE 17, 1999, WASHINGTON, DC

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CONTENTS

	Page
Hearing held June 17, 1999	1
Statements of Members:	
Cubin, Hon. Barbara, a Representative in Congress from the State of Wyoming, prepared statement of	18
Gibbons, Hon. Jim, a Representative in Congress from the State of Nevada	1
Additional material submitted by	34
Rahall, Hon. Nick, a Representative in Congress from the State of West Virginia, prepared statement of	36
Underwood, Hon. Robert A., a Delegate in Congress from the Territory of Guam	19
Prepared statement of	20
Statements of witnesses:	
Leahy, Dr. P. Patrick, Chief Geologist, U.S. Geological Survey, U.S. Department of the Interior	20
Prepared statement of	21
The Coastal and Marine Geology Program for 1999	39
Thomas, Dr. William A., Professor of Geosciences, University of Kentucky, on behalf of The American Geological Association	29
Prepared statement of	31
Additional material submitted for the record by	46
Woodfork, Dr. Larry D., West Virginia Geological and Economic Survey, and President, Association of American State Geologists	26
Prepared statement of	27
Additional material supplied:	
Text of H.R. 1528	2

H.R. 1528, THE NATIONAL GEOLOGIC MAPPING REAUTHORIZATION ACT OF 1999, TO REAUTHORIZE AND AMEND THE NATIONAL GEOLOGIC MAPPING ACT OF 1992

THURSDAY, JUNE 17, 1999

HOUSE OF REPRESENTATIVES,
SUBCOMMITTEE ON ENERGY AND
MINERAL RESOURCES,
COMMITTEE ON RESOURCES,
Washington, DC.

The Subcommittee met, pursuant to call, at 2 p.m. in Room 1334, Longworth House Office Building, Hon. Jim Gibbons presiding.

STATEMENT OF HON. JIM GIBBONS, A REPRESENTATIVE IN CONGRESS FROM THE STATE OF NEVADA

Mr. GIBBONS. The Subcommittee on Energy and Mineral Resources will come to order.

This Subcommittee meets today to take testimony on H.R. 1528, the National Geologic Mapping Reauthorization Act of 1999, the bill to reauthorize and amend the National Geologic Mapping Act.

[The information follows:]

I

106TH CONGRESS
1ST SESSION

H. R. 1528

To reauthorize and amend the National Geologic Mapping Act of 1992.

IN THE HOUSE OF REPRESENTATIVES

APRIL 22, 1999

Mrs. CUBIN (for herself, Mr. YOUNG of Alaska, Mr. RAHALL, Mr. GIBBONS, Mr. TANCREDO, and Mr. UDALL of Colorado) introduced the following bill; which was referred to the Committee on Resources

---

A BILL

To reauthorize and amend the National Geologic Mapping Act of 1992.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled,

SECTION 1. SHORT TITLE.

This Act may be cited as the "National Geologic Mapping Reauthorization Act of 1999".

SEC. 2. FINDINGS.

Section 2(a) of the National Geologic Mapping Act of 1992 (43 U.S.C. 31a(a)) is amended—

(1) in paragraph (7), by striking "and" at the end;

(2) by redesignating paragraph (8) as paragraph (10);

(3) by inserting after paragraph (7) the following:

"(8) geologic map information is required for the sustainable and balanced development of natural resources of all types, including energy, minerals, land, water, and biological resources;

"(9) advances in digital technology and geographical information system science have made geologic map databases increasingly important as decision support tools for land and resource management; and"; and

(4) in paragraph (10) (as redesignated by paragraph (2)), by inserting "of surficial and bedrock deposits" after "geologic mapping".

SEC. 3. DEFINITIONS.

Section 3 of the National Geologic Mapping Act of 1992 (43 U.S.C. 31b) is amended—

(1) by redesignating paragraphs (4), (5), (6), and (7) as paragraphs (6), (7), (8), and (10), respectively;

(2) by inserting after paragraph (3) the following:

"(4) EDUCATION COMPONENT.—The term 'education component' means the education component of the geologic mapping program described in section 6(d)(3).

"(5) FEDERAL COMPONENT.—The term 'Federal component' means the Federal component of the geologic mapping program described in section 6(d)(1)."; and

(3) by inserting after paragraph (8) (as redesignated by paragraph (1)) the following:

"(9) STATE COMPONENT.—The term 'State component' means the State component of the geologic mapping program described in section 6(d)(2).".

SEC. 4. GEOLOGIC MAPPING PROGRAM.

Section 4 of the National Geologic Mapping Act of 1992 (43 U.S.C. 31c) is amended—

(1) in subsection (b)(1)—

(A) in the first sentence, by striking "priorities" and inserting "national priorities and standards for";

(B) in subparagraph (A)—

(i) by striking "develop a geologic mapping program implementation plan" and inserting "develop a 5-year strategic

plan for the geologic mapping program"; and

(ii) by striking "within 300 days after the date of enactment of the National Geologic Mapping Reauthorization Act of 1997" and inserting "not later than 1 year after the date of enactment of the National Geologic Mapping Reauthorization Act of 1999";

(C) in subparagraph (B), by striking "within 90 days after the date of enactment of the National Geologic Mapping Reauthorization Act of 1997" and inserting "not later than 1 year after the date of enactment of the National Geologic Mapping Reauthorization Act of 1999"; and

(D) in subparagraph (C)—

(i) in the matter preceding clause (i), by striking "within 210 days after the date of enactment of the National Geologic Mapping Reauthorization Act of 1997" and inserting "not later than 3 years after the date of enactment of the National Geologic Mapping Reauthorization Act of 1999, and biennially thereafter";

(ii) in clause (i), by striking "will coordinate" and inserting "are coordinating";

(iii) in clause (ii), by striking "will establish" and inserting "establish"; and

(iv) in clause (iii), by striking "will lead to" and inserting "affect"; and

(2) by striking subsection (d) and inserting the following:

"(d) PROGRAM COMPONENTS.—

"(1) FEDERAL COMPONENT.—

"(A) IN GENERAL.—The geologic mapping program shall include a Federal geologic mapping component, the objective of which shall be to determine the geologic framework of areas determined to be vital to the economic, social, environmental, or scientific welfare of the United States.

"(B) MAPPING PRIORITIES.—For the Federal component, mapping priorities—

"(i) shall be described in the 5-year plan under section 6; and

"(ii) shall be based on—

"(I) national requirements for geologic map information in areas of

1 multiple-issue need or areas of com-
2 pelling single-issue need; and
3 "(II) national requirements for
4 geologic map information in areas
5 where mapping is required to solve
6 critical earth science problems.
7 "(C) INTERDISCIPLINARY STUDIES.—
8 "(i) IN GENERAL.—The Federal com-
9 ponent shall include interdisciplinary stud-
10 ies that add value to geologic mapping.
11 "(ii) REPRESENTATIVE CAT-
12 EGORIES.—Interdisciplinary studies under
13 clause (i) may include—
14 "(I) establishment of a national
15 geologic map database under section
16 7;
17 "(II) studies that lead to the im-
18 plementation of cost-effective digital
19 methods for the acquisition, compila-
20 tion, analysis, cartographic produc-
21 tion, and dissemination of geologic
22 map information;
23 "(III) paleontologic, geochrono-
24 logic, and isotopic investigations that
25 provide information critical to under-

1 standing the age and history of geo-
2 logic map units;
3 "(IV) geophysical investigations
4 that assist in delineating and mapping
5 the physical characteristics and 3-di-
6 mensional distribution of geologic ma-
7 terials and geologic structures; and
8 "(V) geochemical investigations
9 and analytical operations that charac-
10 terize the composition of geologic map
11 units.
12 "(iii) USE OF RESULTS.—The results
13 of investigations under clause (ii) shall be
14 contributed to national databases.
15 "(2) STATE COMPONENT.—
16 "(A) IN GENERAL.—The geologic mapping
17 program shall include a State geologic mapping
18 component, the objective of which shall be to es-
19 tablish the geologic framework of areas deter-
20 mined to be vital to the economic, social, envi-
21 ronmental, or scientific welfare of individual
22 States.
23 "(B) MAPPING PRIORITIES.—For the State
24 component, mapping priorities—

"(i) shall be determined by State panels representing a broad range of users of geologic maps; and

"(ii) shall be based on—

"(I) State requirements for geologic map information in areas of multiple-issue need or areas of compelling single-issue need; and

"(II) State requirements for geologic map information in areas where mapping is required to solve critical earth science problems.

"(C) INTEGRATION OF FEDERAL AND STATE PRIORITIES.—A national panel including representatives of the Survey shall integrate the State mapping priorities under this paragraph with the Federal mapping priorities under paragraph (1).

"(D) USE OF FUNDS.—The Survey and recipients of grants under the State component shall not use more than 15.25 percent of the Federal funds made available under the State component for any fiscal year to pay indirect, servicing, or program management charges.

1 "(E) FEDERAL SHARE.—The Federal
2 share of the cost of activities under the State
3 component for any fiscal year shall not exceed
4 50 percent.
5 "(3) EDUCATION COMPONENT.—
6 "(A) IN GENERAL.—The geologic mapping
7 program shall include a geologic mapping edu-
8 cation component for the training of geologic
9 mappers, the objectives of which shall be—
10 "(i) to provide for broad education in
11 geologic mapping and field analysis
12 through support of field studies; and
13 "(ii) to develop academic programs
14 that teach students of earth science the
15 fundamental principles of geologic mapping
16 and field analysis.
17 "(B) INVESTIGATIONS.—The education
18 component may include the conduct of inves-
19 tigations, which—
20 "(i) shall be integrated with the Fed-
21 eral component and the State component;
22 and
23 "(ii) shall respond to mapping prior-
24 ities identified for the Federal component
25 and the State component.

"(C) USE OF FUNDS.—The Survey and recipients of grants under the education component shall not use more than 15.25 percent of the Federal funds made available under the education component for any fiscal year to pay indirect, servicing, or program management charges.

"(D) FEDERAL SHARE.—The Federal share of the cost of activities under the education component for any fiscal year shall not exceed 50 percent.".

SEC. 5. ADVISORY COMMITTEE.

Section 5 of the National Geologic Mapping Act of 1992 (43 U.S.C. 31d) is amended—

(1) in subsection (a)(3), by striking "90 days after the date of enactment of the National Geologic Mapping Reauthorization Act of 1997" and inserting "1 year after the date of enactment of the National Geologic Mapping Reauthorization Act of 1999"; and

(2) in subsection (b)—

(A) in paragraph (1), by striking "critique the draft implementation plan" and inserting "update the 5-year plan"; and

1 (B) in paragraph (3), by striking "this
2 Act" and inserting "sections 4 through 7".

3 **SEC. 6. GEOLOGIC MAPPING PROGRAM 5-YEAR PLAN.**

4 The National Geologic Mapping Act of 1992 is
5 amended by striking section 6 (43 U.S.C. 31e) and insert-
6 ing the following:

7 **"SEC. 6. GEOLOGIC MAPPING PROGRAM 5-YEAR PLAN.**

8 "(a) IN GENERAL.—The Secretary, acting through
9 the Director, shall, with the advice and review of the advi-
10 sory committee, prepare a 5-year plan for the geologic
11 mapping program.

12 "(b) REQUIREMENTS.—The 5-year plan shall
13 identify—

14 "(1) overall priorities for the geologic mapping
15 program; and

16 "(2) implementation of the overall management
17 structure and operation of the geologic mapping pro-
18 gram, including—

19 "(A) the role of the Survey in the capacity
20 of overall management lead, including the re-
21 sponsibility for developing the national geologic
22 mapping program that meets Federal needs
23 while fostering State needs;

24 "(B) the responsibilities of the State geo-
25 logical surveys, with emphasis on mechanisms

1 that incorporate the needs, missions, capabili-
2 ties, and requirements of the State geological
3 surveys, into the nationwide geologic mapping
4 program;
5 "(C) mechanisms for identifying short- and
6 long-term priorities for each component of the
7 geologic mapping program, including—
8 "(i) for the Federal component, a pri-
9 ority-setting mechanism that responds to—
10 "(I) Federal mission require-
11 ments for geologic map information;
12 "(II) critical scientific problems
13 that require geologic maps for their
14 resolution; and
15 "(III) shared Federal and State
16 needs for geologic maps, in which
17 joint Federal-State geologic mapping
18 projects are in the national interest;
19 "(ii) for the State component, a pri-
20 ority-setting mechanism that responds to—
21 "(I) specific intrastate needs for
22 geologic map information; and
23 "(II) interstate needs shared by
24 adjacent States that have common re-
25 quirements; and

1 "(iii) for the education component, a
2 priority-setting mechanism that responds
3 to requirements for geologic map informa-
4 tion that are dictated by Federal and State
5 mission requirements;
6 "(D) a mechanism for adopting scientific
7 and technical mapping standards for preparing
8 and publishing general- and special-purpose
9 geologic maps to—
10 "(i) ensure uniformity of cartographic
11 and scientific conventions; and
12 "(ii) provide a basis for assessing the
13 comparability and quality of map products;
14 and
15 "(E) a mechanism for monitoring the in-
16 ventory of published and current mapping in-
17 vestigations nationwide to facilitate planning
18 and information exchange and to avoid redun-
19 dancy.".
20 **SEC. 7. NATIONAL GEOLOGIC MAP DATABASE.**
21 Section 7 of the National Geologic Mapping Act of
22 1992 (43 U.S.C. 31f) is amended by striking the section
23 heading and all that follows through subsection (a) and
24 inserting the following:

1 **"SEC. 7. NATIONAL GEOLOGIC MAP DATABASE.**

2 "(a) ESTABLISHMENT.—

3 "(1) IN GENERAL.—The Survey shall establish
4 a national geologic map database.

5 "(2) FUNCTION.—The database shall serve as a
6 national catalog and archive, distributed through
7 links to Federal and State geologic map holdings,
8 that includes—

9 "(A) all maps developed under the Federal
10 component and the education component;

11 "(B) the databases developed in connection
12 with investigations under subclauses (III), (IV),
and (V) of section 4(d)(1)(C)(ii); and

14 "(C) other maps and data that the Survey
15 and the Association consider appropriate.".

16 **SEC. 8. BIENNIAL REPORT.**

17 The National Geologic Mapping Act of 1992 is
18 amended by striking section 8 (43 U.S.C. 31g) and insert-
19 ing the following:

20 **"SEC. 8. BIENNIAL REPORT.**

21 "Not later 3 years after the date of enactment of the
22 National Geologic Mapping Reauthorization Act of 1999
23 and biennially thereafter, the Secretary shall submit to the
24 Committee on Resources of the House of Representatives
25 and the Committee on Energy and Natural Resources of
26 the Senate a report that—

1 "(1) describes the status of the national geo-
2 logic mapping program;
3 "(2) describes and evaluates the progress
4 achieved during the preceding 2 years in developing
5 the national geologic map database; and
6 "(3) includes any recommendations that the
7 Secretary may have for legislative or other action to
8 achieve the purposes of sections 4 through 7.".

9 **SEC. 9. AUTHORIZATION OF APPROPRIATIONS.**

10 The National Geologic Mapping Act of 1992 is
11 amended by striking section 9 (43 U.S.C. 31h) and insert-
12 ing the following:

13 **"SEC. 9. AUTHORIZATION OF APPROPRIATIONS.**

14 "(a) IN GENERAL.—There are authorized to be ap-
15 propriated to carry out this Act—
16 "(1) $28,000,000 for fiscal year 1999;
17 "(2) $30,000,000 for fiscal year 2000;
18 "(3) $37,000,000 for fiscal year 2001;
19 "(4) $43,000,000 for fiscal year 2002;
20 "(5) $50,000,000 for fiscal year 2003;
21 "(6) $57,000,000 for fiscal year 2004; and
22 "(7) $64,000,000 for fiscal year 2005.
23 "(b) ALLOCATION OF APPROPRIATIONS.—Of any
24 amounts appropriated for any fiscal year in excess of the
25 amount appropriated for fiscal year 2000—

1 "(1) 48 percent shall be available for the State
2 component; and
3 "(2) 2 percent shall be available for the edu-
4 cation component.".

○

Mr. GIBBONS. This is the third iteration of legislation affecting the national cooperative geologic mapping program within the U.S. Geological Survey. In the 102nd Congress, our colleague Nick Rahall of West Virginia sponsored a bill which became law, establishing the NGMA. In passing that measure, Congress voted for the practice of the USGS using a portion of its apropriation for geologic mapping to support the various State geologic surveys in cooperative efforts to prioritize national and State needs and then to start in on the identified workload. The original bill was reauthorized and amended through this Subcommittee in 1997, and now we are here to review H.R. 1528, which seeks to reauthorize the program from fiscal year 2001 through 2005.

The cooperative geologic mapping program has been successful in my view because it is just that, cooperative. State geologic surveys and academia both have lots to offer the Federal survey in the way of geologic mapping expertise and the training of future field mappers, as well as strongly held views on where the most immediate mapping needs are. It is not a free ride for these groups; the NGMA has always required a 50-50 match of the Federal dollars passed through by the USGS, and a triage takes place in the form of a peer review panel before proposals are funded. Thus a good deal of scrutiny of projects occurs before either State or Federal appropriated dollars are committed.

As we will hear from today's witnesses, the components of this bill remain the same as its precursors, Federal, State and educational. What is new, it seems to me is the willingness of the administration to support a renewed emphasis on the most basic role of the USGS, making maps of the geologic framework of our country. I find this attitude refreshing, but I also realize it is one thing for the Office of Management and Budget to clear testimony in support of the authorization levels in H.R. 1528 and yet another thing for the President's budget submission to Congress next February to actually ask for the increase in funds so authorized. I trust that the folks at the Department of the Interior who are already beginning to conjure up the fiscal year 2001 budget request are focusing in on the USGS's unwavering support for this bill and the benefits it brings to have modern geologic maps and adequate scales to protect our citizens from geologic hazards and ground water contamination or to broadly assess the mineral potential of our Federal lands or to otherwise utilize knowledge incorporated in a geologic map to make sound land use decisions.

I would like to say that I am one of the cosponsors of this legislation, and I don't want that to unnecessarily influence my colleague here, but I now turn to the Ranking Democratic Member, Mr. Underwood, for any opening statements that he may have.

Mr. Underwood.

[The prepared statement of Mrs. Cubin, offered by Mr. Gibbons, follows:]

STATEMENT OF HON. BARBARA CUBIN, A REPRESENTATIVE IN CONGRESS FROM THE STATE OF WYOMING

The Subcommittee on Energy and Minerals meets today to take testimony on a bill to reauthorize and amend the National Geologic Mapping Act. This is the third iteration of legislation affecting the national cooperative geologic mapping program within the U.S. Geological Survey. In the 102nd Congress our colleague Nick Rahall

of West Virginia sponsored the bill which became law establishing the NGMA. In passing that measure, Congress voted for the practice of the USGS using a portion of its appropriation for geologic mapping to support the various state geological surveys in cooperative efforts to prioritize national and state needs, and then to start in on the identified workload. The original bill was reauthorized and amended through this Subcommittee in 1997, and now we are here to review H.R. 1528 which seeks to reauthorize the program from Fiscal Year 2001 through 2005.

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STATEMENT OF HON. ROBERT A. UNDERWOOD, A DELEGATE IN CONGRESS FROM THE TERRITORY OF GUAM

Mr. UNDERWOOD. Thank you, Mr. Chairman. You always unduly influence me.

I am pleased to welcome the panel of witnesses today who are here to discuss reauthorization of the Geologic Mapping Act. We need geologic mapping in our society for many worthwhile purposes, including emergency preparedness, environmental protection, land use planning and resource extraction. Over the years, the need for geologic maps has grown steadily, but map production has not kept up. The Earth provides the physical foundation for our society. We live upon it and we use its resources. Therefore, we need to work towards a better understanding of the Earth's resources and potential dangers.

Geologic maps are one effective way to convey the Earth science information needed for better understanding and decision-making by all of us—Federal agencies, State and local governments, private industry, and the general public alike.

The National Geologic Mapping Act of 1992 authorized a national program of geologic mapping to be accomplished through a partnership with State geologic surveys, academia, the private sector, and the USGS. This partnership is essential if we are to develop the extensive amount of material needed for informed decision-making.

Mr. Chairman, I look forward to hearing the testimony of today's witnesses.

[The prepared statement of Mr. Underwood follows:]

STATEMENT OF HON. ROBERT A. UNDERWOOD, A DELEGATE IN CONGRESS FROM THE STATE OF GUAM

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I look forward to hearing the testimony of today's witnesses.

Mr. GIBBONS. I thank the distinguished Ranking Democratic Member on the panel.

I would now like to introduce the first panel that is before us here. Dr. Patrick Leahy, chief geologist for the U.S. Geological Survey, testifying for the Department of the Interior; Dr. Larry D. Woodfork, State Geologist of West Virginia testifying for the West Virginia Geological and Economic Survey and the Association of American State Geologists; and Dr. William A. Thomas, Professor of Geosciences at the University of Kentucky testifying for the American Geological Institute.

Gentlemen, I know that we have invited you here under the guidelines of having up to 10 minutes for your testimony. Let me encourage you that if there is anything that you can do to expedite this, to make this matter go quickly, it would be appreciated. And also your full statements will be entered into the record without objection.

The Chair would now recognize Dr. Leahy.

STATEMENT OF DR. P. PATRICK LEAHY, CHIEF GEOLOGIST, U.S. GEOLOGICAL SURVEY, U.S. DEPARTMENT OF THE INTERIOR

Dr. LEAHY. Thank you, Mr. Chairman. I am pleased to be here today to express the Administration's support for geologic mapping, House bill 1528 and Senate bill 607. These are identical bills that would reauthorize the National Geologic Mapping Act of 1992.

I would like to begin by emphasizing the close coordination and agreement between the U.S. Geological Survey and the Association of American State Geologists on this reauthorization bill and on geologic mapping in general. With the development of digital mapping technology, geologic mapping has experienced a renaissance in both its use and applicability.

The reason for this growth is quite simple. Geologic maps are increasingly needed to bring together and interpret information about the Earth. Geologic maps are used by land, water and other natural resource managers at Federal, State and local levels and by the private sector to achieve the most efficient use of the Earth's resources. Economic growth, as you know, is driven largely by access to the Earth is resources. Geologic maps provide the spatial

framework to locate energy, construction materials and other mineral resources. They also constitute the framework to locate and monitor the cleanliness and availability of groundwater resources.

To the extent possible, humans must be safe from natural hazards. Although earthquakes, volcanic eruptions, landslides and floods cannot be stopped, recognizing and planning for these dangers significantly minimizes the damages and costs of disasters. Identifying the location of hazardous areas on geologic maps allows land managers, industry and the public to predict potential losses and to develop strategies to mitigate these impacts.

Unlike topographic maps, which show the elevation of the Earth's surface, geologic maps display the array of different types of soils, sediments and rocks that are present both at and below the surface of the Earth. Advances in computer technology and the development of Geographic Information Systems, permit map users to display and analyze map information in three dimensions. This ability allows non-geologists to understand and use geologic maps more readily, which has further increased the demand.

There are three components of the program and all three components contribute to the construction of the National Geologic Map database. The initial phase of the database is an Internet-based catalogue of printed geologic maps.

The second phase of the project is under way to adopt standards for GIS use and to provide access and delivery of digital geologic map data on the Internet. Through the three components that you mentioned, the program conducts geologic mapping in all 50 States.

In concluding my remarks, I would like to state for the record that the National Geologic Mapping Act has been instrumental in helping focus attention on the Nation's need for a new generation of high-quality geologic maps. The Administration supports reauthorization and urges support for this legislation.

Thank you, Mr. Chairman, for the opportunity to express my views and those of the Geologic Survey on the benefits of the Mapping Act and the value of reauthorizing this program. I will be happy to answer any questions that you might have.

Mr. GIBBONS. Thank you very much, Dr. Leahy. I appreciate your testimony. It was very helpful and we are also very glad to see the administration in such strong support of the reauthorization Act.

[The prepared statement of Mr. Leahy follows:]

STATEMENT OF PATRICK LEAHY, CHIEF GEOLOGIST, U.S. GEOLOGICAL SURVEY, U.S. DEPARTMENT OF THE INTERIOR

Madam Chairwoman, I am pleased to be here today to express the Administration's support for H.R. 1528 and S.607, identical bills that would reauthorize the National Geologic Mapping Act of 1992.

I would like to begin by emphasizing the close coordination and agreement between the USGS and the Association of American State Geologists (AASG) on this reauthorization bill and on geologic mapping in general. The bill was reviewed by the Federal Advisory Committee for the National Cooperative Geologic Mapping Program in April of 1998 and we have been in close and frequent communication with the AASG on all aspects of the bill since that time.

The principal changes in this reauthorization bill are: First, an increase from approximately 20 percent to 48 percent of new funds that will be made available for matching-funds grants to State geological surveys, and second, an increase in the authorization levels. These changes are the result of an increased demand for geologic maps and a renewed emphasis by the USGS on one of our most basic mission

responsibilities: producing objective and authoritative geologic maps and information systems, and represent an increased capacity of the States to provide matching funds. The authorization levels contained in the bill are not assumed in the Administration's current outyear funding levels and represent a significant challenge in terms of acquiring, in the years to come, the necessary resources through the Administration and Congressional budget and appropriations process.

At recent public forums in Alaska, California, Indiana, Ohio, and Virginia, and in opinion surveys conducted by State geological surveys, we have heard a consistent message—more geologic mapping is needed, and geologic mapping is considered as a principal strength and responsibility of the USGS and our State survey partners. In response, the President's FY 2000 budget proposes an increase of approximately 8 percent in funding for the Geologic Mapping Program.

With the development of digital mapping technology, geologic mapping is experiencing a renaissance in its use and applicability. We anticipate increased demand for digital geologic maps in the future. The reason for this growth is simple, geologic maps are increasingly needed to bring together and interpret information about the Earth. Geologic maps are used by land, water, and natural resource managers at the Federal, State and local levels of government and by the private-sector to achieve the most efficient use of Earth resources in a way that is at once both sustainable and economically viable.

The economy is driven by access to the Earth's resources, among other things. Geologic maps provide the spatial framework to locate energy resources such as coal, petroleum, and natural gas; construction materials such as sand, gravel, limestone, and building stone; soil and rock types that enhance agricultural productivity; and metals and other mineral resources as diverse as gold and fertilizer. They also constitute the framework to locate and to monitor the cleanliness and availability of our ground-water resources.

To the extent possible, humans must be safe from natural hazards. Although hazardous events such as earthquakes, volcanic eruptions, landslides and floods cannot be stopped, recognizing and planning for these dangers significantly reduces the damages and costs of disasters. Identifying the location of hazardous areas on maps allows land managers, industry, and the public to predict potential losses, and develop strategies to minimize these losses. Geologic mapping is the principal means for discovering and recording areas that will be affected by natural hazards and geologic maps and Geographic Information Systems are the principal means for communicating the dangers and risks.

Unlike topographic maps, which show the elevation of the earth's surface and can increasingly be produced using remote sensing methods, geologic maps display the array of different types of soils, sediments, and rocks that are present at and below the surface of the Earth. Advances in computer technology and the development of Geographic Information Systems permit map users to display and analyze map information in three dimensions. This new ability to visualize geologic map information allows non-geologists to understand and use geologic maps more readily, which has further increased demand.

The geologic map has been a keystone product of the U.S. Geological Survey through its 120-year history. As reflected in the President's FY 2000 budget proposal, the USGS is again making geologic mapping a high priority. The Geologic Mapping Act of 1992 anticipated the increased demand for geologic mapping, and the reauthorization bill before this Committee will assist USGS and our partners in the States and Universities in responding.

To meet the need for new maps, our response must be coordinated with both those who use geologic maps and those who produce them. The broadest range of stakeholders must determine what information is needed so that our mapping efforts are well targeted. All of those who prepare geologic maps, from the U.S. Geological Survey to State geological surveys and the academic community, must work cooperatively to maximize each other's strengths and to avoid duplication. It is in this cooperative spirit that the National Geologic Mapping Act was written, and under which the National Cooperative Geologic Mapping Program was built.

NATIONAL COOPERATIVE GEOLOGIC MAPPING PROGRAM

The National Cooperative Geologic Mapping (NCGM) Program was established by the National Geologic Mapping Act of 1992. Through involvement with private industry, policy makers, and the public, the program seeks to ensure that mapping efforts are focused on priority areas. The program uses stakeholder input to determine what formats are most needed as new geologic maps are being produced in digital formats and indexed for delivery on the Internet. The NCGM Program has been designed so that the Nation will have the accurate geologic maps needed to address tomorrow's problems. To this end, the following goals are being pursued:

- Continued enhancement of outreach to stakeholders ensures that our maps address societal priorities and are produced at appropriate scales and in forms that are easily accessible and usable. For example, on February 24, 1999, the NCGMP participated in three separate public stakeholder meetings to discuss the availability and quality of water resources in New Mexico, the value of 3-dimensional earth science information for the Great Lakes Region, and the mitigation of geologic hazards in the Pacific Northwest. The net effect of this enhanced outreach is the design of geologic mapping projects that address high-priority issues and the incorporation of local and regional priorities into a national agenda for geologic mapping,
- Expanded cooperative mapping with the State geologic surveys and academic institutions, and expanded cooperation with other Federal agencies, and private-sector firms to enhance the usefulness of map information and data.Development of metadata (data about data) for the National Geologic Map database and development of standards and data models to make geologic maps accessible through the Internet.

The NCGMP supports the Mapping Act through three main components FEDMAP, STATEMAP, and EDMAP. Since its authorization by the National Geologic Mapping Act in 1992, the Geologic Mapping Program has worked with the States and Universities of the nation to produce more than 4,000 new maps and related scientific reports for high-priority areas in virtually every state of the Union. However, the job is far from complete. The 7.5 minute-geologic quadrangle map is the common denominator for Federal and State mapping, and this scale of work is widely accepted as the starting point for more detailed site-specific studies conducted by private industry. However, there are more than 50,000 such quadrangles across the nation, and high-priority areas must be re-mapped periodically to incorporate new scientific concepts, new technology, and new demands from the public. For example, most of the geologic mapping in the upper Mid-west was done more than 80 years ago, less than 2 percent is available at the 7.5 minute quadrangle scale, and an even smaller fraction is available in modern digital formats.

Early generations of geologic mapping were focused on locating mineral resources. This remains a focus in many areas of the country. However, the missions of the Federal and State geological surveys and the needs for geologic maps have expanded. For example, we are now making three-dimensional geologic maps to meet the needs of a nation that is increasingly turning to ground water for drinking, agricultural, and industrial uses.

The Federal-mapping component (FEDMAP) currently consists of 18 regional geologic mapping and synthesis projects. Government and private-sector clients and cooperators are involved in planning new FEDMAP projects. The NCGMP has increased interactions with other USGS programs and with State survey partners during the last four years in order to share expertise, leverage financial resources, and to respond directly to customer needs. Due to this change, the scientific emphasis of the program has shifted to issues that increasingly affect society and human health such as:

- Discovery and protection of ground water
- Identification and mitigation of natural hazards
- Assessment of our nation's mineral and energy resources
- Establishment of scientific baselines for environmental restoration
- Land resource assessment in support of infrastructure needs

The State mapping component, STATEMAP, awarded 3.8 million dollars to 45 states in FY 1999, a record number, and every Federal dollar was matched by a State dollar. The awards will fund more than 150 geologic mapping projects. State Mapping Advisory Committees met in all forty-five states during 1998 to help the Mapping Program prioritize geologic mapping needs. Over 500 individuals from Federal, State, and local government, academia, industry, and geoscience consulting firms, participated in these meetings. In addition, where the priorities of FEDMAP, STATEMAP, and EDMAP geologic mapping projects align well, regional coalitions have formed and resources are leveraged to maximize efficiency and benefit to the public.

The university-mapping component, EDMAP, is the matching-funds educational program with universities to train a new generation of geologic mappers. In FY-1999 EDMAP awarded approximately 380 thousand dollars to 60 geology students at 41 universities and colleges. Again, each Federal dollar was matched. Our effort to help geologic mappers has grown stronger each year. This year's proposals showed that the students and their faculty advisors are working more closely with mapping projects at State geological surveys and the USGS. Student mapping is tied more directly to societal needs than in the past, and more of these maps are being published by state geological surveys.

National Geologic Map Database

All three components of the National Cooperative Geologic Mapping Program contribute to the construction of the National Geologic Map Database. The initial phase of the database is an Internet-based catalog of printed geologic maps. The index is available on the Internet at http://ngmdb.usgs.gov and is being populated with metadata (approximately 55 percent of USGS holdings are completed as of April, 1999). The second phase of the project is underway to adopt standards for GIS use and to provide access and delivery of digital geologic map data on the Internet. This is an area of continued emphasis in FY 1999 and increased effort in FY 2000. The USGS is currently working with both producers and users of geologic map information to develop draft format, symbols, and technical attribute standards so that digital geologic map information can be accessed, exchanged, and compared efficiently as part of the National Spatial Data Infrastructure.

Federal Partnerships

The geologic mapping program is developing cooperative relationships with Federal partners in addition to our State and academic cooperators. The most mature of these is with the National Park Service (NPS). In 1995, the USGS and NPS signed a Memorandum of Understanding that outlined areas of interaction between the two bureaus. The geologic mapping program has responded by working with NPS as part of their "Science in the Parks" initiative to direct a portion of the program's geologic mapping and supporting activities toward priorities established by NPS. This cooperative program has continued each year since 1995. NPS-identified priorities are merged with USGS capabilities in FEDMAP projects that create geologic maps and related interpretive products to serve the 286 million annual visitors to our Nation's parks.

We are currently conducting geologic mapping projects in partnership with NPS at more than a dozen Parks. For example, at Death Valley National Park in California, we are partnering with NPS, the Department of Energy, and Nye County by making geologic maps as the three-dimensional framework for modeling the ground-water system that originates in central Nevada, flows under the Nevada Test Site and terminates in Death Valley. In Shenandoah and Great Smoky Mountains National Parks we are making geologic maps that show the widespread distribution of landslide hazards and the impacts of landslides on mountain stream habitats for trout. And at a variety of Parklands across the Nation we are making geologic maps to assist the NPS explain the geologic treasures of the Parks to a curious and appreciative public.

Examples of Geologic Mapping Projects

I would like to cite a series of our geologic mapping projects on a State-by-State basis and give a brief description of the reasons for the mapping in each case. Because this is a national program, with projects in virtually every state, it is a simple matter to select examples that may have particular meaning to the membership of this Committee.

California:

FEDMAP and STATEMAP efforts are defining the structure and history of the San Andreas Fault system and its relation to earthquake hazards in the Los Angeles and San Francisco Bay areas. Detailed geologic maps produced by these efforts help to define seismic hazard zones, enabling local governments to plan accordingly. FEDMAP projects are also mapping ground-water basins in three-dimensions to support the water resource needs of the populous desert region of the state.

Colorado:

STATEMAP funds support geologic mapping in the Colorado Springs and Idaho Springs areas where areas of geologic hazards such as landslides, rockfalls, swelling soils, and subsidence over underground mines are being mapped. Our FEDMAP project and the Colorado Geological Survey are evaluating landslides, subsidence and infrastructure resources along the developing I-70 and Front Range corridors, and assessing sources for salt in the Colorado River.

Louisiana:

Our STATEMAP project supports geologic mapping of the Baton Rouge area where a detailed knowledge of active faults is necessary to protect critical aquifers from contamination and to aid in siting of solid-waste repositories. EDMAP projects in Louisiana supported the training of three students at Centenary College of Louisiana and the University of New Orleans.

Oregon:

A FEDMAP project is mapping the earthquake-prone urban corridor of western Oregon and Washington. The project locates earthquake faults and defines areas that are susceptible to liquefaction, ground failure, and damage during earthquakes. Availability of ground water, forest health, and seismic and landslide hazards are principal issues addressed by STATEMAP projects in Klamath Falls, the upper Grand Ronde Basin, and the central Willamette Valley. An EDMAP project at Portland State University is investigating surface and subsurface water interaction in the upper Williamson River.

Nevada

FEDMAP Projects in Death Valley and the Las Vegas Urban Area are investigating geologic controls on regional ground-water resources in southern Nevada and the potential for contamination as the result of underground nuclear testing at the Nevada Test Site. These projects are conducted cooperatively with the Department of Energy, National Park Service, Fish and Wildlife Service and programs within the Water Resources Division of USGS.

Rhode Island

Bedrock and surficial geologic maps of Rhode Island are included as part of the National Cooperative Geologic Map Database. The database is an effort coordinated jointly by the NCGMP and the Association of American State Geologists (AASG). The database is available over the World Wide Web and allows anyone easy access to detailed geologic map information across the Nation.

Texas

STATEMAP efforts are aimed at defining the extent of the Edwards karst aquifer and evaluating source areas for potential contaminants. The aquifer is the principal source of water for communities in south central Texas that are experiencing rapid growth. Information gained from these efforts will meet the needs of a variety of professionals that respond to the demands placed on the environment and resources of Texas.

Utah

In cooperation with the U.S. Forest Service, the Natural Resources Conservation Service, and the State Division of Water Resources, the NCGMP is supporting geologic mapping of the Ogden Quadrangle. The area is characterized by active faults and landslides that will be evaluated. The detailed STATEMAP product will update the previous mapping completed in 1963. The geologic data will form the foundation for a comprehensive Geographic Information System database for the area.

Washington

A FEDMAP Project is a key component in the USGS Urban Hazards Initiative in the Puget Sound region, which is coordinated with FEMA's Project Impact study of Seattle. The NCGMP project role is mapping and defining the regional geology work and fault structure to better understand earthquake and landslide hazards.

Wyoming:

Geologic mapping of the Lander/Riverton area is underway by our STATEMAP project. This area was targeted for increased emphasis by the Wyoming Business Council to promote economic development. Geologic mapping is also being done in a number of areas where Environmental Protection Agency and the Wyoming Geological Survey are studying aquifer vulnerability to contamination from pesticides.

Conclusion

Madam Chairwoman, in concluding my remarks, I would like to state that the National Geologic Mapping Act of 1992 has been instrumental in helping focus attention on the Nation's need for a new generation of high-quality geologic maps. The Administration supports reauthorization and urges bipartisan support for this legislation. Thank you, Madam Chairwoman for the opportunity to express the views of the U.S. Geological Survey on the benefits of the National Geologic Mapping Act and the value of reauthorizing this program. I would be happy to respond to any questions you may have.

Mr. GIBBONS. I turn now to Dr. Larry Woodfork for your testimony, sir.

STATEMENT OF DR. LARRY D. WOODFORK, WEST VIRGINIA GEOLOGICAL AND ECONOMIC SURVEY, AND PRESIDENT, ASSOCIATION OF AMERICAN STATE GEOLOGISTS

Dr. WOODFORK. Thank you, Chairman Gibbons.

I come before you as State Geologist of West Virginia and current President of the Association of American State Geologists. I have 35 years of experience in geoscience enterprise in academia, the private sector and government. The group that I am speaking for today, the Association of American State Geologists, represents a group that has been extant since 1908, composed of the State geologists in the 50 States, as well as those in equivalent positions in the territories, protectorates and possessions of the United States.

Over the 70-year period that this group has been extant, they have brought the very vital State perspective to geoscience issues facing the Nation. The State geological surveys—the very first geological survey was established in 1823 in North Carolina. When the Federal survey, the USGS, was established in 1879, there were already extant 35 geological surveys, 25 east of the Mississippi and 10 west.

In the intervening 120 years since the Federal survey was established, the State geological surveys have interacted continuously with the Federal enterprise, usually in a mutually beneficial and supportive role to promote the needs of the Nation and the products that fed the engines of the great enterprise that we enjoy today in the United States. The geological maps that were produced by both of those groups led to the economic development that largely—the publicly available information that allowed our Nation to grow and prosper out there.

The National Geological Mapping Act is the latest iteration of those mutually beneficial enterprises. I believe that most of my colleagues would share my view that over the years that is the best of the best. I will tell you why I think that to be the case. It is the one that has been most closely coordinated. It has resulted from joint planning, and the products that come out of it are prompt; you get a lot of bang for your buck.

The State map component, which I am going to spend a couple more minutes on, the one that I am the most familiar with, is one that I can absolutely attest to the fact that the priorities that are established within that component are set by State advisory committees within the respective States. They reflect real societal needs out there.

The advisory panels are composed of people from academia, the private sector, individual citizens, organizations. They reflect the real needs of society. The awards that are given under that—and it is a 50-50 match, and the States actually have much more money to ante up than has so far been advanced by the Federal Government, are awarded on a competitive peer reviewed process.

The national panel consists of State geologists and feds. There is strict accountability for the spending of those funds. If you don't produce, your proposal will not be received favorably the next time; I can assure you of that. I know many—it is certainly not an entitlement program.

There are many more proposals that are advanced than are ever funded. So, in summary, what I will tell you, in my experience, this

is a program that is an outstanding example of a successful State-Federal partnership to the benefit of the Nation. I would encourage you—and I know that you will hear on this Subcommittee from the State geologists in your respective States, specific examples of what I am telling you.

It is a great program. It has broad support, I know it does, throughout academia, industry and government. And I would urge you to act affirmatively and favorably on the reauthorization and amendment bill before you today and the Nation would be the benefit of your wisdom.

Thank you, and I will entertain any questions now or later if you would like.

Mr. GIBBONS. Thank you very much, Dr. Woodfork, and thank you again for your ringing endorsement of the State geologic surveys as the purveyors of Earth sciences and the guardians of geologic truth.

I also understand from some of the remarks that your 1-year sentence as the President of the Association of American State Geologists is almost up and you are about to be paroled, soon to allow, I believe, a Wisconsin State geologist to serve his time in your place.

I think all of us on this Committee want to wish you well and congratulate you for the hard work and service that you have given us in that regard.

With that, we will turn to our next panelist.

Dr. WOODFORK. Thank you, Chairman Gibbons.

Mr. GIBBONS. You bet.

[The prepared statement of Dr. Woodfork follows:]

STATEMENT OF LARRY D. WOODFORK, STATE GEOLOGIST OF WEST VIRGINIA AND PRESIDENT, ASSOCIATION OF AMERICAN STATE GEOLOGISTS (AASG)

Good afternoon, ladies and gentlemen. Madam chairman and members of the Subcommittee on Energy and Mineral Resources of the U.S. House of Representatives Committee on Resources, thank you for providing me the opportunity to appear before you today in support of H.R. 1528, a bill to reauthorize and amend the National Geologic Mapping Act of 1992.

My name is Larry D. Woodfork. I am the State Geologist of West Virginia and the current president of the Association of American State Geologists (AASG) (attachment A). Our organization was founded in 1908 and represents the geological surveys of the 50 states of our nation as well as those in its territories, possessions, and protectorates (attachment B). Over the past 91 years, our organization has brought the critical state perspective on geoscience issues facing the nation to the attention of the Federal Government. We cherish the trust and confidence placed in us when we are given the opportunity to share our perspective with you, and we zealously guard our well-earned reputation for geological expertise, integrity, candor, and fidelity. In public applied geoscience, state geological surveys are truly "where the rubber meets the road!"

Since the establishment of the first state geological survey in 1823 in North Carolina, state geological surveys have played a unique and vital role in the scientific establishment in our country. They have provided much of the publicly available geological information that led to the national growth, economic development, environmental quality, general prosperity, and quality of life that we enjoy today. Their mission remains of equal importance to our nation's future.

State geological surveys had already been established in 35 states prior to the establishment of the U.S. Geological Survey (USGS) in 1879. Over the past 120 years, the state geological surveys and the USGS have interacted nearly continuously, usually in a cooperative and mutually beneficial manner to, jointly and separately, provide the nation and its citizens with relevant, credible, and timely geologic maps, information, and expertise on energy, mineral, water, land, biological and environmental resources, as well as on geological hazards such as earthquakes, volcanoes,

landslides, and the like. No other external organization has the institutional memory or in-depth knowledge of U.S. Geological Survey programs that we in AASG possess.

The long history and heritage of USGS-state geological survey interaction and collaboration in geoscience is replete with a multitude of successful and beneficial joint programs and projects. Among the myriad examples of such programs, however, the consensus of my colleagues within AASG, and generally throughout the entire geoscience community, would be that the National Cooperative Geological Mapping Program (NCGMP) represents the "best of the best." Over the past seven years, it has provided the nation with a multitude of new critically needed geologic maps in the most effective and cost-efficient manner. It has become the model for joint planning, close coordination, and prompt delivery of products. It's a great state-Federal partnership success story in which we can all take justifiable pride!

Because the reauthorization and amendment bill before you today has been jointly crafted and closely coordinated between the U.S. Geological Survey and our association (AASG), it represents the latest step in the continuing evolution of the program and encompasses significant improvements in what was already a good program with a solid reputation and widely acknowledged record of cost-efficient high productivity of critically-needed, mission-oriented products.

The recommended reauthorization funding levels as amended and percentages in the proposed legislation were similarly arrived at through joint deliberation based on past experience, future needs, and capabilities. They are honest, uninflated, fair, realistic, and verifiable funding figures required to continue and advance the program to an optimal level. There is no "smoke and mirrors," no "fat nor fluff," no "waste, fraud, or abuse" in the reauthorization and amendment recommendations.

I am sure that many, if not all, of you on the Subcommittee have already heard directly from, or will shortly hear from, the state geologists in your respective states concerning the value of the National Cooperative Geologic Mapping Program to your state with numerous specific examples. I am equally sure that my Federal colleagues within the U.S. Geological Survey have provided, or will provide, you with additional details and specifics concerning various aspects of the program, its several components, proposed funding levels, etc. Because I know that there is broad support for the program within the overall geoscience community throughout the nation, I'm sure you will also receive positive feedback and support for the program from numerous professional and scientific organizations as well as from academia, the private sector, and the many users of geologic maps. I note that representatives from academia as well as the USGS are on the docket today. The reason for such broad support for reauthorization and amendment of the program is clear, simple, and unequivocal. Reauthorization and amendment at the proposed levels will enhance and continue an excellent cooperative Federal-state program, and grow it into an optimal one clearly necessary to meet the societal challenges we face in the new millennium.

Before I close, let me make a couple of very important points about the part of the National Cooperative Geologic Mapping Program that I am personally most familiar with: the STATEMAP component. That is the part of the program under which state geological surveys match state dollars with Federal dollars to conduct prioritized, strategically-targeted geologic mapping to meet current and anticipated societal needs. The resultant geological maps serve very practical purposes: they identify needed resources (energy, minerals and water); they identify natural hazards so they might be avoided or their impact mitigated; and they provide very important basic information requisite for sound land use, environmental management, and ecosystem considerations. Such considerations and their enlightened resolution are key to maintaining our preeminence as a nation and an international leader and power.

It should be noted that STATEMAP project priorities are set by state advisory committees consisting of representatives of all user groups: the private sector, government, academia, industry, citizens—the entire spectrum of users of geologic maps. Therefore, they reflect real, pressing societal needs determined at the state and local level, not merely curiosity driven research projects (not that such projects are necessarily without merit).

Lastly, but not of lesser importance, funding for STATEMAP projects among the participating state geological surveys is awarded on a competitive basis through a rigorous peer-review process. The national review panel that ultimately reviews proposals and allocates funding is composed of state geologists and USGS personnel who follow rigorous, mutually agreed-upon guidelines, priorities and procedures. STATEMAP is definitely not an entitlement program. Not all proposals are funded, as I can personally attest.

To summarize, let me state forthrightly and with complete confidence that H.R. 1528, reauthorization and amendment of the National Cooperative Geologic Mapping Act of 1992, is a critical investment in our country's future that we simply cannot afford to pass up! The nation's need for geologic maps is clear and compelling and the National Cooperative Geologic Mapping Program provides the best mechanism to meet that need. Its reauthorization and amendment by H.R. 1528 fully merit your support. Your constituents and the entire nation will be the beneficiary of the wisdom of your affirmative action.

Thank you for considering my views and recommendations. Should you have any questions now or later, I'll be happy to answer them.

Mr. GIBBONS. Dr. William Thomas, the floor is yours.

STATEMENT OF DR. WILLIAM A. THOMAS, PROFESSOR OF GEOSCIENCES, UNIVERSITY OF KENTUCKY, ON BEHALF OF THE AMERICAN GEOLOGICAL ASSOCIATION

Dr. THOMAS. Thank you, Mr. Chairman. I am pleased to speak as an active participant in the EDMAP program on behalf of the reauthorization of the National Geologic Mapping Act. My own work emphasizes field geology and three-dimensional interpretations from geologic maps. I have been active in directing graduate students in geologic mapping in the EDMAP program since its inception.

I am also here to express the support of the American Geological Institute for this important legislation. I currently serve as Treasurer of AGI, which is a nonprofit federation of 34 geoscience societies with a total membership of more than 100,000.

AGI's mission emphasizes geoscience education and public awareness of geosciences. We are currently preparing a booklet for public information on the applications of geologic maps to human needs.

An extreme special need for geologic maps arose during the Second World War when the demands of the war effort and disruption of normal import channels threatened the supply of strategic minerals. An intense program of geologic mapping was instituted, and because of the urgent needs, some geologists who otherwise would have been eligible for the military were deferred and assigned to the mapping project.

Normal depletion of natural resources does not reach the crisis level of a world war, but systematic mapping will support our long-range planning to sustain supplies of essential raw materials that fuel our national economy.

Geologic mapping is a long-term investment in our economy because geologic maps portray the spatial distributions of rocks and surficial materials that contain the natural resources which drive our industry. A single corporation cannot make the up-front investment of time and money to construct geologic maps of large regions such as whole States. But when geologic maps are available, the corporation can focus on areas selected for resource potential from the maps.

For example, the massive construction and preparation for the 1996 Olympic Games in Atlanta severely stressed the local supply of cement. Geologic maps served to focus an efficient search for additional limestone suitable for cement manufacture.

To illustrate another application of geologic maps, I want to tell you about an EDMAP project. The Girl Scout camp near Rome, Georgia, operated for many years as a primitive camp using water

from a large spring. Later the camp was modernized with indoor plumbing necessitating a septic tank and bleeder field. In the absence of a detailed geologic map, the septic field was placed on an area of exposure of what later turned out to be the aquifer that fed the spring, and illnesses developed at the camp soon thereafter. Subsequent testing showed that water from a flushed toilet reached the spring through the aquifer in less than 48 hours.

That same aquifer is important as a domestic water supply in a large area, and my student, with EDMAP support, made a geologic map of the aquifer and related rocks. Now, the recharge area is clearly delineated, and protection from contamination can be planned.

Let me show you our EDMAP product from the past year. This colorful map accurately shows the distribution of rock types at the surface in an area of complex geology. The rock layers represented by the bright blue color on the map form the primary groundwater aquifer that is used for domestic water supplies. The map includes measurements that enable us to geometrically project the depth of a specific rock layer below ground, as illustrated in these cross sections. Using the map, we can identify the area where the aquifer is at the surface and must be protected from contamination, and we can calculate the necessary depth to drill a water well.

These projects exemplify the dual objectives of EDMAP, training of future mappers and producing geologic maps. More than 40 institutions participate in EDMAP each year. From 1996 to 1999, EDMAP has awarded nearly $1.5 million to 84 different universities in 43 States and the District of Columbia. Federal funds have been matched, dollar for dollar, by these universities, yielding a total investment in geologic mapping of approximately $3 million. Proposals for EDMAP projects are coordinated with priorities of State geological surveys or the USGS, and the proposals are reviewed by a national panel of representatives from universities, State surveys, and USGS.

I currently serve on the panel, and I can attest to the high quality and careful planning exhibited in these proposed projects. This year well-qualified proposals with well-justified budget requests substantially exceeded the available funds.

The tangible products of EDMAP are geologic maps. The ED part, however, is really fundamental to the program. In recent years many academic institutions and funding agencies have come to emphasize laboratory science rather than field geology and mapping. As a result, the number of geologic mappers being trained by university geology departments has declined. At the same time, increasing needs for the geologic maps that provide information essential to sustain our economy and environment now require a more systematic approach to the education of geologic mappers for the future. We simply must not lose the ability to make geologic maps.

EDMAP represents a clear national incentive to expand our educational efforts in geologic mapping, and it attracts students to the topic. A well-done geologic map provides a wealth of information as a basis for development of resources that fuel our economy and for protection of our living environment. The making of a geologic map requires a particular educational background, and EDMAP sup-

ports that education. I am convinced and I hope I have convinced you of the vital role of EDMAP and the National Geologic Mapping Act.

I would be pleased to answer any questions you have.

Mr. GIBBONS. Thank you very much, Dr. Thomas.

[The prepared statement of Dr. Thomas follows:]

STATEMENT OF WILLIAM A. THOMAS, M.S., PH.D., PROFESSOR OF GEOSCIENCES, UNIVERSITY OF KENTUCKY ON BEHALF OF THE AMERICAN GEOLOGICAL INSTITUTE

Madam Chair and Members of the Subcommittee:

I am pleased to be here today to speak as an active participant in the EDMAP program on behalf of reauthorization of the National Geologic Mapping Act of 1992. My name is William A. Thomas. I am Professor of Geological Sciences at the University of Kentucky, where I have just developed a new course in basic geosciences for undergraduate students in science, engineering, agriculture, and science education. A primary emphasis of that new course is on the use of geologic maps in solving real problems in the respective disciplines of the students. My own research and that of graduate students whose research I have directed is in field geology with emphasis on three-dimensional interpretations from geologic maps. I have been active in directing graduate students in geologic mapping in the context of the EDMAP component of the U.S. Geological Survey (USGS) National Cooperative Geologic Mapping Program since its inception.

I am also here to express the support of the American Geological Institute (AGI) for this important legislation. I currently serve as Treasurer on the Executive Committee of the Institute, which is a nonprofit federation of 34 geoscientific and professional associations that represent more than 100,000 geologists, geophysicists, and other Earth scientists. Founded in 1948, AGI provides information services to geoscientists, serves as a voice for shared interests in our profession, plays a major role in strengthening geoscience education, and strives to increase public awareness of the vital role the geosciences play in mankind's use of resources and interaction with the environment. I am currently working with others in AGI to prepare a booklet for public information on the applications of geologic maps to human needs.

Perhaps no greater testimony to the crucial nature of geologic maps can be found than the strategic minerals mapping program during World War II. The demands of the war effort and the disruption of normal import channels threatened the adequacy of the supply of vital minerals. In order to locate undiscovered essential resources, a focused program of geologic mapping was instituted, and the urgency of the circumstances is reflected in the fact that some geologists, who were otherwise military-eligible, were deferred and assigned to the mapping effort. Although the normal depletion of natural resources does not reach the crisis-level crescendo of a world war, a program to systematically map and assess resource potential will allow the best possible long-range planning to sustain the supplies of necessary raw materials that fuel our national economy.

Geologic mapping is a long-term investment in the future of our economy, because most manufacturing depends upon natural resources from geologic materials, and geologic maps portray the spatial distributions of rocks and surficial materials that hold those resources. A typical user of natural resources, generally a corporation, cannot make the up-front investment of time and money to construct geologic maps of large regions such as whole states. However, when geologic maps are available, the corporate research effort can be focused on smaller areas which can be selected for their resource potential from the maps. In other words, the availability of a geologic map provides the information base that enables private investment to locate and develop resources. For example, the massive construction in preparation for the 1996 Olympic Games in Atlanta, Georgia, severely stressed the local supply of cement. Available geologic maps were sufficiently detailed to generally focus the search for additional limestone suitable for cement manufacture; however, it was quickly realized that more detailed maps were needed for this specialized purpose. The scale of geologic maps prepared through the EDMAP program is suitable for this kind of resource development.

I could provide similar examples of other applications of geologic maps in, for example, coal-mine planning, oil and gas exploration, assessment of landslide hazards, and exploration for metals. Instead, I want to tell you about an EDMAP project with which I was involved and the application it addressed. A Girl Scout camp near Rome, Georgia, operated for many years as a primitive camp, using water from a large spring. In due course, although continuing to use the spring as a water supply, the camp was modernized with indoor plumbing, necessitating a septic tank and

bleeder field. In the absence of a detailed geologic map, the septic field was placed on the area of exposure of the aquifer that fed the spring, and illnesses developed soon thereafter. Subsequent testing showed that water from a flush toilet reached the spring through the aquifer in less than 48 hours. The same aquifer is important as a domestic water supply in a large area around Rome, and my student Aaron Baldwin with EDMAP support and University of Kentucky matching funds made a geologic map of the aquifer and related rocks, so the recharge area is clearly delineated, and protection from contamination can be planned. This project illustrates the best of EDMAP. We developed our mapping plan in coordination with priorities of the geological survey of Georgia. The student received an education in the techniques of geologic mapping, interpretation of the underground three-dimensional extent of a particular rock, and the design of a research project to solve a problem. The finished map has been provided to USGS.

Let me show you our EDMAP product for the past year. This is a geologic map of an area northwest of Fort McClellan in Alabama. Springs supply the water for several towns in the area, and in addition to the standard observations in making a geologic map, my student Greg Graham located the larger springs in the context of rock types and geologic structures. Perhaps the colorful map does look like a piece of modem art, but it accurately shows the distribution of rock types at the surface in an area of complex geologic structures. Of particular importance, the map includes carefully measured angles of dip of the rock layers, so that rocks exposed at the surface can be geometrically projected below ground. Using this kind of data, we can calculate the depth necessary to drill to a particular rock layer at any particular locality. This is important in developing groundwater resources. For example, the rocks represented by the bright blue color on the map form the primary groundwater aquifer that is used for domestic water supplies in this part of Alabama. From the map we get two important pieces of information: (1) we can identify the area where the aquifer is at the surface and must be protected from contamination; and (2) for the many farms that use well water, we can predict the necessary depth to drill. My student who made this map learned the mapping techniques, as well as the interpretation of the rocks at depth; and we have provided the map to the USGS and the Alabama Geological Survey to be publicly available. This project exemplifies the dual objective of EDMAP: training of future mappers, and producing geologic maps. Greg Graham completed his M.S. degree a few weeks ago, and last week I provided a reference interview for the U.S. Forest Service in consideration of that agency's hiring this new graduate to map landslide potential in the Klamath Mountains.

Mine is but one of more than 40 institutions participating in EDMAP each year. In fiscal year (FY) 1999, EDMAP provided $382,150 to support mapping projects by 60 students in 41 universities in 29 states and the District of Columbia. From 1996 to 1999, the USGS has awarded $1,487,276 to 84 universities in 43 states and the District of Columbia; Federal funds have been matched on a dollar-for-dollar basis by these universities, for a total investment of approximately $3 million. EDMAP has been funded at the authorized percentage (2 percent of program funds) since 1996. Proposals for EDMAP projects are coordinated with a state geological survey or USGS, and proposals are reviewed by a national panel of representatives from universities, state geological surveys, and USGS. I currently serve on the review panel, and I can attest to the high quality and careful planning exhibited in these proposed projects. Indeed, in this past year, well-qualified proposals with well-justified budget requests substantially exceeded available funds. Important issues addressed by EDMAP projects include groundwater assessment and protection, landslide hazards, mineral resource potential (both metallic and aggregate), mapping of National Park lands, and earthquake hazards. The proposals are specifically reviewed for a mentoring plan, wherein the supervising faculty member spends time in the field with the student mapper. The willingness of faculty to participate in this relatively time-consuming teaching activity is further testimony to the wide-spread support for the training of the next generation of geologic mappers.

Although the tangible products of EDMAP are geologic maps, the "ED" part is fundamental to the program. As in all fields of academic endeavor, students in the geosciences gravitate to the current hot topics in which research funding is available. In recent years, many of our academic institutions and funding agencies have emphasized laboratory science. Laboratory research has contributed to significant advances in a broad spectrum of the geosciences; however, students with laboratory training alone do not develop the perspective necessary to understand spatial relationships and three-dimensional projections in geologic maps. In other words, many of today's geoscience students are not educated in the preparation and use of geologic maps that provide information essential to sustain our economy and environment. In short, during the past 20 years, the number of geologic mappers being

trained by university geology departments has decreased. At the same time that our educational system has shifted away from field mapping and into the laboratory, the accelerated growth of needs for new and more detailed geologic maps requires a systematic approach to the education of geologic mappers for the future. EDMAP represents a clear national incentive to expand our educational efforts in geologic mapping, and it attracts students to the topic. Already, EDMAP awards have helped to support the training of more than 220 future geologic mappers. These young mappers are beginning to enter the workforce and make a difference. Informal information indicates that previous EDMAP students have been hired by state geological surveys, oil companies, and environmental consulting companies.

A well-done geologic map provides a wealth of information as a basis for development of resources that fuel our economy and for protection of our living environment. The making of a geologic map requires a particular educational background, and EDMAP supports that education. I am convinced, and I hope that I have convinced you, of the vital role of EDMAP and the National Geologic Mapping Act. I would be pleased to answer any questions that you may have.

Mr. GIBBONS. I want to applaud each of you for doing something that none of us could have done, having been a panel of three Ph.D.s, all given 10 minutes to talk about your field of specialty and having completed it within the time allotted is a remarkable experience. None of us would have been able to do that, at least talk anywhere near that short a time period.

When you held that map up, I was extremely pleased. It reminded me of my youth. I was very good at coloring. In fact, I think that I colored all of the walls of in the house and became a geologist because I loved to color maps, and that is one of the real treasures, I think, of being a geologist, being able to map things out and put them into perspective.

Also, in the interests of full disclosure here, not just for the panel but members of the Committee as well, I would like to note that we have an adjunct professor with your Department of Geoscience at the University of Kentucky and the Kentucky geologic survey. David Wunsch has been an AGI-sponsored Congressional Science Fellow with this Subcommittee for the past 9 months.

I have had the great pleasure of having him out to Subcommittee hearings in Nevada as well. I did this because of the excellent cooperative spirit in the Act that is fostered between the Federal Government, States, and academic institutions.

I would ask now for unanimous consent to place a letter from the National Association of State Universities and Land-Grant Colleges that was addressed to the chairman, Barbara Cubin, on H.R. 1528, expressing their support for this bill into the record.

[The information follows:]

NASULGC National Association of State Universities and Land-Grant Colleges

June 14, 1999

Honorable Barbara Cubin
Chairwoman
House Subcommittee on Energy and Mineral Resources
1626 Longworth HOB
Washington, D.C. 20515

Dear Madam Chair:

The Board on Natural Resources of the National Association of State Universities and Land-Grant Colleges strongly supports H.R. 1528, legislation to reauthorize the National Geologic Mapping Act. We want to commend you for all your hard work in crafting this fine piece of legislation, and for your outstanding leadership in focusing attention on the importance of geologic mapping.

One of the most fundamental programs of the USGS and state geological surveys has been the preparation of geologic maps. These maps are the foundation of basic geologic knowledge and are key to understanding the fundamentals of all earth systems. The maps have widespread use in land-use planning, in understanding geologic hazards, and for finding and evaluating all non-fuel and fuel minerals. In their modern analog, digital geologic maps are a basic "coverage" essential to most Geographic Information System (GIS) analysis. Without a strong, and fully authorized Geologic Mapping Program, efforts to cut the program within the Administration or in Congress will increase. We have seen such attempts over the past few years. Any reductions in NGMP will seriously impact an already strained program and greatly handicap our understanding the basic fundamentals of our planet and deny our resource managers the tools necessary to provide the American people with critical information.

NASULGC has over 200 member institutions -- including 17 historically black institutions -- located in all fifty states, representing the country's major public research institutions. The Association's overriding mission is to support high quality public education through efforts that enhance the capacity of member institutions to perform their traditional teaching, research, and public service roles. The Board on Natural Resources brings together leading educators and research scholars in the Association's universities to promote university-based programs dealing with natural resources, ecology, energy, and the environment.

Again, thank you very much for your efforts to reauthorize NGMP. Please be assured that we will continue to actively work in support of this critical program.

Sincerely,

Lee Saperstein

Lee W. Saperstein
Dean, School of Mines and Metallurgy
University of Missouri-Rolla
Chair, Board on Natural Resources

cc: Rep. Robert Underwood, Ranking Minority Member

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www@nasulgc.org

Mr. GIBBONS. To the Members of the panel, we have allowed you 10 minutes. You have been very gracious in that fact. We do limit ourselves to 5 minutes in terms of our own questions, and let me take the lead and start my 5 minutes and go back to Dr. Leahy.

I just want to thank you again for your comments regarding the administration's support for this. You state in your testimony that one of the USGS's goals is to expand cooperative mapping with State surveys, academic institutions and other Federal agencies in the private sector.

Can you elaborate upon the role of the private sector and the role it plays in cooperative efforts with the USGS related to geologic mapping?

Dr. LEAHY. Of course, as you know, geologic mapping is a research activity. However, there is considerable support of activities that we do through contracting with the private sector. These include such things as aerial photography, geophysical surveys, the use of geographic information systems, and the acquiring of the hardware and software associated with that and base map materials.

All of these maps are prepared on a topographic base. All those base maps come from our National Mapping Division. Many of their activities, a large percentage, are contracted out to the private sector.

Mr. GIBBONS. Dr. Woodfork, I noticed in your testimony, in both in your written and verbal testimony, that you say that the State geologic surveys and the USGS—I use the word emphasized, you usually interact in a cooperative and mutually beneficial manner.

With that testimony, are you suggesting that there are times when the two agencies may not interact as well and maybe there should be some improvements? Would you care to expand on this?

Dr. WOODFORK. There is always room for improvement. There no doubt have been times in the past and probably will be in the future that we might not share the same perspective because the States represent the State interests and the Federal survey has a different perspective; the Federal issue may have considerations in it that we don't make. I would say that that has generally been the loyal opposition role that we might play. It is not uncommon, the dynamic tension that probably always exists between the Federal Republic and the States that comprise that probably has led to all of our benefit over the years. It is not—it is viewed, as you well know, from a different perspective. It is not—I did not mean it to be a derogatory. It is simply the way I think it is supposed to work.

Mr. GIBBONS. Has the availability of State-appropriated dollars for West Virginia surveys or your colleagues' surveys increased as a result of the initial success of even the 1992 Act or have these funds always been available if the Federal matching funds had been there?

Dr. WOODFORK. You know, I can't say that there is a cause and effect there. What I can tell you is that there are sufficient funds there to match, the State funds to match Federal funds. We did have an ad hoc committee of ASG appointed to determine in the foreseeable future—and that is the time frame that we were talking about, 2001 to 2005—whether or not there would be sufficient State funds to match those. And although I can't give you the pre-

cise figure, my recollection—and I will provide it to you later—is that there were at least half again as much funds available out there, matching funds from State surveys to match the Federal dollars that are scheduled in the bill that you have before you.

Mr. GIBBONS. Dr. Thomas, dedication of 2 percent of the USGS geologic mapping budget to EDMAP, is that sufficient to ensure a continuing stream of skilled geologic mappers that will come out of our universities? And where do the schools get 50 percent matching money which the program requires?

Dr. THOMAS. On the first point, my experience has been with the panelists last year. Members of the panel who had served in previous years commented on the steadily increasing quality of the proposals that the panel was receiving. It was our perception that meritorious proposals could not be fully funded simply because of total limitation of the budget. Whether that falls in the realm of the total budget or percentage, I am not sure. But we, as a panel, felt that we should have funded some of the proposals at a higher level than we were able to in order to assure that the students were able to get the experience in the field. The universities matching commitment for the most part is in the area of faculty salaries and the commitment of faculty time. Because field work, as you well know, is a time-intensive activity, and the expectation or even the requirement of EDMAP is that the faculty member be actively in the field with the student in an instructional sense. So there is a substantial commitment of faculty time to this activity.

Mr. GIBBONS. As you can see, I didn't stay within the green light. I now have a red light here, so I need to turn to my colleague from Guam.

Mr. Underwood, the time is yours.

Mr. UNDERWOOD. Thank you, Mr. Chairman. The colors actually seem more psychedelic to me, a throwback to the 1960s, very artistic and very graphic.

First of all, I would like to ask unanimous consent to enter a statement by our colleague, Congressman Rahall, expressing his words of welcome to Dr. Woodfork.

Mr. GIBBONS. Without objection

[The prepared statement of Mr. Rahall follows:]

STATEMENT OF HON. NICK RAHALL, A REPRESENTATIVE IN CONGRESS FROM THE STATE OF WEST VIRGINIA

I would simply like to welcome the distinguished State Geologist, from the great State of West Virginia, Larry Woodfork, to the Subcommittee this afternoon.

Larry has held that position for a little over ten years now, and throughout that period we have worked closely on a number of initiatives to advance the geosciences in not only West Virginia, but nationwide.

One product of that partnership is the National Geologic Mapping Act of 1992, which is being considered for reauthorization today.

Larry, welcome to the Subcommittee.

Mr. UNDERWOOD. I want to thank all of you for your testimonies. I am very interested and very gratified to hear about the levels of cooperation that occurred between the Federal Government and the State map and the EDMAP projects. Although I fully understand, primarily coming from an academic background myself, that there never appears to be sufficient effort, level of effort, in trying to provide funding for the many and multi-faceted educational programs

that those of us who come from academia always have lots of time to figure out.

But I do think that it is a very critical activity that you are carrying out.

I did want to ask Dr. Leahy, in terms of the projects for the insular areas, for the territories, if you could give me a status report perhaps. When has the Survey last done a geologic map for Guam?

I want to be real specific, if you don't mind, Mr. Chairman.

Dr. LEAHY. I think we would prefer to answer that question for the record, writing to you in terms of what mapping we have done.

[The additional material follows:]

The most recent geologic map of the Island is included in: Tracey, Joshua I., Jr., Schlanger, Seymour O., Stark, John T., Doan, David B., May, Harold G., General Geology of Guam, Professional Paper, P 0403-A, p. Al-A104, illus., geol. maps, 1964.

In addition, the National Geologic Map Database includes three recent publications.

(1.) Tonikai, J.D., 1997, Rainfall, ground water, and ocean-tide data, Guam, 1996: U.S. Geological Survey, Open-File Report OF-97-239, scale 1:107000.

(2.) Otton, J.K., 1993, Preliminary geologic radon potential assessment of Guam: U.S. Geological Survey, Open-File Report OF-93-292-K, scale 1:200000.

(3.) Richmond, B.M., and Jaffe, B.E., 1991, Typhoon Russ effects on the shoreline of Guam: U.S. Geological Survey, Open-File Report OF-91-571, scale 1:50000.

As part of the National Geologic Mapping Act, the National Cooperative Geologic Mapping Program has created the National Geologic Map Database (NGMDB) to serve as a "national archive" of geologic maps. The initial phase of the database is an Internet-based catalog of printed geologic maps. The index is available on the Internet at http://ngmdb.usgs.gov and is being populated with metadata (approximately 90% of USGS holdings as of 6/99). The second phase of the project is underway to adopt standards for GIS use and to provide access and delivery of digital geologic map data on the Internet.

I will point out that the initial passage of the National Geologic Mapping Act in 1992, did not include the territories as eligible in terms of participating in the State-map element of the program. However, that was changed in the last reauthorization to include Puerto Rico, Guam, the Virgin Islands and so forth. So they are now eligible for the funding under this program.

We have been working with Puerto Rico, but I don't think that we have worked with the other territories in the context of this program, although we have done geologic mapping in those areas.

Mr. UNDERWOOD. But I am sure that you are more than willing to work with them if the occasion arises?

Dr. LEAHY. Yes.

Mr. UNDERWOOD. I know that part of the responsibilities for the Geologic Survey have to do with providing information for the economic utility of mineral resources. And one of the issues that always comes to mind in an insular area is the EEZ, the exclusive economic zone, which is most often thought of in terms of fishing.

We just had a hearing a few weeks ago on methane hydrates. There has also been a lot of discussion about the possibility of mining manganese nodules on the ocean floor. What thought has been given to the issue of mapping those potential economic resources which are under the jurisdiction of an exclusive economic zone?

Dr. LEAHY. That is a complicated question, but let me try to answer it. First of all, the National Geologic Mapping Act is a land-based program. So the mapping activities that are supported under this particular program are focussed on land—not on sea bottom mapping.

However, in 1983, the USGS, under our Coastal and Marine Geology Program, began a major effort to map the sea bottom of the EEZ and that work is completed. So we have complete digital imagery of sea floor conditions for the entire EEZ.

Now, the next step has not been taken in terms of evaluating those for mineral potential, at least not on a national scale. Certainly they have looked at individual areas of interest. Again, it is a different program and I would be glad to provide you information about the Coastal and Marine Program.

[The above mentioned material follows:]

Insert: Page 31, line 597

The Coastal and Marine Geology Program for 1999

Providing critical earth science information following Year of the Ocean and beyond

Coastal and Marine Issues

More than one-half of all Americans live within an hour's drive of an ocean, the Gulf of Mexico, or the Great Lakes. Our coastal oceans are a vital resource for transportation, commerce, and recreation. They provide food, energy, and minerals for the entire Nation; on a global scale, they harbor critical biologic habitats and drive global climate.

Changes within the coastal and marine environment, whether naturally occurring or human induced, can endanger our quality of life, threaten property, pose risk to fragile environments, and affect livelihoods. Catastrophic events such as hurricanes, earthquakes, landslides, and tsunamis cost the Nation more than $30 billion per year and have serious economic consequences for coastal communities. Wetland loss increases the threat of flooding, decreases water quality, and threatens wildlife. Degraded sea-floor and coastal habitats are failing to support fisheries. Coastal and offshore aquifers are subject to seawater intrusion and nutrient contamination. The coastal oceans have become a repository for sewage, chemicals, and toxics dumped or discharged offshore, or brought downstream by rivers.

All 35 coastal States and the island territories are experiencing coastal erosion and are threatened by the rise in relative sea level; many have replenished eroded beaches at great cost. The management challenge faced by all coastal communities is to balance the competing needs of citizens, government, industry, and the environment.

Sound marine science is critical for making such management decisions.

The Year of the Ocean

The United Nations and President Clinton proclaimed 1998 as the International Year of the Ocean (YOTO). Governments, organizations, and individuals participated in the Monterey National Ocean Conference (NOC) to raise public awareness of the important role the oceans play in our lives and to introduce several new initiatives. CMGP co-led preparation for one of the NOC sessions and is active in preparing the follow-up report and recommendations to the President's Council on Environmental Quality. The USGS continues YOTO's objectives and goals as part of its education and outreach efforts.

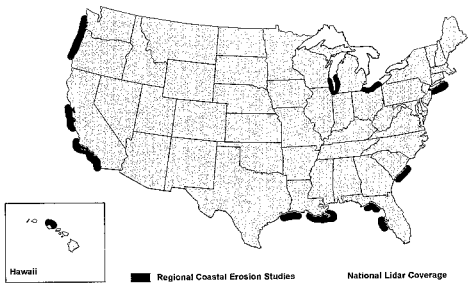
Program Goals

The goal of the Coastal and Marine Geology Program is to describe the geology of coastal and marine systems. Objective scientific information is critical to ensuring the wise use and protection of the Nation's coastal and offshore resources. By using knowledge of the fundamental geologic processes that create, modify, and maintain coastal and marine systems, program researchers develop models of these systems. The models are then used by scientists, planners, and managers to predict future change, such as the effects of hurricanes, earthquakes, El Niño, or of sea level rise.

USGS scientists study coastal and marine issues at both local and regional scales. Because the marine environment is made up of complex interrelated systems that cross political boundaries, the USGS, in collaboration with other Federal, State, and local agencies, addresses and responds to changing national needs and develops and maintains long-term national data bases. Credible data is available to State and local agencies as they consider mitigation strategies and develop land management plans. Our success in these endeavors is being assessed this year by an external review from National Research Council.

Although the program's primary focus is on coastal, estuary, and continental shelf regions, studies encompass the Great Lakes, as well as offshore deep-ocean areas within the U.S. Exclusive Economic Zone (EEZ). Several approaches are taken to accomplish the Program's goals:

1. **Fundamental studies** improve the understanding of coastal and marine geologic processes. Knowledge gained is broadly applicable to National and International issues.
2. **Regional studies** increase knowledge of specific coastal and marine geologic systems. Most are conducted within the US EEZ or the Great Lakes, but many systems (such as coral reef status, pollutant transport, earthquake impacts) cross political borders, requiring international collaboration.



New LIDAR mapping technology is enabling the USGS, in partnership with NASA and NOAA, to better understand shoreline dynamics.

3. **Catastrophic event studies** address the effect that rare or large-magnitude events have on coastal and marine geologic systems. Hurricanes, earthquakes, tsunamis, floods, and pollutant or nutrient discharges require rapid response, and a long-term commitment to the acquisition of baseline data is needed.
4. **Long-term observations** define the time scales and the magnitude of change in geologic systems. Analyses of long-term measurements are essential to distinguish human-induced effects from natural changes. Data from long-term observations provide a range of conditions, including catastrophic and rare events, for use in models.
5. **Assessments** provide a systematic evaluation of the status of geologic systems or processes. These activities may be undertaken regionally but are leading to national synthesis. The program also provides coastal and marine geologic expertise for national assessments led by other Federal agencies.

Program Research

Within the Coastal and Marine Geology Program, four research areas of national importance have been identified: Environmental Quality and Preservation, Natural Hazards and Public Safety, Natural Resources, and Information and Technology. The Program will be refocusing and emphasizing projects in line with the goals and objectives of the Geologic Division's Science Strategy (USGS Circular 1172).

Environmental Quality and Preservation

Geologic issues influence the long-term quality and preservation of coastal and marine environments. Program projects are undertaken on issues of pollution and waste disposal, wetlands, coral reefs, marine reserves and benthic habitats. Results from these studies improve our understanding of geologic processes so that natural and man caused changes to the coast, sea floor, and lake floors can be predicted or understood. Models of these systems allow the influence of human activities to be measured and evaluated.

Natural Hazards and Public Safety

Certain hazards, such as offshore earthquakes, tsunamis, storms, and submarine landslides, are catastrophic. Other hazards, coastal and nearshore erosion, for example, are also the result of longer term processes. Natural hazards studies improve our understanding of the frequency, intensity, and distribution of catastrophic events, and enables scientists to learn about the origin of natural marine geologic hazards and their influence on people, property, and the environment.

Natural Resources

Studies of coastal and offshore water, energy, and mineral resources provide an understanding of where they are located, their status or condition, how the resources were formed, and how easily and safely they may be extracted. Program investigations address water resources in coastal aquifers; offshore sand for beach nourishment; minerals such as manganese phosphates and cobalt; and energy resource geologic framework, as well as potential offshore resources such as methane gas hydrate.

Information and Technology

Information and technology research addresses the need for national assessments and a national source of information and data about the geologic status of our coastal and marine realms. Accurate scientific information is critical to manage and protect marine environments and resources. Efforts include systematic mapping of the coast and sea floor; building comprehensive user-friendly information banks; assessing environments, hazards and resources, as well as acquiring instrumentation, technology, and facilities.Program Operations

Program Operations

Facilities

The Program's 250 scientists and support staff are located at three regional research centers: Menlo Park, CA; St. Petersburg, FL; and Woods Hole, MA. Facilities are co-located with other Federal and academic Geo-Marine institutions to facilitate cooperation and to share expertise and resources.

For more information

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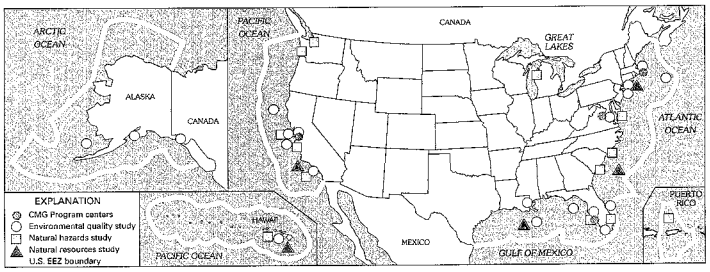
Visit our web sites:

Program	**http://marine.usgs.gov**
St. Petersburg	**http://coastal.er.usgs.gov**
Woods Hole	**http://woodshole.er.usgs.gov**
Menlo Park	**http://walrus.wr.usgs.gov**



Locations where USGS Coastal and Marine Geology Program research is carried out.

Selected Issues in
THE USGS MARINE AND COASTAL GEOLOGY PROGRAM
U.S. DEPARTMENT OF THE INTERIOR U.S. GEOLOGICAL SURVEY

The Face of the U.S. Seafloor

Insert: Page 31, line 597

"In the early days, we were all thrilled by seafloor features never before seen by man. Today, we are constantly challenged by the possibilities of applying this technology to our everyday needs of managing our environment and resources."

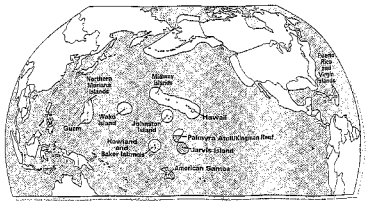
—Dr. Jim Gardner,
U.S. Geological Survey

In 1983, President Reagan signed the Proclamation declaring the Exclusive Economic Zone (EEZ) of the United States.

The charter of the **U.S. Geological Survey** (USGS) places the primary responsibility for mapping territories of the United States within the USGS. Upon declaration of the EEZ, which extends from the coastline to 200 nautical miles offshore, the territory of the United States was enlarged by more than 13 million square kilometers, all of which are under water. The USGS program to systematically map the entire 13 million square kilometers began in 1984.

The challenges encountered in mapping the seafloor thousands of meters beneath the sea surface are similar to the challenges of mapping the Moon or Mars.

The marine environment is hostile, the tools rely on remote sensing, and mapping requires geological intuition, imagination, and experience. Reconnaissance views of the seafloor, however, will allow the next generation of scientists to concentrate on those critical areas that will provide the keys to understanding the geology and geological processes of the ocean floor.



Map showing location of the United States Exclusive Economic Zone.

Geologic LOng Range Inclined ASDIC (GLORIA) is a digital side-scan sonar system capable of producing digital image maps of the seafloor from reflected sound waves.

GLORIA is an electronic mapping system built by the **Institute of Oceanographic Sciences** in the United Kingdom and selected by the USGS specifically to conduct surveys of the EEZ. The sound source and receivers are built into a "fish" that is towed about 200 meters behind a ship and emits a pulse of sound every 30 seconds. The pulse travels through the ocean to the bottom where it is partly absorbed and partly reflected by the seafloor. The amount of energy returned to the GLORIA fish, termed *backscatter*, is recorded by shipboard computers. Seafloor features that backscatter a lot of sound energy are recorded as bright areas, and those features that backscatter little energy are shown as dark areas. The data are digital so that digital image maps can be constructed and combined with other data as part of Geographic Information Systems.

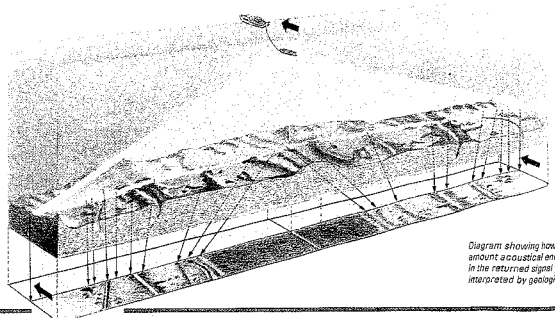


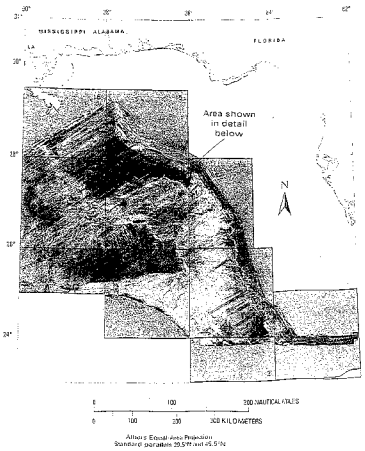
Diagram showing how seafloor topography creates changes in the amount acoustical energy reflected back to GLORIA. This variation in the returned signal yields the light and dark areas that can be interpreted by geologists.

GLORIA surveys provide a road map of the ocean floor.

The GLORIA surveys of the EEZ have compiled more than 300,000 kilometers of ship tracks, a distance that represents about 12 circumnavigations of the Earth. The surveys required 40 cruises totalling about 1,500 days at sea, involving more than 300 scientists, engineers, technicians, and ships' crews. Surveys require about 6 months of sea time per year, in approximately 24-day long cruises. The entire program, including ship costs (ship, crew, fuel, food, and port fees), shipboard scientific equipment, shore-based computers, and production of atlases of the data, has cost about $5 million per year. About $40 million has been spent during the first 8 years, and the program is expected to last another 4 to 6 years. The taxpayer spends about 1 penny per acre to survey the EEZ.

USGS scientists correlate mosaics of sonar images with existing geological information.

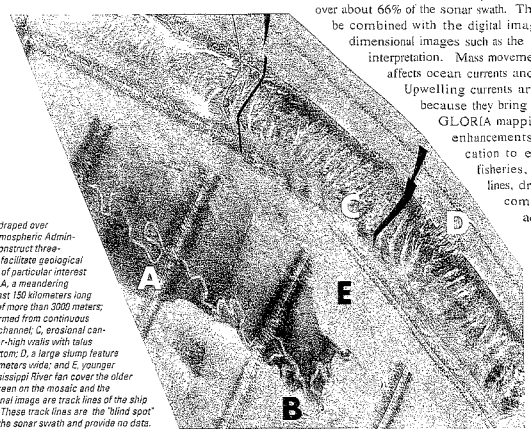
The resolution of GLORIA, which is similar to Landsat satellite images of land, allows scientists to interpret major faults and large mass movements of sediments. Detailed, high-resolution seismic data are combined with extensive seafloor sampling and bottom photography to produce true geologic maps of the EEZ. Higher-resolution images of selected areas of the seafloor are necessary because these surveys accentuate subtle features that are not seen on the reconnaissance data. The interpretive maps are among the first derivative products produced by USGS scientists. Atlases compiled from sidescan images allow workers to view the seafloor as a composite of areas of similar geologic affinity (terrains), and to look for trends and associations giving insight into processes and structures on the seafloor. For example, USGS scientists have learned from GLORIA mapping in the Gulf of Mexico that models for sediment dispersal on the Mississippi fan must be revised. Industry has used these models to explore for oil and gas



Mosaic of GLORIA imagery in the eastern Gulf of Mexico taken from Atlas of the Exclusive Economic Zone—Gulf of Mexico (I–1884–A). Each pixel of data represents 200 meters on the seafloor.

Planned USGS mapping of western Pacific islands will include USGS design enhancements to the GLORIA system.

Since the first surveys in 1984, the GLORIA system has been continuously upgraded as new technology becomes available. Future planned surveys of the American Flag islands of the western Pacific will include the capability of collecting digital bathymetry over about 66% of the sonar swath. This digital bathymetry can be combined with the digital image data to create three-dimensional images such as the image at left, which aids interpretation. Mass movement of rock and sediment affects ocean currents and the health of fisheries. Upwelling currents are important to fisheries because they bring nutrients to the surface. GLORIA mapping, with its technology enhancements, has significant application to earthquake prediction, fisheries, communications, pipelines, drilling, military, shipping, commerce, and technology advancement.



GLORIA imagery can be draped over National Oceanic and Atmospheric Administration bathymetry to construct three-dimensional images that facilitate geological analysis. Some features of particular interest shown in this image are: A, a meandering submarine channel at least 150 kilometers long formed at water depths of more than 3000 meters; B, an oxbow meander formed from continuous lateral movement of the channel; C, erosional canyons that form 1000 meter-high walls with talus accumulations at the bottom; D, a large slump feature left a scar nearly 10 kilometers wide; and E, younger sediments from the Mississippi River fan cover the older channel. Parallel lines seen on the mosaic and the enlarged three-dimensional image are track lines of the ship towing the GLORIA fish. These track lines are the "blind spot" at the central portion of the sonar swath and provide no data.

For more information please contact: Dr. Jim Gardner, USGS, Palo Alto, CA 94306 (415) 354-3095

Mr. UNDERWOOD. I would certainly be very interested in that. I am trying to understand exactly where that responsibility may lie or where that activity should occur, whether it should occur in your agency or perhaps in Commerce. I think it is a matter that should be pursued.

Perhaps the gentleman from West Virginia or people from academia might venture a comment on that. Have you given any thought to that issue?

Dr. WOODFORK. Age before beauty.

Dr. THOMAS. I am afraid my activities are also quite land-based, coming from Kentucky.

Mr. UNDERWOOD. We may have to teach you how to swim then.

Dr. THOMAS. I did want to comment on the map. We have thought that possibly one way to improve the overall budget for EDMAP would be if we could sell this as a work of art.

Mr. UNDERWOOD. Very good.

Dr. WOODFORK. I deal with Paleozoic oceans to the extent of many eons ago. I have tried to sell that program to the Mineral Management Service, that those Paleozoic coastlines should be eligible for consideration thereto, so far unsuccessfully. I cannot give you any specific insight into the manganese mapping issues on the current ocean base. I think it is a project worthy of merit.

Mr. UNDERWOOD. Okay. Thank you very much.

Mr. GIBBONS. Thank you very much, Mr. Underwood. We will have just one quick second round of questions to kind of clear things up here and then certainly allow you gentlemen to be released from the Committee here.

Dr. Leahy, let me ask a question about the process, the mapping that has taken place since the 1879 evolution of the USGS using the 7½-minute quadrangle scale, which is the normal scale. Has any State been adequately mapped at that scale since your testimony only relates to a 2 percent coverage that you stated in there?

Dr. LEAHY. I think the Nation right now has about 20 percent coverage of modern geologic maps at a 7½ minute scale, so we have a long way to go. The only States that are fully mapped at a 7½ minute scale are Kentucky and Connecticut. So we do not have complete coverage at 7½-minute scale except for those two States.

Mr. GIBBONS. Let me ask a question, Dr. Leahy, for the chairwoman of this Committee who is unavoidably absent today due to an illness. But she wanted me to ask about your testimony mentioning a project in the Lander-Riverton area of Wyoming as an ongoing example of a State map component of this cooperative program and that local business councils had sought this work.

Are you familiar yet or are you apprised of any preliminary results of the result of this mapping?

Dr. LEAHY. In terms of impact or——

Mr. GIBBONS. I presume it is whether there is any result from the effort of mapping to date.

Dr. LEAHY. That effort is still in progress. Therefore, I can't tell you about the impact of the mapping yet. I suspect they are still in the field, compiling the data, producing the map. Once it is done,

then I think the stakeholders will be able to use it for economic development.

I believe there is an environmental aspect associated with groundwater vulnerability in that area as well.

Mr. GIBBONS. Any significant results that have shown or come to light as a result of this mapping in the area?

Dr. LEAHY. Not that I am aware of.

Mr. GIBBONS. Dr. Thomas, let me ask a question about—the evolution and the practice of geology has traditionally been one in the male world. I know there is a great deal of interest now in the society for female geologists. Is the program working to improve conditions for development of female geologists in your institution and throughout the program?

Dr. THOMAS. I can speak specifically about my own institution. I have EDMAP funding for a project that is currently under way. The student doing that work is a female Ph.D. student at the University of Kentucky. She was in the field last year in Alabama, and we have also been notified that we have received funding for a second year on her project, and she will again be working in the field next winter.

Mr. GIBBONS. Is the trend in female undergraduate enrollment in geology or other majors of that type, or grad students in the area, is it growing, staying level, or declining?

Dr. THOMAS. I am not sure about the rate of growth. It certainly has been a steady increase over the years of my experience. I was in school in the 1950s. There were very few female students in geology at that time. Now I think the percentage—I am sorry, I can't say exactly what the percent is, but it is a substantial percentage. I think more importantly, the women geology students are in all aspects of geology.

We tend to think of some things, particularly field geology, for example, as being kind of a male-dominated activity. But some of my better field students have been females.

Mr. GIBBONS. Dr. Woodfork, final question. In the testimony here we see this reauthorization Act allows for, I see, some fairly healthy increases in the USGS geologic mapping budget. Can you state to this Committee that the portion of those funds that go to the State map component of this Act will be able to be matched by various State surveys that submit grant proposals which make it through the peer review process?

Dr. WOODFORK. Based on our survey, I can state unequivocally that the money is there to accomplish that.

Mr. GIBBONS. Thank you very much.

Mr. Underwood, any further questions?

Mr. UNDERWOOD. No.

Mr. GIBBONS. Gentlemen, I want to again thank you for your time and your testimony here today. I would like to ask that if the Committee or the staff has further questions, that we may submit them to you in writing and that you will respond to those written questions as if you were here testifying before this Committee, if that is agreeable with you.

And there is no further business of this panel. The chairman

thanks the members of the panel for being here, the Subcommittee, and especially the witnesses.

This Subcommittee now stands adjourned.

[Whereupon, at 3 p.m., the Subcommittee was adjourned.]

[Additional material submitted for the record follows.]

U.S. HOUSE OF REPRESENTATIVES,
WASHINGTON, DC,
June 25, 1999.

Dr. WILLIAM THOMAS,
Department of Geological Sciences,
University of Kentucky,
Lexington, KY 40505

Dear Dr. Thomas:

Thank you for testifying before the House Resources Subcommittee on Energy and Mineral Resources during the hearing on H.R. 1528, the "National Geologic Mapping Reauthorization Act of 1999."

Due to time constraints, Members did not have time to ask all of their questions about the EDMAP component of the National Geologic Act. The Subcommittee would like answers to the following questions:

1. How much time and "manpower" were necesssary to complete the geologic mapping of the state of Kentucky at the 1:24,000 scale?
2. What are the differences in geologic education, if any, between the current generation of geology students, and the geologic mappers that completed this massive mapping project?
3. Can you explain the role of field camps in teaching geologic mapping to geologists? Do EDMAP matching funds play a part infield camp training programs?
4. Can you describe the benefits reaped by your home state of Kentucky that resulted from its comprehensive geologic mapping coverage?

We would appreciate if you could provide answers to the above questions in the same format as they are asked before July 1, 1999. This letter and your reply will be included in the hearing record.

On behalf of the entire Subcommittee, I look forward to receiving your reply to our follow-up questions no later than Thursday, July 1, 1999.

Sincerely,

BARBARA CUBIN,
Chairman,
Subcommittee on Energy and Mineral Resources

ANSWERS TO QUESTIONS FROM THE SUBCOMMITTEE BY DR. WILLIAM A. THOMAS

Dear Representative Cubin:

I enjoyed the opportunity to testify before the House Subcommittee on Energy and Mineral Resources during the hearing on H.R. 1528, the "National Geologic Mapping Reauthorization Act of 1999," and I am happy to respond to the additional questions posed in your letter of June 25. My responses are numbered to correspond to the questions.

1. Concerning time and "manpower" to complete geologic mapping of the entire state of Kentucky at 1:24,000 scale, I can report data compiled by the U.S. Geological Survey and the Kentucky Geological Survey. The state encompasses 707 quadrangles at 1:24,000 scale. Geologic mapping began in 1960. Field work was completed in 1977, and the final quadrangle map was published in 1978. The total effort required 661 professional man-years, and an estimated more than 200 different individuals contributed to the mapping. The total budget was $20,927,500 over the 18 years of the project. Most of the mappers were USGS geologists, but some Kentucky Geological Survey geologists and university faculty members were employed in the mapping.

2. It is difficult to quantify the differences in geologic education received by the mappers of the 1960-1978 Kentucky project and that offered in current geology programs; however, I can describe the primary differences in terms of my own experience. As an undergraduate student in 1952-1956, I attended an 8-week summer field course that consisted almost entirely of geologic mapping; during the succeeding fall semester, each student was required to complete a full geologic report on the area mapped. I also took 5 field courses that consisted of geologic mapping on Saturdays throughout the academic year. In addition, I took a second 8-week summer field course as an elective to do geologic mapping in especially challenging areas. The undergraduate program that I followed may have emphasized field mapping to a somewhat higher degree than some contemporary programs, but an intense involvement in field work was characteristic of geology departments of that time. Through the years, an increasing sophistication of laboratory work in the geosciences, advances in remote sensing techniques, and growth of numerous subspecialties in the geosciences have resulted in progressive decreases in the time de-

voted to instruction in geologic mapping in the typical curriculum. In response, several changes have occurred in the teaching of geologic mapping. Most notably, most summer field courses (field camps) are now in session for six weeks or less. Part of the reduction in length is driven by cost. Field camp is somewhat costly to the student, and university funds for off-campus travel are limited. Furthermore, many students depend on summer jobs for income, and field camp takes much of the summer. In addition to the simple reduction in length, many summer field courses now include exercises in a variety of specialized field techniques, thereby reducing the amount of time devoted to mapping. Some summer field courses are devoted entirely to special topics other than mapping; for example, hydrogeology field camps are now common. Each of the specialized topics for instruction is appropriate, but none is a suitable replacement for the understanding that arises from geologic mapping. Most of the specialized courses would benefit from a prerequisite of a geologic mapping course. For example, data on geologic maps are essential to define the geometry of groundwater aquifers that must be known in order to plan water wells, and geologic maps show where the aquifer is at the surface (the recharge area) to enable protection from pollution. The allocation of time for instruction in geologic mapping is a difficult dilemma. The evolving techniques and subspecialties are changing and improving our abilities to resolve many types of problems; however, geologic maps remain the essential tie from all facets of geoscience to the real conditions of the Earth. While not every geoscientist must be able to make a high-quality geologic map, any geoscientist who lacks the ability to read and interpret a geologic map is at a serious disadvantage. The only effective way to learn map interpretation is by the practice of making a map, and this is one essential reason to re-establish an emphasis on field geology and mapping. A more direct critical need, however, is to maintain a well-trained cadre of field geologists who will be available to make the geologic maps that we will continue to need. For this purpose, the EDMAP program is crucial. It is a clear mandate for geology departments to maintain the teaching of geologic mapping, and it involves students as active geologic mappers.

3. Field courses (field camps) and EDMAP have complementary but different missions. The primary purpose of field camp is to take a student at an introductory level and provide basic instruction in making a geologic map. This is in a learn-by-doing approach, and the final product is a geologic map. The sites for study are carefully selected so that the students will encounter a suitable level of complexity, quality of exposure, variety of rocks and structures, etc. Each new class typically works on the same sites; therefore, successive years of field camps do not progressively cover a previously unmapped region. Each class has the benefit of working on a locality that is especially suited to teaching the techniques of mapping. This is really necessary to the educational objective. In contrast, EDMAP projects are coordinated with priorities defined by the U.S. or state geological surveys, and one objective is to map an area for which a map is needed. The educational component of EDMAP takes a student who has already completed the field camp introduction to geologic mapping and provides additional instruction to reach a professional level of competence in mapping. In this sense, EDMAP provides a kind of on-the-job training that would be appropriate for any senior or graduate student going into an industry job. Because of these differences in objectives, a field camp should not be expected to generate the deliverables that are rightly required of EDMAP projects. Field camp experience, however, may lead to the identification of appropriate EDMAP projects, and it is essential as preparation for mapping at the skill level required for EDMAP. I strongly support the concept of field camp as an essential educational enterprise; however, in my opinion, it would be inappropriate to use EDMAP funds to support field camps. If other funds could be made available, external support would alleviate the cost problems of attending field camp described in item 2; however, I would not favor diverting those funds from EDMAP which is currently underfunded in terms of ability to fully support all deserving proposals.

4. The geologic quadrangle maps of Kentucky are sold to the public through the state geological survey and other offices. The numbers of these maps that have been sold attest to the usefulness ascribed to them. Statistics at the Kentucky Geological Survey show that more than 105,000 maps were sold between 1965 and 1978; 58,000 of those during the last four years of that period, when many maps were being published. Predictably, as the various corporations and institutions acquired complete sets of maps, the large initial demand began to decrease. A measure of the continuing market is in recent sales statistics: 3,950 copies in 1996, 3,275 in 1997, and 2,605 in 1998. Raster images are being made available as an alternative to the paper copies of maps. At present, work is underway to digitize the existing geologic maps at 1:24,000 scale, and this level of availability will further enhance the many uses of the maps. In particular, the digitized maps will expand the use of the geologic maps in the display of many kinds data in a GIS format. The sale of maps

is but one measure of the value placed on these data sets by the general public. Many specific uses of the maps are documented, and I will cite a few here as examples. Geologic maps are used extensively in the exploration for and development of coal resources, one of the mainstays of Kentucky's economy. Tracing of coal beds is necessary to extend the area of mining, and the geologic maps have been used for that purpose by many companies. Documented reports describe the finding of additional coal resources at many scattered localities in amounts from one-half million to several million tons. A simple example illustrates that a single discovery of only 195 acres of 6-foot-thick coal yields a value of $21,000,000, the total cost of the entire state mapping project. Similar examples of the use of the geologic maps in mining of fluorspar in western Kentucky and in petroleum exploration throughout the state are available. Several oil and gas operators have reported the discovery of new fields as a direct result of the use of the maps. In addition to bedrock data, the maps show alluvium along stream systems and other surficial deposits. These surficial deposits are important resources of clay, sand, and gravel, and the geologic maps greatly focus the search for these materials. Nearly every example of the development of resources through the use of the published geologic maps falls into the category that I described in my previous testimony: a corporation cannot invest the time and money to map large areas, but where geologic maps are available, they serve to focus the search for resources. Clearly, this is working in Kentucky. The geologic maps have also proven useful in engineering applications, particularly in highway design and construction. For example, a new highway in eastern Kentucky through an area prone to landslides was under construction while the mapping was being conducted. With the use of the maps, the highway was redesigned and relocated greatly reducing the risk of landslides of the type that had destroyed earlier parts of the road. The Kentucky Department of Transportation now uses complete geologic map coverage as part of the design and planning for all new road construction; the up-front investment in geologic mapping is underwriting this aspect of highway construction. The geologic maps are coming to be used extensively in studies of groundwater movement and in planning protection of groundwater from pollution. For example, in central Kentucky, soluble limestone bedrock is susceptible to sinkholes and small caverns, and the tracing of these rocks on geologic maps is essential to understanding of the flow of surface water into the groundwater system. In addition to the geologic maps, numerous other reports on the scientific aspects of rocks in Kentucky were generated, and the availability of the maps continues to support geological research in the state. The maps are useful in archaeological studies of Native American sites; for example, a massive sandstone that forms numerous rock shelters in eastern Kentucky can be traced from the geologic maps. A dollar value is difficult to put on the many benefits Kentucky has derived from the geologic mapping project; however, it is clear that only a very small part of the increased coal productivity alone is more than adequate to pay the total cost of mapping several times over.

During the hearing, I offered my own personal observations without documented numbers in response to a question posed by Rep. Gibbons for Rep. Cubin concerning the numbers of women in the geosciences. With data from the files of the American Geological Institute, I would like to enter the following more specific information into the record. According to data compiled by the American Geological Institute, women have made considerable advances in the geosciences in terms of enrollments and degrees granted since 1980. That year, women made up 24 percent of undergraduate enrollments and 21 percent of graduate enrollments. In 1996 (the last year for which data are complete), that percentage had grown to 37 percent for undergraduate students and 32 percent for graduate students. Because of decreasing geoscience undergraduate enrollments through that period, the absolute numbers of women geoscience undergraduates increased only by 14 percent (from 7,390 to 8,455). In contrast, graduate enrollments increased, and the actual number of women rose 54 percent (from 2,108 to 3,242). In terms of degrees granted, women have also seen their numbers rise from 25 percent of geoscience bachelor's degrees in 1980 to 36 percent in 1996. For master's degrees, the change is from 20 percent to 31 percent, and for doctorates, the change is from 10 percent to 22 percent.

I appreciate this opportunity to provide this additional information for the Subcommittee, and I will be happy to respond to any further questions you may have.

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