

THE GEOLOGICAL SURVEY OF WYOMING
Gary B. Glass, State Geologist

FIFTY-THIRD ANNUAL REPORT
of the
GEOLOGICAL SURVEY OF WYOMING
for Fiscal Year 1986
July 1, 1985 to June 30, 1986

by

Gary B. Glass



Laramie, Wyoming
September, 1986

THE GEOLOGICAL SURVEY OF WYOMING

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TABLE OF CONTENTS

	Page
Introduction	1
Organization	2
Functions and accomplishments in fiscal year 1986	3
Provide information, advice and assistance	3
Conduct and report on field and laboratory investigations	6
Publish timely and significant reports and maps	7
Gather and continuously update and maintain files and libraries	11
Revenues generated by the Geological Survey	12
Outside funding sources (grants)	12
Major accomplishments by program	14
Administrative Program	14
State Geologist (Gary B. Glass)	15
Coal Section (Richard W. Jones)	16
Editorial Section (Sheila Roberts)	17
Geologic Hazards Section (James C. Case)	18
Laboratory Section (Jay T. Roberts)	20
Metallic Minerals Section (W. Dan Hausel)	20
Oil and Gas Section (Rodney H. DeBruin)	22
Stratigraphy Section (Alan J. VerPloeg)	23
Uranium and Industrial Minerals Section (Ray E. Harris)	24
Publications program	25
Problem areas and recommendations	26

Figures

1. Biennial budgets for the Geological Survey	1
2. Organization chart for the Geological Survey of Wyoming in FY 86	2
3. Assessed valuation of Wyoming's mineral production	13
4. Annual fiscal year income from Survey publications	13
5. General content of publications and number of new publications per decade	18

Table

1. Percentage breakdown of Staff Geologists' activities	15
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INTRODUCTION

The Office of the State Geologist was established in 1890 with the Wyoming State Constitution (Art. 9, Sec. 6) and modified by legislative enactment in 1969, 1975, 1977, 1979 and most recently Laws 1982, Ch. 62, §3 (Title 9, Ch. 2, Art. 8, W.S. 9-2-803). Gary B. Glass, the incumbent since June 18, 1981, was reappointed State Geologist by Governor Herschler for a full six-year term in March 1982.

The Geological Survey of Wyoming was created by the Legislature in 1933, and has since been modified by legislative enactment in 1957, 1969, 1977, 1979 and most recently Laws 1982, Ch. 62, §3 (Title 9, Ch. 2, Art. 8, W.S. 9-2-803 through 9-2-809). Under these statutes, the Agency's principal functions are service-oriented and broadly grouped into four categories:

1. *Provide information, advice and assistance for inquiries on geology and mineral resources* -- This includes requests for assistance from the Executive and Legislative branches of State Government, State and Federal agencies, industry, special interest groups and the public.

2. *Conduct field and laboratory investigations* -- These are geologic or mineral resource projects that contribute new data or information which have a practical bearing on Wyoming's communities or people.

3. *Publish maps and reports* -- The Agency publishes and distributes reports and maps that communicate the results of its investigations as well as some investigations by others.

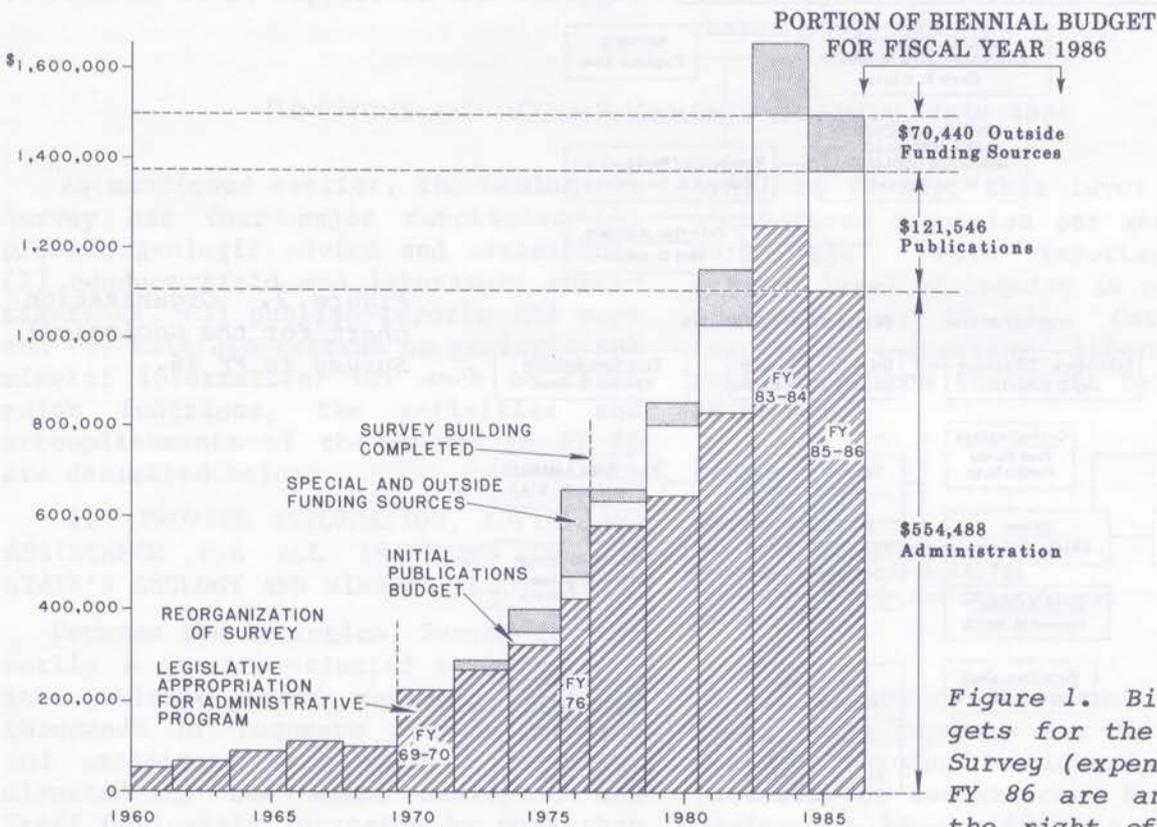


Figure 1. Biennial budgets for the Geological Survey (expenditures for FY 86 are annotated to the right of the biennial budgets).

4. Maintain files and libraries on the State's geology and mineral resources -- These files are part of the Agency's permanent records and, with few exceptions, are available for public use.

Fiscal affairs of the Survey are administered through direct appropria-

tions from the Legislature in two separate accounts: Administration (001) and Publications (002); in addition, the Survey contracts for funding from outside sources to conduct cooperative investigations and studies. Figure 1 illustrates the Survey's biennial budgets between 1960 and the present, and shows that portion of the biennial budget expended in FY 86.

ORGANIZATION

For operational purposes, the Agency's personnel are divided into an Administrative Section, six Geologic Sections, a Laboratory Section and an Editorial Section (Figure 2). In addition to the activities and functions of the

State Geologist, the Administrative Section (Deputy Director, administrative secretary and bookkeeper) is responsible for the day to day administrative matters of the Survey (payroll, personnel, budget, vouchering, etc.).

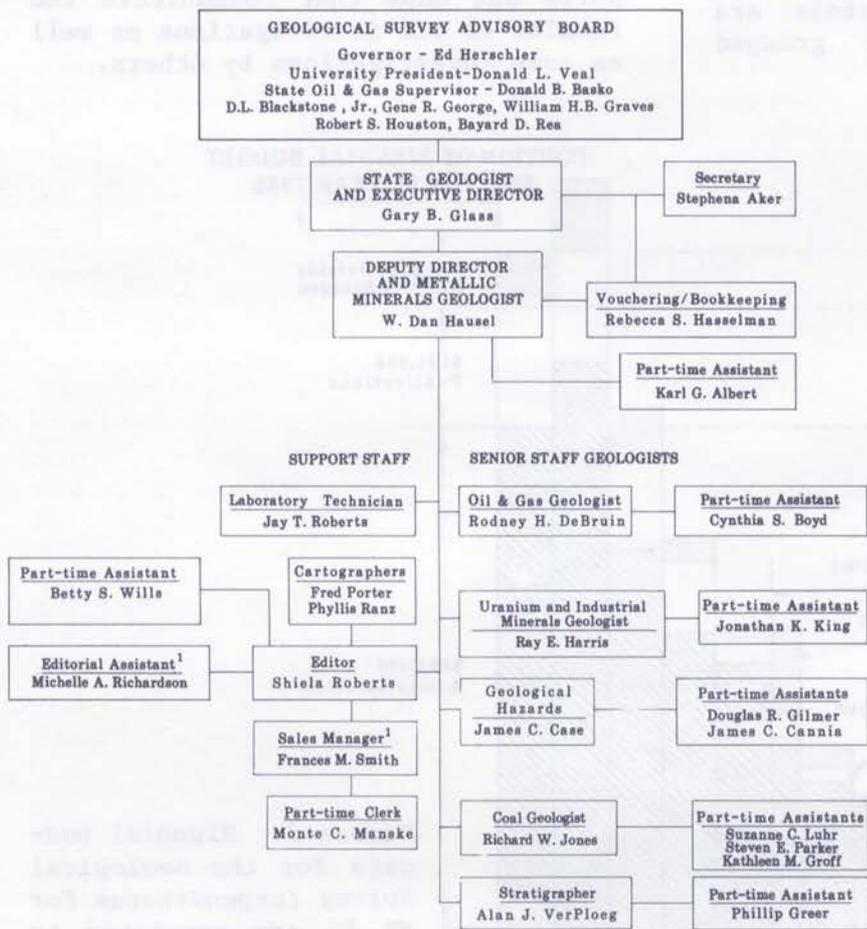


Figure 2. Organization chart for the Geological Survey in FY 86.

¹ These positions are paid out of the Publications Program.

The Geologic Sections are divided into six one-man sections: Coal, Geologic Hazards, Metallic Minerals, Oil and Gas, Stratigraphy and Uranium and Industrial Minerals. Each Section is headed by a Staff Geologist, who enlists the part-time help of student assistants from the University of Wyoming as the need occurs and funds permit.

Because the Staff Geologists are each experts in their special fields of geology, these geologists are expected to initiate their own investigations and projects on the basis of priority of need. About 90 percent of the projects are undertaken by the individual Staff Geologists with assistance from the support staff of the Editorial and(or) Laboratory Sections. The remaining 10 percent are handled on a team basis that occasionally involves the entire geological staff as well as the State Geologist and other Sections of the Survey.

The Laboratory Section is another one-man Section. It provides analytical as well as field support to the Geologic

Sections. This Section also provides mineral and rock identifications for the general public.

In addition, the Agency has a seven person Editorial Section (Editor, Editorial Assistant, cartographers, Publication Sales Manager and stockman), which is headed by the Editor. This Section has three major functions: (1) preparation of manuscripts and maps for publications, (2) preparation of bid specifications and supervision of commercial printing and (3) sale and(or) distribution of Survey publications. The two full-time and one part-time cartographers put all illustrative material (drawings, maps, charts, etc.) into publishable form and make proof copies and printer-ready negatives. The Editor and Editorial Assistant edit and put all manuscripts into printer-ready formats, write printing specifications and see that reports are satisfactorily published. The Publication Sales Manager sells Survey publications over-the-counter, by phone and by mail, keeps an inventory of publications and mails exchange publications.

FUNCTIONS AND ACCOMPLISHMENTS IN FISCAL YEAR 1986

As mentioned earlier, the Geological Survey has four major functions: (1) provide geologic advice and assistance, (2) conduct field and laboratory investigations, (3) publish reports and maps and (4) maintain records on geologic and mineral information. For each of these major functions, the activities and accomplishments of the Survey in FY 86 are described below:

1. PROVIDE INFORMATION, ADVICE AND ASSISTANCE FOR ALL INQUIRIES ON THE STATE'S GEOLOGY AND MINERAL RESOURCES.

Because the Geological Survey is primarily a service-oriented organization, its geologic staff responds to many thousands of requests for information and assistance each year. Inquiries directed to the State Geologist and Staff Geologists increased by more than 20 percent in FY 86 (4,020 in FY 85 and

4,837 in FY 86); this level equates to about three inquiries per geologist per work day. More importantly, this current level of inquiry is nearly twice the level of FY 81. Categories of inquirers requesting information and assistance from the Staff Geologists in FY 86 were:

Category	Percentage
General Public	21%
Business and Industry	34%
Wyoming and Local Agencies	18%
Federal, Foreign and Other States	12%
Universities	15%

In regard to State and local entities, these services are divisible into routine ongoing assistance and spot requests for assistance. Major ongoing assistance is provided to seven State agencies and is described below:

Commissioner of Public Lands -- The Survey's Oil and Gas Section provided (1) weekly reports of oil and gas activities on or near State lands, (2) oil and gas tract evaluations to assist with selecting tracts for the lease auction, (3) an updated listing of oil and gas potential and sale results on 5,000 State lease tracts; the State Geologist reviewed and made recommendations on all fossil-collecting permits (there were 7 applications in FY 86) and inspected the quarries. Spot assistance included the State Geologist's participation in the Ad Hoc Alluvial Valley Floor (AVF) Coal Exchange Committee and participation in a meeting regarding the possible theft of fossil specimens.

Department of Environmental Quality, Land Quality Division -- (1) The Survey's Geologic Hazards Section provided reviews and recommendations on paleontology portions of mining plans, (2) the Minerals Sections and Coal Section of the Survey reviewed approximately 23 Abandoned Mined Land Reclamation Projects and made comments and(or) recommendations on reclamation strategies for these projects and (3) spot assistance included the submittal of information on mine subsidence at Hanna and a detailed geologic field and laboratory investigation and report on the Sunrise iron ore mine property in the Hartville area.

State Planning Coordinator and Governor's Clearing House -- The State Geologist and Staff Geologists reviewed 90 documents in FY 86 and submitted written comments on 31. These were the Resource Management Plans for the Kemmerer and Lander Resource Areas, Devils Tower National Monument, Shoshone National Forest, Fossil Butte National Monument and Grand Teton National Park; environmental assessments for Anschutz's Moose Gulch Exploratory Unit, Sohio's Little Indian Creek Well No. 26B, seismograph stations at Grand Teton National Park and the Faust Regional Airport at Cody; Environmental Impact Statements for the Williams Telecommunications Fiber Optic Cable Project, the Owl Creek Wilderness Suitability Study and the Bighorn

National Forest Plan; scoping statements for the Jim Creek/Nelson Park area, the North Afton Water and Sewer District's spring development and pipeline plan, the Casper Bowl Restaurant at Jackson Hole, the Threemile and Warren Analysis Areas in Medicine Bow National Forest, Exxon's Leidy Creek Unit No. 2 Well, Cheyenne's Stage II Water Transmission Pipeline, Chevron's Beamer Bluff Federal No. 41-24 Well, the Ten Sleep Canyon Hydroelectric Plant and Amoco's Sohore No. 2 Well; Records of Decision for the Bighorn National Forest Plan; and reviews of a Hanna Area Mine Subsidence Report, the Little Horn Water Project, the Clareton-Lance Road Improvement Project, the Kaycee Water Well Project, the Bureau of Land Management/Forest Service Interchange National Summary Review, the Grand Teton National Park Land Exchange and the Wyoming Futures Report.

Industrial Siting Administration -- The Survey reviewed and commented on the application for Amoco's Bairoil Carbon Dioxide Project.

Legislative Service Office -- Each September, the Survey estimates future production and assessed value for minerals produced in the State. The Survey's estimates and those of several other agencies are used to reach a consensus on future mineral production and assessed values. Later these consensus estimates are used by the Consensus Revenue Estimating Group (CREG) to provide a forecast of mineral revenue for use by both the Governor and the Legislature.

Oil and Gas Conservation Commission -- Wyoming Statute 30-5-103 makes the State Geologist one of the Commissioners of this regulatory agency. Monthly hearings, which were routinely 1-1.5 days long in early FY 86, tapered off to 1/2-1 day sessions in late FY 86. The State Geologist has been the Acting Chairman of the Commission when the Governor is absent. Matters related to the Oil and Gas Conservation Commission, in addition to the hearings, routinely require another one-half to one day of effort by the State Geologist each month.

Department of Administration and Fiscal Control (DAFC), Research and Statistics Division -- The State Geologist is a member of DAFC's Consensus Revenue Estimating Group (CREG), which makes revenue estimates for use by the Governor and the Legislature, prior to each Legislative Session. In FY 86, updated estimates of mineral production and revenue were also required before and after the Legislative Session because of falling oil and gas prices. The State Geologist and the Staff Geologists continually apprised CREG of the minerals situation throughout FY 86.

Emergency Management Agency -- The Geologic Hazards Section assisted this Agency with their State Civil Defense and Disaster Plan by providing statewide overviews of geologic hazards. The Head of the Geological Hazards Section is the Survey's Liaison to the Emergency Management Agency and is a member of the Governor's Multi-Hazard Task Force. At the request of the Emergency Management Agency, the Geologic Hazards Geologist discussed earthquakes and geologic hazards at Earthquake Planning Workshops in both Teton and Lincoln Counties.

Spot requests for assistance from State and local entities are many and varied each year. The following list highlights the requests made of the Survey in FY 86, but is not all inclusive:

Archives, Museums and Historical Department -- Cooperative efforts are progressing in the preparation of a Wyoming diamond exhibit for the State Capitol and in the coordination of plans for a traveling exhibit of Green River Basin fossils. The Survey's Deputy Director is the Associate Curator of Mineralogy for the Wyoming State Museum.

Department of Agriculture -- The Survey continued to provide drafting and(or) technical assistance on the compilation of a *Land inventory map of Wyoming* and a *Natural resource atlas of the Cheyenne 30x60-minute topographic map area*.

City of Kaycee -- The Geologic Hazards and Stratigraphy Sections of the Survey

reviewed the Kaycee municipal water well project and prepared a report on their findings with recommendations.

Economic Development and Stabilization Board (EDS Board) -- Various Sections of the Survey provided information on mineral production, markets or the location of mines or mineral occurrences. The State Geologist also met with a Chinese trade representative at the request of the EDS Board to discuss mineral resources in Wyoming.

Department of Health and Social Services -- The Geologic Hazards and Uranium and Industrial Minerals Sections are cooperating in a radon monitoring project with the Department of Health and Social Services and the U.S. Environmental Protection Agency.

Lincoln County -- The Geologic Hazards Section provided geologic hazard information and assistance to the Lincoln County Planning Office in preparing their County Management (Master) Plan. The Geologic Hazards Section is also cooperating on a project that may culminate in trenching studies of the Star Valley fault at Afton. These trenching studies could refine the probabilities for renewed movement along this active fault.

Recreation Commission -- The Deputy Director of the Survey collected and donated rock specimens for this Commission's interpretive exhibit of South Pass.

State Engineer -- At the request of the State Engineer, the Geologic Hazards Section examined a recent landslide, which destroyed portions of an irrigation canal near Arlington. A report with recommendations was prepared.

University of Wyoming, Institute for Policy Research -- The State Geologist and several Staff Geologists provided quarterly minerals outlook articles for publication in the Institute's *Wyoming quarterly update*.

Water Development Commission -- The Geologic Hazards and Stratigraphy Sections are cooperating in a study of the occurrence of selenium in the Baggs-Savery area. The study is a cooperative effort of the U.S. Geological Survey, the University of Wyoming and the Geological Survey of Wyoming and is funded by the Water Development Commission.

In addition, the Survey received requests for assistance or information from the Ad Valorem Tax Division, Attorney General, Board of Control, City of Laramie, Department of Revenue and Taxation, Employment Security Commission, Energy Conservation Office, Game and Fish Department, Governor's Office, Highway Department, Inspector of Mines, Lincoln County Sheriff's Office, Public Service Commission, School of Human Medicine, State Archeologist, State Historic Preservation Office, State Library, Sweetwater, Sublette and Teton County Planning Offices, Travel Commission, Treasurer's Office, University of Wyoming's National Park Service Research Center and Water Quality and Solid Waste Divisions of the Department of Environmental Quality.

Requests for assistance and information were also received from the Bonneville Power Authority, Bureau of Indian Affairs, Colorado Geological Survey, Federal Energy Regulatory Commission, Internal Revenue Service, Jet Propulsion Laboratory, Library of Congress, Lunar and Planetary Institute of the National Aeronautics and Space Agency, National Oceanic and Atmospheric Administration, National Park Service, Peru Economic Agency, Small Business Administration, Turkey Geological Survey, U.S. Department of Defense, U.S. Department of Justice, U.S. Minerals Management Service, U.S. Bureau of Land Management, U.S. Bureau of Mines, U.S. Bureau of Reclamation, U.S. Department of Energy, U.S. Environmental Protection Agency, U.S. Federal Housing Administration, U.S. Fish and Wildlife Service, U.S. Forest Service, U.S. General Accounting Office, U.S. Geological Survey, U.S.

Housing and Urban Development Administration, U.S. Mine Safety and Health Administration, U.S. Nuclear Regulatory Commission, U.S. Office of Surface Mining, U.S. Soil Conservation Service, United Nations (UNITAR/UNOP) and Utah Geological and Mineral Survey.

As an extension of this service-related function, the State Geologist and Staff Geologists collectively presented thirty-five talks or briefings on mineral resources, geology or geologic hazards to the following groups: Albany County Energy Council; American Institute of Mining and Metallurgical Engineers, American Institute of Professional Geologists (Wyoming Section); Casper Rock Club; Castle Rock Gem and Mineral Society; Cheyenne Gem and Mineral Society; Federal Mapping Coordination Meeting; First United Methodists Church; Friends of Mineralogy (Colorado Chapter); Geological Society of America; Interagency Soil Scientist Workshop; International Archean Geochemistry Field Conference; Laramie Senior Lyceum; Lincoln County Earthquake Planning Workshops (2 talks); Methodists Mens Club; Natrona County Rock Hound Club; Oregon Trail Grange; Teton County Earthquake Planning Workshop; University of Wyoming - National Park Service Research Center Meeting on Earthquakes and Associated Hazards; University of Wyoming Agriculture Extension Service; University of Wyoming Common Ministry (3 talks); Wyoming Association of General Contractors; Wyoming Geological Association (six talks); Wyoming Mining Association's Teacher Workshops (two talks) and Wyoming Science Teachers Association (2 talks).

2. CONDUCT AND REPORT ON FIELD AND LABORATORY INVESTIGATIONS THAT CONTRIBUTE NEW GEOLOGICAL KNOWLEDGE TO THE STATE CONCERNING MINERAL RESOURCES AND OTHER MATTERS THAT HAVE A PRACTICAL BEARING ON WYOMING'S COMMUNITIES AND PEOPLE.

The following investigations were completed in FY 86:

(1) A geological and hazards study related to reclamation work on the Colorado Fuel and Iron Company's Sunrise iron ore mine property.

(2) A field investigation of ten significant tar sand and heavy oil occurrences in Wyoming.

Ongoing investigations include:

(1) Field sampling and laboratory processing of diamond-bearing kimberlite from the Laramie Range and other areas of the State as a cooperative project with the University of Wyoming's Mining and Mineral Resource Research Institute.

(2) Reconnaissance surveys of mineral occurrences throughout the State as in-house projects in the two Minerals Sections.

(3) Cooperative study with the University of Wyoming, the U.S. Geological Survey and the Water Development Commission of selenium occurrences in the Baggs-Savery area of Carbon County.

(4) Cooperative study with the Wyoming Health and Social Services Department and the U.S. Environmental Protection Agency of radon occurrences in the State.

(5) Compilation of coal data for entry into the U.S. Geological Survey's National Coal Resources Data System.

(6) Compilation of background gamma radiation levels across Wyoming for publication as maps.

(7) Geologic mapping of the South Pass-Atlantic City area of Fremont County.

(8) Statewide research and mapping of geologic hazards. Primary emphasis is currently on landslides.

(9) Geologic mapping of the southeastern Bighorn Mountains in Johnson, Natrona and Washakie Counties.

3. PUBLISH TIMELY AND SIGNIFICANT REPORTS AND MAPS THAT LEAD TO A BETTER

UNDERSTANDING OF THE LOCAL AND REGIONAL GEOLOGY OF THE STATE AND ITS MINERAL RESOURCES.

The following 53 reports, maps and posters were published in FY 86:

ANNUAL REPORT

Fifty-second annual report of the Geological Survey of Wyoming, July 1, 1984 to June 30, 1985, by G.B. Glass (1985).

INFORMATION CIRCULARS

Bibliography and index of graduate theses and dissertations of the Department of Geology and Geophysics, University of Wyoming, compiled by Josephine Battisti, Janet French and R.H. DeBruin (1985).

Complete list of publications by the Geological Survey of Wyoming from its beginnings in the Territorial Period (1877-1890) to the present, compiled by G.B. Glass (1986).

Geology of Wyoming, by G.B. Glass and D.L. Blackstone, Jr. (1986).

Guide to some rocks and minerals of Wyoming, W.D. Hausel, F.K. Root and K.G. Albert (1986).

Hints for rock hunting and prospecting in Wyoming, W.D. Hausel (1986).

MAP SERIES

Index to U.S. Geological Survey Miscellaneous Investigations Maps (I) in Wyoming: MS-9D, compiled by R.H. DeBruin (revised 1985).

Index to U.S. Geological Survey Water-Supply Paper maps in Wyoming: MS-9F, compiled by R.H. DeBruin (revised 1985).

Index to U.S. Geological Survey Oil and Gas Investigations Maps (OM) in Wyoming: MS-9I, compiled by R.H. DeBruin (1985).

Index to U.S. Geological Survey Open File Reports that contain geologic maps for Wyoming: MS-9J, compiled by R.H. DeBruin (1985).

Index to U.S. Geological Survey Circulars, Folios and Annual Reports that contain geologic maps for Wyoming: MS-9K, compiled by R.H. DeBruin (1985).

Index of Geological Survey of Wyoming publications that contain geologic maps, excluding Open File Reports: MS-9L, compiled by R.H. DeBruin (1985).

Index to Geological Survey of Wyoming Open File Reports that contain geologic maps: MS-9M, compiled by R.H. DeBruin (1985).

Metallic and industrial minerals map of Wyoming: MS-14, compiled by R.E. Harris, W.D. Hausel and J.E. Meyer (1985).

Map showing the present configuration of the Heart Mountain fault and related features, Wyoming and Montana: MS-15, by W.G. Pierce (1985).

Geologic map of Black Mountain Quadrangle, Wyoming: MS-16, by M.E. Finley (1985).

Geologic map of Shell Quadrangle, Wyoming: MS-17, by K.A. Manahl (1985).

Geologic map of Devils Kitchen Quadrangle, Wyoming: MS-18, by C.C. Reppe (1985).

Geologic map of Greybull North Quadrangle, Wyoming: MS-19, by L.M. Kozimko (1985).

Geologic map of Sheep Canyon Quadrangle, Wyoming: MS-20, by R.E. Ladd (1985).

Construction materials map of Wyoming: MS-21, by R.E. Harris and J.E. Meyer (1986).

OPEN FILE REPORTS

Description of two test holes drilled in the vicinity of Yoder, Goshen County, Wyoming: OFR 85-12, by R.M. Summer (1985).

Geologic map of Converse County, Wyoming: OFR 85-13, compiled by R.H. DeBruin (1985).

Preliminary report and map on potentially seleniferous areas in Wyoming: OFR 85-14, by J.C. Case and C.S. Boyd (1985).

Selected bibliography pertinent to periglacial wedges in Wyoming: OFR 85-15, by T.C. Nissen (1985).

Preliminary map of mined-out areas and mine subsidence in Wyoming: OFR 86-1, by J.C. Case (1986).

Preliminary map of liquefaction-prone areas in Wyoming: OFR 86-2, by J.C. Case (1986).

Preliminary map of landslides in Wyoming: OFR 86-3, by J.C. Case (1986).

Reported gold concentrations in sediment samples from U.S. Department of Energy's National Uranium Resources Evaluation (NURE) Reports: OFR 86-4, by K.G. Albert (1986).

Preliminary map of suspected active faults with surficial expression in Wyoming: OFR 86-5, by J.C. Case (1986).

Structure contour map on top of the uppermost Cretaceous Lance Formation, Bighorn Basin, Wyoming: OFR 86-6, by S.E. Parker (1986).

Isopachous map of the uppermost Cretaceous Lance Formation, Bighorn Basin, Wyoming: OFR 86-7, by S.E. Parker (1986).

Isopachous map of the Tertiary overburden above the latest Cretaceous

Lance Formation, Bighorn Basin, Wyoming: OFR 86-8, by S.E. Parker and R.W. Jones (1986).

Structure contour map on top of the Upper Cretaceous Cody Shale, Bighorn Basin, Wyoming: OFR 86-9, by S.E. Parker (1986).

Extent of coal-bearing rocks and locations of coal mines in the Wind River coal basin, Wyoming: OFR 86-10, by K.M. Groff and R.W. Jones (1986).

Coal resources of the Tongue River Member, Fort Union Formation (Paleocene), Powder River Basin, Wyoming and Montana: OFR 86-11, by W.B. Ayers, Jr. (1986).

Analyses and measured sections of seven coal samples from the Rock Springs district, Green River Basin coal field, Wyoming: OFR 86-12, by G.B. Glass and J.T. Roberts (1986).

Earthquakes and related geologic hazards in Wyoming: OFR 86-13, by J.C. Case (1986).

Reconnaissance examination of selected oil-sand and oil-spring occurrences in Wyoming: OFR 86-14, by A.J. VerPloeg (1986).

Sulfur resources of Wyoming: OFR 86-15, by R.E. Harris and J.K. King (1986).

PUBLIC INFORMATION CIRCULARS

Bibliography of graduate theses and dissertations on the geology of Wyoming, 1899 through early 1984 (exclusive of the University of Wyoming): PIC 24, compiled by G.B. Glass (1985).

Metallic and nonmetallic deposits of Wyoming and adjacent areas, 1983 conference proceedings: PIC 25, edited by Sheila Roberts (1986).

REPORT OF INVESTIGATIONS

Trapper Canyon tar sand deposit, Big Horn County, Wyoming: an exhumed stratigraphic oil trap: RI 30, by A.J. VerPloeg and R.H. DeBruin (1985).

Petrology of Hanna and Ferris Formation coals from the Hanna coal field, Wyoming: RI 32, S.C. Teerman, J.C. Crelling and G.B. Glass (1985).

Oil and gas potential of the Washakie (South Absaroka) Wilderness and adjacent study areas, Wyoming: RI 33, J.D. Love (1985).

Foreland compressional tectonics: southern Bighorn Basin and adjacent areas, Wyoming: RI 34, D.L. Blackstone, Jr. (1986).

WYOMING GEO-NOTES

No. 8: by G.B. Glass, W.D. Hausel, R.E. Harris, A.J. VerPloeg and R.W. Jones (September, 1985).

No. 9: by G.B. Glass, W.D. Hausel, A.J. VerPloeg, R.E. Harris, R.W. Jones and R.H. DeBruin (December, 1985).

No. 10: by G.B. Glass, R.H. DeBruin, R.E. Harris, R.W. Jones and W.D. Hausel (March, 1986).

No. 11: by G.B. Glass, R.H. DeBruin, R.E. Harris, R.W. Jones and W.D. Hausel (June, 1986).

ADVERTISING MATERIALS

Publications available from the Geological Survey of Wyoming, July, 1985, compiled by M.A. Richardson (1986).

Publications available from the Geological Survey of Wyoming, January,

1986, compiled by M.A. Richardson (1986).

Poster advertising Wyoming topographic maps, designed by Sheila Roberts (1986).

The following seven publications are already in preparation for publication in early FY 87:

BULLETINS

Fossils of Wyoming: Bulletin 54, by M.W. Hager (reprinted 1986).

Minerals and rocks of Wyoming: Bulletin 66, by W.D. Hausel (1986).

OPEN FILE REPORTS

Diatomite (diatomaceous earth) in Wyoming: OFR 86-16, by R.E. Harris and J.K. King (1986).

Pumice, scoria and pumicite in Wyoming: OFR 86-17, by R.E. Harris and J.K. King (1986).

PUBLIC INFORMATION CIRCULARS

Earthquakes and related geologic hazards in Wyoming: PIC 26, by J.C. Case (1986).

REPORT OF INVESTIGATIONS

Coal resources of the Tongue River Member, Fort Union Formation (Paleocene), Powder River Basin, Wyoming and Montana: RI 35, by W.B. Ayers, Jr. (1986)

ADVERTISING MATERIALS

Poster advertising popular publications available from the Geological Survey of Wyoming, designed by Sheila Roberts (1986).

In addition, the State Geologist and(or) the Staff Geologists wrote the following 24 papers and reports for outside publishers:

American Institute of Mining and Metallurgical Engineers Preprints: *Preliminary report on the geology and gold mineralization of the South Pass greenstone belt, Wind River Mountains, Wyoming*, by W.D. Hausel (1986); *Case Histories: Archean gold mineralization within the South Pass greenstone terrain, Wyoming*, by W.D. Hausel (in press); *Mining Engineering: Overview of the geology and production of trona*, by R.E. Harris (1985); *Wyoming [Exploration in 1985]*, by R.E. Harris, R.W. Jones and W.D. Hausel (1986).

American Association of Petroleum Geologists Bulletin: *Developments in coal in 1984*, by S.A. Friedman, R.W. Jones and M.L. Jackson (1985).

Association of American State Geologists, *The State Geologists Journal: Wyoming [Geological Survey activities]*, by G.B. Glass (1986).

Friends of Mineralogy (Colorado Chapter), *Colorado Pegmatites Symposium Proceedings: Wyoming pegmatites*, by R.E. Harris and W.D. Hausel (1986).

Geological Society of America Abstracts with Programs: *Upper Cretaceous and lower Tertiary rocks of the Bighorn Basin, Wyoming: a new look at the basin's stratigraphy and tectonic history*, by S.E. Parker and R.W. Jones (1985).

Governor's Workshop on Earthquake Hazards in Wyoming Proceedings: *Overview of historical earthquakes and geological hazards in Wyoming*, by J.C. Case (1985).

International Archean Geochemistry Field Conference Guidebook: *Road log*, by W.D. Hausel (1985).

Journal of Orthomolecular Medicine: *Hair selenium levels and children's classroom behavior*, by M. Marlowe, J. Errera and J.C. Case (1986).

Lunar and Planetary Institute, Workshop Manual: *Preliminary report on the geology and gold mineralization of the South Pass granite-greenstone terrain, Wind River Mountains, western Wyoming* [extended abstract], by W.D. Hausel (1986).

McGraw-Hill, Inc., Keystone Coal Industry Manual: *Wyoming [coal]*, by G.B. Glass, (in press).

Rocky Mountain Association of Geologists, Field Conference Guidebook: *Mineral deposits of the Encampment district, Sierra Madre, Wyoming and Colorado*, by W.D. Hausel (in press).

U.S. Bureau of Mines Preprint from the 1984 Bureau of Mines Minerals Yearbook: *The mineral industry of Wyoming*, by K.E. Starch and G.B. Glass (1986).

U.S. Department of Energy: *Reconnaissance examination of selected oil sand and oil spring occurrences in Wyoming*, by A.J. VerPloeg (in press).

University of Wyoming, Institute of Policy Research, Wyoming Quarterly Update: *Minerals update*, by G.B. Glass, W.D. Hausel, R.W. Jones, A.J. VerPloeg, R.H. DeBruin and R.E. Harris [Volume 5, no. 1, Volume 5, no. 2 and Volume 5 no. 3] (1985 and 1986).

Utah Geological Association Publication 14: *Wyoming trona in 1985*, by R.E. Harris (1985).

Wyoming Geological Association, The Contact [newsletter]: *Diamond exploration in Wyoming and Colorado*, [abstract], by W.D. Hausel (1986).

Wyoming Mining Association, The Mining Claim [newsletter]: *Overview of Wyoming's mineral industries in 1985*, by G.B. Glass (1986); *Trona: a push for markets*, by R.E. Harris (1986); *Wyoming coal in 1985*, by R.W. Jones (1985).

4. GATHER AND CONTINUOUSLY UPDATE AND MAINTAIN FILES AND LIBRARIES ON ALL AVAILABLE REPORTS, RECORDS, MAPS AND OTHER DATA RELATING TO THE SURFACE AND SUBSURFACE GEOLOGY AND MINERAL RESOURCES OF THE STATE.

In FY 86, the Agency (1) enlarged its inventory of mapped and identified geologic hazards, particularly landslides and seleniferous rocks, (2) examined and described numerous mineral occurrences across the State, (3) expanded its coal data in the Bighorn and Wind River Basins and (4) added many thousands of dollars worth of documents, reports and maps to the University of Wyoming's Geology Library and the Survey's library through its publication exchange agreements with Federal, foreign and other State agencies as well as the geological surveys of other States.

The Survey also maintains a "Confidential" file of drilling records from holes drilled on State mineral leases. As mandated in Wyoming Statute 36-6-102, all these subsurface drilling reports must be given to the Geological Survey within three years of drilling, after which they become a permanent file. These drilling records remain confidential for seven years after their receipt or until expiration of the lease, whichever is less (see also page 26).

With the exception of the "Confidential" drilling records mentioned above, files and libraries of the Survey are available to the public. A public-use area is provided on the second floor of the Wyoming Geological Survey Building. This area hosts microfiche and paper copies of many oil and gas well logs, aerial photography, unpublished geologic and mineral reports, U.S. Geological Survey and U.S. Bureau of Mines Open File Reports on Wyoming, U.S. Department of Energy uranium reports for Wyoming, Environmental Impact Statements, Industrial Siting Applications, numerous trade journals, scientific magazines as well as other items.

Near the end of FY 86, the Survey acquired an IBM PC/XT microcomputer with digitizing and plotting capabilities. A concerted effort was immediately begun to enter mineral resource data into this computer for easier management and manipulation of data. The initial goals

of this computerization effort are the input of mineral production, reserves and contract and price information. Information on coal mines, coal mine locations, coal thicknesses and coal quality is also being entered.

REVENUES GENERATED BY THE GEOLOGICAL SURVEY

The sale of reports and maps is an important function of the Geological Survey, and these sales provide the major source of direct revenue generated by the Agency. Publication sales in FY 86 were \$71,317, up 13 percent from the \$63,029 collected in FY 85. The total publication revenue for the 1985-1986 Biennium was \$134,346. Although this revenue for FY 85-86 is 18 percent below the \$164,000 goal set by the Joint Appropriations Committee in March, 1984, it is an increase of 10 percent over the \$122,013 collected in FY 83-84. The projected revenue from publication sales in FY 87-88 is an estimated \$140,000. To increase its publication revenues in the face of recessionary pressures, the Survey raised its prices an average of 56 percent and accelerated the prepara-

tion and publication of its reports and maps. This accelerated effort produced 31 new publications in FY 85 and 53 new publications in FY 86 (a new record). Without an increase in printing funds, however, further acceleration of publication activities is unlikely. As shown in Figures 3 and 4, there has been good correlation between Wyoming's mineral valuation and the sale of Survey publications.

The only other direct annual revenue generated by the Geological Survey is for space rented to the U.S. Geological Survey on the second floor of the Wyoming Geological Survey Building. Rental for this space was \$7,196.04 in FY 86.

OUTSIDE FUNDING SOURCES (GRANTS)

Grants are another source of revenue. But unlike the publications sales and the rental revenues which go directly into the General Fund, grant funds are used by the Geological Survey to support special projects or investigations. These grants come from outside sources with the Survey providing service in kind. The Survey does not seek any General Fund appropriations for these types of projects as each project is 100 percent funded by the cooperating entity, be it State or Federal.

Investigations and projects of this sort provide data that the Agency otherwise could not assemble or collect in as timely a manner. In all cases, the Geological Survey only undertakes these projects when they support mandated functions and are clearly of mutual

benefit to the State of Wyoming. Each of these projects results in a salable publication. Revenue from the sale of these reports eventually repays a part of the in-kind expenses. The Geological Survey is able to solicit these grants because of its exemplary performance on past grants. The Survey is not dependent on these funding sources, but is only augmented by them when it is in the best interest of the State.

The Survey's grant expenditures from outside sources in FY 86 were \$70,440. Survey geologists completed or are completing work on nine grants: 03.10 (\$6,937 carryover from FY 85) for geologic mapping of the South Pass-Atlantic City area of Fremont County, funded by the U.S. Geological Survey's COGEOMAP Program (Revenue Code 78008); 03.20

(\$7,854 carryover from FY 85) for geologic mapping in the southern Bighorn Mountains, funded by the U.S. Geological Survey's COGEOMAP Program (Revenue Code 78008); 03.30 (\$17,104 carryover from FY 85) for entry of coal data into the U.S. Geological Survey's National Coal Resources Data System (NCRDS) (Revenue Code 78008); 03.40 (\$1,275 carryover from FY 85) for support of the 03.10 and 03.20 grants, funded by the U.S. Geological Survey's COGEOMAP Program (Revenue Code 78008); 03.12 (\$8.00) for continuation of geologic mapping in the South Pass-Atlantic City area, funded by the U.S. Geological Survey's COGEOMAP Program (Revenue Code 78008) (This grant

was awarded late in FY 86 and little money was spent that fiscal year); 03.22 (\$4,304) for continuation of geological mapping in the southern Bighorn Mountains, funded by the U.S. Geological Survey's COGEOMAP Program (Revenue Code 78008); 03.60 (\$17,988) for mapping of landslides in Wyoming, funded by the U.S. Geological Survey (Revenue Code 78001); 03.70 (\$11,658) for continued entry of coal data into the U.S. Geological Survey's NCRDS Project (Revenue Code 78008); and 03.80 (\$3,313) for geologic mapping and hazards assessment of the Sunrise iron ore mine area, funded by Western Water Consultants of Laramie, Wyoming (Revenue Code 51001).

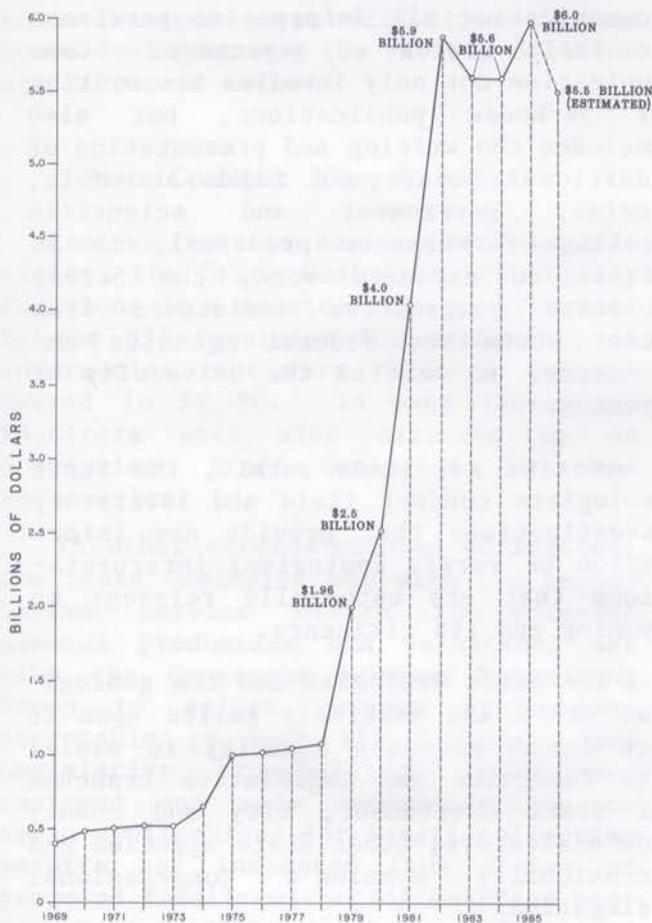


Figure 3. Assessed valuation of Wyoming's mineral production.

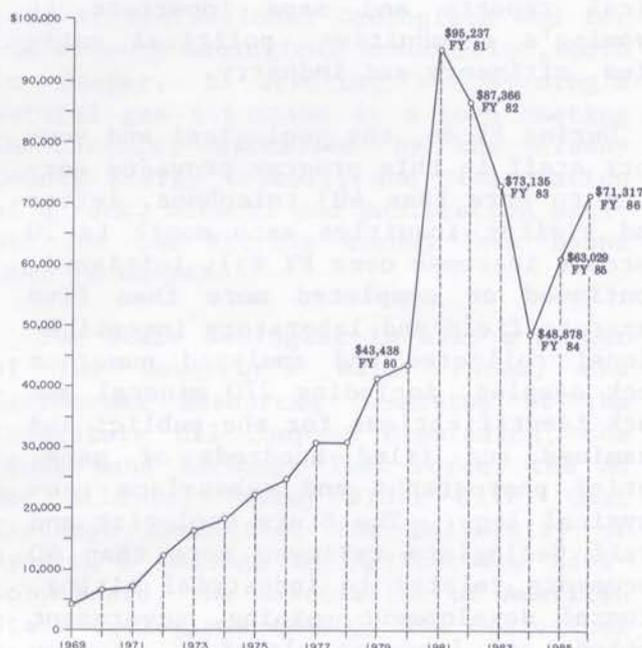


Figure 4. Annual fiscal year income from Survey publications.

Although none of the above grants currently extends past the 1985-1986 Biennium, the Survey anticipates that new, similar, cooperative working agreements will be developed during the 1987-1988 Biennium although funding from these outside sources is likely to be at much reduced levels. The financial aspect of each future project will be

handled on a case-by-case basis, and no grant can be accepted without the Governor's prior approval. Although it is anticipated that the COGEOMAP grants with the U.S. Geological Survey will be renewed when they expire in FY 86, The U.S. Geological Survey will probably not renew their NCRDS projects.

MAJOR ACCOMPLISHMENTS BY PROGRAM

Administrative Program

General Fund expenditures for the Administrative Program were \$554,488 in FY 86. This program implements the principal functions of the Geological Survey which are investigation and service as described above. The Survey acts as a collecting facility and clearing house for all information related to the geology of the State, present and future mineral resources that have economic and(or) scientific significance and as a source of technical reports and maps important to Wyoming's communities, political entities, citizenry and industry.

During FY 86, the geological and support staff in this program provided service to more than 403 telephone, letter and visitor inquiries each month (a 20 percent increase over FY 85); initiated, continued or completed more than five separate field and laboratory investigations; collected and analyzed numerous rock samples, including 270 mineral and rock identifications for the public; and examined and filed hundreds of maps, aerial photographs and subsurface geophysical logs. The State Geologist and Staff Geologists reviewed more than 90 documents related to industrial siting, mineral development, mining, government actions and land-use planning. Survey personnel researched, wrote, prepared or edited 53 publications in FY 86. This compares with 31 publications in FY 85

and sets an all time record for the Survey.

The Staff Geologists are in effect the State's experts on their fields of geology, and they are responsible for collecting, organizing, interpreting and communicating all information pertinent to their fields of expertise. Communication not only involves the writing of in-house publications, but also includes the writing and presentation of additional papers and talks at civic, social, government and scientific meetings. Whenever practical, in an effort to expedite work, the Survey solicits cooperative assistance from other State and Federal agencies and industry, as well as the University of Wyoming.

As time and funds permit, the Staff Geologists conduct field and laboratory investigations that provide new information or verify geological interpretations that are especially relevant to Wyoming and its citizenry.

The State Geologist and the geological staff are routinely called upon to act in an advisory capacity to assist the Executive and Legislative branches of State Government, city and county administrators, other State agencies and occasionally Wyoming's Congressional Delegation.

Table 1 shows a percentage breakdown of the Staff Geologists' activities by category.

Table 1. Percentage breakdown of Staff Geologists' activities.

	Range	Average
Services to the general public, State agencies, Federal agencies and others	40-60%	45.0%
Field and laboratory projects	10-20%	15.0%
Data organization	10-25%	17.5%
Report writing and editorial reviews	10-20%	15.0%
Administration	3-5%	4.0%
Other activities	2-5%	3.5%

As evidenced above, each of the Staff Geologists, with the help of part-time personnel, conducted other activities in addition to their service role. General summaries and major activities of the State Geologist and the various Sections are discussed below.

State Geologist (Gary B. Glass)

Besides routine administrative activities, the State Geologist principally functions in a service role as evidenced by the 855 inquiries for assistance or information that were received and answered in FY 86. In many instances, inquirers were also directed to an appropriate Staff Geologist for more information.

In other service-related activities, the State Geologist met with the Legislative Service Office to forecast mineral production and valuation; met with the Consensus Revenue Estimating Group to select revenue projections acceptable to both the Executive and Legislative branches of government; reviewed and made recommendations on seven applications for fossil-collecting permits and inspected five active or proposed fossil-collecting quarries near Kemmerer; reviewed documents and reports and provided technical assistance and data to other State agencies; taught a three-hour course on the geology of solid fuels (coal, tar sand and oil shale) and a one-hour course on Wyoming coal deposits as a part-time Lecturer of

Geology at the University of Wyoming; and reviewed 90 documents submitted by the Governor's Clearing House and prepared comments on 31 of those documents.

In this service role, the following six talks or briefings were also presented: talks on Wyoming's mineral industry and geology for the University of Wyoming Common Ministry and for the Wyoming Mining Association's Teacher Workshop in Casper; talks on the Agency's activities for the American Institute of Professional Geologists and for the Wyoming Geological Association, both in Casper; a briefing on Wyoming's natural gas situation at a town meeting in Laramie, sponsored by the Albany County Energy Council; and presentation of a rock, mineral and publication exhibit for the Natrona County Rock Hound Club in Casper.

The State Geologist is also a member of the Governor's Water Forum, the Geothermal Resources Committee of the Interstate Oil Compact Commission, the State Land Exchange Task Force, the Ad Hoc Alluvial Valley Floor (AVF) Coal Exchange Committee, the University of Wyoming's College of Agriculture Advisory Board, the Association of American State Geologists (AASG), the Geological Society of America, the Energy Minerals Division of the American Association of Petroleum Geologists (AAPG), the Society of Mining Engineers, the American Society for Testing and Materials and the Wyoming Geological Association; the Editor for the American Institute of

Professional Geologists and a member of the Editorial Board of Elsevier's *International Journal of Coal Geology*; and a committee member for the Energy Minerals Division of AAPG, which is planning their Rocky Mountain Section Annual Meeting in September 1986 in Casper.

The State Geologist is also a Commissioner on the Wyoming Oil and Gas Conservation Commission (see earlier discussion on page 4). This is the only regulatory activity of the State Geologist or the Survey and in this regard the State Geologist serves on the Commission in his capacity as State Geologist rather than as the chief administrative officer of the Geological Survey.

In FY 86, the State Geologist authored or coauthored ten articles or reports published by the Survey and six published by outside publishers (see pages 7 to 11).

Coal Section (Richard W. Jones)

The Coal Section serves as a major source of information on Wyoming's coal deposits and development of the State's coal industry. Office, field and laboratory investigations are designed to better define and characterize the State's coal resources through collection and compilation of data, maintenance of a reference library and working files of coal-related data and publication of maps and reports resulting from the investigations.

The Coal Section responded to requests for coal information from a wide variety of users, including State and Federal agencies, the coal industry, geological and engineering consultants, business and manufacturing companies and the general public. In FY 86, 449 inquiries were answered by the Section; the Section Head spent about 60 percent of his time responding to these inquiries.

The compilation of a new *Coal resources map of Wyoming* continued in FY 86. A third year of funding from the U.S. Geological Survey (\$27,000) continued the Coal Section's project to enter coal data into the National Coal Resources Data System (NCRDS). Work on this cooperative project continued in the Bighorn and Wind River Basins. Personnel from the Section completed field and office work that resulted in publication of Geological Survey of Wyoming Open File Reports 86-6, 86-7, 86-8 and 86-9 (Bighorn Basin) and Open File Report 86-10 (Wind River Basin) (see pages 8 and 9). Work on this planned five-year project ceased at the end of FY 86 when Federal budget cuts stopped additional funding. Two part-time personnel on the project terminated their employment at that time.

Funds from the U.S. Geological Survey grant, augmented with additional funds from the Geological Survey of Wyoming, enabled the Section to purchase a micro-computer system and peripheral equipment in FY 86. This computer system will permit entry of a variety of coal data (including drill hole information and chemical analyses) into not only the NCRDS, but also other data bases containing coal resource, reserve, production, contract and marketing information. The system will also provide access to several national coal data systems as well as mapping and resource programs developed by the U.S. Geological Survey. Section personnel completed preliminary computer entry for several projects in FY 86.

The Coal Section continued to provide information to the Geologic Hazards Section, other State agencies, consultants and the public in regard to underground mine locations, subsidence features, underground mine fires and historical data on coal mining.

In addition, personnel in the Section presented papers to the Geological Society of America, the Wyoming Geologi-

cal Association and the Wyoming Science Teachers Association; authored or coauthored nine maps or reports published by the Survey as well as another eight articles published by outside publishers (see pages 8 to 11).

Editorial Section (Sheila Roberts)

As stated earlier, the primary functions of this Section are (1) to prepare manuscripts and maps for publication, (2) to prepare bidding specifications and to supervise commercial printing of the Survey's publications and (3) to sell and(or) distribute Survey publications. The Editor is the Head of the Section, which also includes an Editorial Assistant, a Publication Sales Manager, two full-time cartographers, one part-time cartographer and one part-time stockman.

Preparation of manuscripts and maps for publication involves editing, cartography and drafting, typesetting and layout, the making of negatives and sometimes the making of colorproof copies. This is most frequently a cooperative effort between the Geologic Sections and the Editorial Section. The Editor and Editorial Assistant also write and prepare some in-house reports on their own. In particular, bibliographies, publication lists, reprints, advertising materials, press releases and information circulars are often produced solely by the Editorial Section. The editing and manuscript preparation of reports and maps submitted for publication by outside authors routinely requires above average efforts by this Section. In FY 86, for example, ten outside publications were published by the Agency and several others were prepared for publication in FY 87.

The Editor, after consultation with the State Geologist, also establishes publishing priorities. The two graphs

in Figure 5 summarize the general subject matter of Survey publications and the number of new publications completed each decade. The number of reports and maps has steadily increased, and recently quite dramatically (a record 53 items were published in FY 86) (see pages 7 to 10), but there is always a backlog of material that cannot be published in any given year because of budgetary constraints. In FY 86, three publications sent out for bid had to be rebid in FY 87 because there was not enough money available for their printing. Three other completed publications were held over for bid in FY 87.

The Editor prepared bid specifications for 32 printing jobs in FY 86 and attended 25 press runs to assure the printed quality of these publications met Survey standards. The Editor also worked with the U.S. Geological Survey in the preparation of two computer-produced, colored, geologic maps for publication in FY 87. With the experience gained here, bids for a commercially-produced computerized geologic map will be let next fiscal year. If this effort is successful and cost effective, the Survey's ability to update and revise its large, colored, wall-sized mineral resource maps as well as other colored geologic maps could be greatly enhanced and accelerated in the future. In FY 87, the Editorial Section will also experiment with computer-derived, camera-ready line drawings using the Survey's new microcomputer. This application of the computer should reduce the time needed to produce camera-ready illustrations for its publications.

The Editor also supervises the Publications Program of the Geological Survey which sells and(or) distributes the Survey's publications. Two of the Editorial Section personnel, most involved in the sale of publications (Editorial Assistant and Publication Sales Manager), are funded out of the Publications Program.

GENERAL CONTENT OF SURVEY PUBLICATIONS
FROM FISCAL YEAR 1911 THROUGH FISCAL YEAR 1986

TECHNICAL AND POPULAR GEOLOGY	135 REPORTS AND MAPS	48%
MINERAL RESOURCES	144 REPORTS AND MAPS	52%

NUMBER OF SURVEY PUBLICATIONS
COMPLETED AND PUBLISHED
PER DECADE

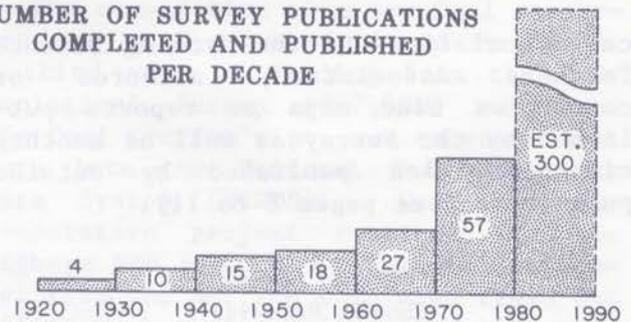


Figure 5. General content of publications and number of new publications per decade.

Geologic Hazards Section
(James C. Case)

The Geologic Hazards Section (formerly the Environmental Geology Section) continued its major program of building an environmental and hazards geology data base for Wyoming. The data base, which has involved the compilation and review of previous works, interpretation of aerial photographs and original mapping, includes information on landslides, earthquakes, active faults, wind-blown deposits, mined-out areas and mine subsidence, flood-prone areas, shrinking-swelling clays, naturally occurring toxic elements and water related topics (dam sitings, water occurrence and water quality).

Increasing public awareness of geologic hazards was a top priority of the Section in FY 86. In addition to responding to 901 inquiries, eleven formal presentations were given to various groups around the State. In October of 1985, a presentation on *Earthquakes and other geological hazards in Wyoming* was given to the Wyoming Science Teachers Convention in Casper. A talk on *Mapping activities of the Geological Survey of Wyoming* was given at the Federal Mapping Coordination meeting in Cheyenne in January. Presentations on geologic hazards,

geared to specific areas or counties in the State, were given to Teton, Lincoln and Park Counties. The talks in Teton and Lincoln Counties were for Earthquake Planning Workshops at the request of the Wyoming Emergency Management Agency, and the one in Park County was for the Cody Chapter of the Wyoming Geological Association. Presentations on geologic hazards were also given to the Laramie Senior Lyceum, Wyoming Geological Association in Casper and the Annual Interagency Soil Scientist Workshop in Laramie.

Wyoming was plagued with a number of damaging landslides in FY 86. Personnel of the Geologic Hazards Section investigated three of the sites, including damaged roads near Afton and Bondurant and a damaged irrigation canal near Arlington. A report suggesting corrective measures for the Arlington landslide was prepared at the request of the State Engineers Office, and distributed to interested parties.

In October, 1985, the U.S. Geological Survey provided additional funds (\$33,716) to continue the Survey's landslide mapping program. This project is coordinated with the U.S. Forest Service and U.S. Geological Survey. A detailed landslide map and report for the State

of Wyoming will be finished in late 1986. To date, Uinta, Lincoln, Teton and Park Counties have been partially or completely remapped. Those counties contain the majority of landslides in the State. An interim report on slope movements in Wyoming is available upon request.

In FY 86, requests for specific earthquake and active fault information were at lower levels than FY 85. However, demand for overview information increased. As a result, a report titled, *Earthquakes and related geological hazards in Wyoming*, was prepared for publication in early FY 87 as Public Information Circular 26. The report contains a map showing historic epicenters and suspected active faults with a surface expression. The Geologic Hazards Section is presently working with Lincoln County on a project that may culminate in trenching the Star Valley fault that trends through Afton, Wyoming. Single movements may have exceeded ten feet of vertical displacement in the last 1,000 years. An estimated maximum credible earthquake of 7.5 magnitude has been assigned to the fault system, but trenching will help to refine that estimate and to assign a recurrence interval.

Naturally-occurring toxic elements are another area of study for the Section. In FY 86, studies were begun on the occurrence of selenium in the Baggs-Savery, Wyoming, area. The geologic units exposed in that area are locally seleniferous in other parts of the State. Selenium indicator vegetation was also found in the study area. The study in the Baggs area is a multidisciplinary cooperative effort of the U.S. Geological Survey, the University of Wyoming and the Geological Survey of Wyoming and is funded by the Water Development Commission. The Section is also cooperating in a statewide radon monitoring project with the Wyoming Health and Social Services Department and the U.S. Environmental Protection Agency. A map of potential radon occurrences was made to guide researchers.

This map will be released as an Open File Report in FY 87.

The Section had increased involvement with various water-related projects in Wyoming. In particular, a preliminary geologic analysis on the Little Horn Pump Storage Project on the Dry Fork of the Little Bighorn River was prepared. That study noted that bedrock at the site was probably fractured and that the fracturing could affect the water-holding capacity of the proposed dam. At the request of a State Senator and the City of Kaycee, a detailed review of a report on a water supply well drilled for the town was prepared. The well had not produced as expected. Section personnel also provided a geologic hazards analysis of a proposed dam site north of Savery, Wyoming. Unstable slopes and faults in the vicinity of the dam were mapped. At the request of the American Geological Institute an early analysis of the effect of local geology on the Cheyenne flood (August 1, 1985) was prepared.

The Section's study of unique geological features in the State continued with an examination of a few unusual sites. A cave near Guernsey, Wyoming, was explored at the request of the Wyoming Department of Public Lands. The cave had a number of spectacular features in it that warranted its protection.

The Section coordinated with and supplied information to the Lincoln County Planning Office for inclusion in the County's Management (Master) Plan. Information on general geology, landslides, earthquakes, active faults, mined-out areas and mine subsidence, shrinking-swelling clays and wind-blown deposits were prepared and supplied at the County's request.

Section personnel also provided extensive assistance to the Wyoming Emergency Management Agency in support of their Civil Defense and Disaster Preparedness Plans. Statewide overviews of geologic hazards were prepared and later

released as Open File Reports of the Survey (see pages 8 and 9). The Section Head is the Agency Liaison to the Wyoming State Emergency Operations Plan as well as a member of the Governor's Multi-Hazard Task Force.

Planning is well underway for a Governor's Conference on Mine Subsidence to be held in FY 87. The Geologic Hazards Section was asked by the University of Wyoming and the Department of Environmental Quality to co-chair this conference.

In summary, activities of the Section have greatly expanded in comparison with previous fiscal years. There has been considerable progress made in making information on geologic hazards available in an understandable format.

Laboratory Section (Jay T. Roberts)

The primary function of the Laboratory Section is to provide analytical services to the Staff Geologists. When practical, the Section also provided such services to the general public. Analytical tools and technologies available to the Section include x-ray diffraction, x-ray spectrometry, x-ray fluorescence, wet chemical methods, mineral separation apparatus and a variety of petrographic, sample preparation and physical testing equipment.

During FY 86, 230 analyses and tests were performed on 120 samples submitted to the Section by Staff Geologists, State agencies and the general public. Methods applied in these analyses, expressed as a percent of the total analyses, were as follows:

X-ray diffraction	36%
Emission spectroscopy	18%
Wet chemistry	14%
X-ray fluorescence	3%
Others (includes optical, mineral separation, fire assay and miscellaneous physical properties)	29%

In addition, to the in-house analyses described above, the Section prepared geochemical and petrographic samples that were sent to commercial laboratories for analysis. The Section also provided some assistance in the Staff Geologist's field investigations, and purchased, designed, constructed and/or maintained much of the laboratory and other equipment in use at the Geological Survey.

Ongoing efforts of the Laboratory Section included experimentation with wet chemical methods for metals analysis (the Survey has no in-house capability for quantitative instrumental analysis), expansion of the capabilities for quantitative x-ray diffraction analysis of mineral mixtures and improvement of mineral separation equipment, in particular the design and construction of a new grease table for diamond separation.

Metallic Minerals Section (W. Dan Hausel)

The Metallic Minerals Section functions as the principal source for information on Wyoming's base, precious, ferrous, ferroalloy and strategic metals; precious and semiprecious stones; and on Precambrian geology. The Section supervises and conducts independent and cooperative investigations on the characteristics and distribution of various mineral deposits throughout the State and adjacent areas, and conducts regional field mapping investigations related to Precambrian geology and to the geology of various metallic mineral deposits. Mining companies, geologic and engineering consultants, universities, prospectors, environmental groups, other State agencies, Federal agencies and the general public obtain information and assistance from the Section.

In its service role, Section personnel examined and identified more than 150 rock and mineral specimens for the general public, industry, the University

of Wyoming, and other State agencies: answered more than 850 inquiries; conducted field trips for various groups and individuals; led tours of the Survey's facilities for some school groups; presented twelve talks on the State's mineral resources and the Survey's activities to professional organizations and general interest groups; and authored or coauthored seven reports published by the Survey (see pages 7 to 10), and eleven papers published by outside publishers (see pages 10 and 11).

In addition, the Section provided information and made recommendations on 19 abandoned mine sites for the Department of Environmental Quality; collected and provided rock specimens for the Recreation Commission for their interpretive exhibit of South Pass; and reviewed and critiqued outside professional publications at the request of outside authors.

During FY 86, the Metallic Minerals Section continued investigations related to the exploration of kimberlite intrusives in the central Laramie Range of southeastern Wyoming. North of Sybille Canyon in the Halleck Canyon region, several anomalous stream sediment samples were collected by the Geological Survey. Approximately one dozen samples collected in this area produced pyrope garnet and chrome diopside. A second area, located 30 to 35 miles south of Sybille Canyon, was under investigation throughout the fiscal year. This second area, known as the Pole Mountain-Happy Jack region, has produced more than three dozen anomalous stream sediment samples.

Somewhat related to the Survey's diamond exploration program, Cominco American, Incorporated donated 126 diamonds totaling 15.38 carats to the Geological Survey of Wyoming during FY 86. These diamonds are an assortment of gem quality and industrial quality stones which were recovered from kimberlite located in the Wyoming portion of the Colorado-Wyoming State Line district. The largest of the 126 diamonds

weighs 0.86 carat. Many of the diamonds were displayed for the public at the Geological Survey of Wyoming Building on February 20th and 21st, the State Capitol Building in Cheyenne on March 10th and the Basko (Oil and Gas Conservation Commission) Building in Casper on April 7th and 8th.

The Section's principal field project during the year was a continuation of the mapping of the South Pass region. South Pass is a fragmented Archean greenstone belt that has been the source of much of the State's gold and iron ore production. Estimates of historic gold production from the Archean terrain range from 80,000 to 327,000 ounces. From 1962 to 1983, more than 90 million tons of taconite were also mined from the belt. Tertiary conglomerates derived from the greenstone belt, located both north and south of the Archean terrain, also contain significant gold resources.

To date, preliminary 7 $\frac{1}{2}$ -minute geologic maps of the Lewiston Lakes and Radium Springs Quadrangles have been completed. These maps cover the eastern margin of the greenstone belt including the historic Lewiston gold mining district. Along the western margin of the belt, the Section nearly completed the Anderson Ridge Quadrangle, and initiated mapping on the NE Parting of the Ways Quadrangle. These quadrangles contain numerous pegmatites, but gold occurrences are sparse.

Because of the increased interest in precious metals, the Section has been extensively revising Report of Investigations 23, *Gold districts of Wyoming*, published in 1980. This revision will include information on a dozen or more additional mines and prospects and will include numerous mine maps, surface maps and assay reports collected by the Survey since 1980.

Additionally, the Section Head is the Deputy Director of the Geological Survey, is a member of some graduate thesis committees in the University of Wyo-

ming's Department of Geology and Geophysics, is the Associate Curator of Mineralogy for the Wyoming State Museum; is an associate editor for *Theophrastus*, a scientific journal published in Athens, Greece, and was a referee for papers submitted for publication by the Fourth International Kimberlite Conference in Perth, Australia.

Oil and Gas Section (Rodney H. DeBruin)

The Oil and Gas Section functions as a principal source of geologic information on Wyoming's oil, natural gas, oil shale and tar sand deposits. In FY 86, 614 inquiries on oil and gas matters were answered by Section personnel. In addition, the Section received several requests for information on carbon dioxide as it related to Exxon's anticipated FY 87 start-up of production from its huge reserves in the La Barge area. In regard to requests from other State agencies, the Section prepared its annual forecast of oil and gas production and value per unit for the Legislative Service Office. All new oil and gas discoveries were routinely evaluated with regard to State mineral ownership, and discoveries on or near State lands were reported to the Commissioner of Public Lands. Every two months the Section Head provided oil and gas tract evaluations to assist the Commissioner of Public Lands with selection of tracts for lease auction. An updated list of evaluations and sale results on nearly 5,000 State tracts was also provided every other month. Oil and gas updates were written every three months for incorporation in the University of Wyoming's Institute for Policy Research's *Wyoming quarterly update*.

In addition, the Section also maintained a library of petroleum-related data. The Section received and filed substantial quantities of new subsurface information provided by the petroleum industry and directed to the Survey through the Wyoming Oil and Gas Conser-

vation Commission. The Section also received a large donation of microfilmed electric logs for Wyoming and surrounding states. These logs will be incorporated into the well log library, filling gaps in the collection.

A field reconnaissance study of tar sand and heavy oil occurrences in Wyoming, which was started in FY 85, was completed in FY 86. A report on the ten most significant deposits was released as Open File Report 86-14 and titled *Reconnaissance examination of selected oil sand and oil spring occurrences in Wyoming*. The report contains a description, photographs and a reconnaissance geologic map for each of the occurrences. This project was partially funded by a grant from the U.S. Department of Energy (administered by the University of Wyoming's Industrial Fund), and a report was also submitted to them in FY 86.

A final expanded report on the Trapper Canyon tar sand deposit was completed in early FY 86 and was published as Report of Investigations 30, titled *Trapper Canyon tar sand deposit, Big Horn County, Wyoming: an exhumed stratigraphic oil trap*. This study was also funded by the U.S. Department of Energy.

During the last half of FY 86, the Section began compiling historic oil and gas production figures from data provided by the Wyoming Oil and Gas Conservation Commission. The largest 264 oil fields (those with annual production of more than 50,000 barrels) represented 94.3 percent of the State's total 1984 production. The largest 217 gas fields (those with annual production of more than 100,000 MCF) represented 98.5 percent of the State's 1984 gas production. Production from these 481 fields for the years 1970 to 1984 was entered into a data base. The Survey has ordered an IBM microcomputer for manipulation of mineral production statistics; when it arrives, the data for these largest fields will be entered. As time permits, data for all oil and gas fields

will be entered. This computerized data base should allow more timely and more accurate predictions of oil and gas production.

Stratigraphy Section (Alan J. VerPloeg)

The Stratigraphy Section functions as a principal source of information on the stratigraphy and general geology of Wyoming. In FY 86, 281 requests for information from industry, the general public, universities and State and Federal agencies were answered. The Section also maintained and solicited materials for a reference library and a working file of stratigraphic data, which was used extensively by other Sections of the Survey. Stratigraphic and geologic investigations, including geologic field mapping, were conducted by the Section. The Section also generated or supplied geologic data in support of projects initiated by other Sections of the Survey.

Field work and compilation for two 7½-minute geologic maps (Fraker Mountain and Barnum Quadrangles) were completed during FY 86. The maps are currently in the drafting stage using digital equipment of the U.S. Geological Survey. They should be released in early FY 87. Near the end of FY 86, field work and interpretation of aerial photographs were initiated on another two geologic maps (Red Fork Powder River and Mayoworth Quadrangles). These maps will be published in FY 87. This mapping project on the southeastern flank of the Bighorn Mountains is partially funded by the U.S. Geological Survey under their COGEMAP Program. If the program continues to be funded, the geology for a total of twenty 7½-minute quadrangles will be mapped at a scale of 1:24,000.

The Section completed five indexes to theses maps prepared for the University of Wyoming's Department of Geology and Geophysics. These indexes, covering maps completed between 1928-1985, are currently in the drafting stage and will be

published in early FY 87. A companion *Bibliography and index of graduate theses and dissertations of the Department of Geology and Geophysics, University of Wyoming* was also compiled and published in FY 86.

A new *Highway geologic map of Wyoming* (scale 1:1,000,000) was compiled by R.D. Christiansen in cooperation with the Geological Survey of Wyoming. This map was reviewed and edited by the Section and will be released in early FY 87. Three 1:24,000 scale geologic quadrangle maps submitted by Iowa State University's Department of Geology were reviewed and edited. These maps (Devils Kitchen, Greybull North and Sheep Canyon Quadrangles) were published along with two maps received earlier from Iowa State (Black Mountain and Shell Quadrangles). A geologic map of Converse County, Wyoming, was compiled and released as Open File Report 85-13. Additions and revisions to Map Series 9, a series of geologic mapping index maps, were also prepared and published (see pages 7 and 8).

A list and map showing the locations of various university geology field camps in Wyoming was compiled in FY 86 and published in *Wyoming Geo-notes No. 9*. In a related project, over 500 questionnaires were mailed to various U.S. universities and Federal agencies to identify ongoing geologic investigations in Wyoming. The results were compiled in late FY 86 and will be published as an Open File Report in early FY 87.

The Section collaborated with the Geologic Hazards Section in an examination of the proposed Little Sandstone Creek Dam Site near Savery, Wyoming. A reconnaissance examination was made to determine the presence of faulting, extent of landslides and any other geologic hazards that may exist in the area affected by the dam and reservoir. This examination was made at the request of a local landowner and was done in cooperation with the Wyoming Water Development Commission.

Work has begun on a new stratigraphic nomenclature chart for the eastern half of the Bighorn Basin. When completed, it will be incorporated in a new chart for the entire state that is currently being assembled by the Wyoming Geological Association in Casper.

Uranium and Industrial Minerals Section (Ray E. Harris)

The Uranium and Industrial Minerals Section is a major source of information on radioactive minerals (uranium- and thorium-bearing), the industrial minerals bentonite, gypsum, limestone and dolomite, phosphate, trona, and zeolites) and construction materials (sand, gravel, clinker, etc.) in Wyoming. Other minerals of sedimentary origin and assorted industrial minerals and rocks such as talc and anorthosite are also the responsibility of this Section.

In FY 86, 857 requests for information regarding these commodities were answered for private citizens, State and Federal agencies and private industry. This was a 40 percent increase over inquiries in FY 85. While inquiries for uranium and bentonite information decreased, inquiries for limestone, construction aggregate, gypsum, zeolites and especially mineral sulfur increased. Inquiries were also received for pumicite and ballast sources.

The Section provided technical advice to the Department of Environmental Quality regarding information on limestone quarries scheduled for reclamation and on several abandoned mines in the Lusk-Hartville area. The Section also worked closely with the Wyoming Economic Development and Stabilization Board (EDS Board) providing information on production and trends and exchanging information on producers and markets for industrial minerals. The Section also prepared forecasts of uranium and industrial minerals production and value for the Legislative Service Office.

The Section completed a 1:500,000 scale *Construction materials map of Wyoming*, which was published in FY 86. Section personnel authored or co-authored another six reports or maps published by the Survey (see pages 8 to 10 and eight papers published by outside publishers (see pages 10 and 11). Talks on Wyoming's mineral resources were presented to the Wyoming Geological Association, the Wyoming Association of General Contractors and the Friends of Mineralogy, Colorado Chapter. In addition, short articles on Wyoming sulfur and Pacific Power and Light Company's power pole numbering system were published in *Wyoming Geo-notes*.

Background gamma-radiation studies of areas in Wyoming continued in FY 86. Field work for the Newcastle 1° x 2° Quadrangle was completed and the report was begun. Studies of the Casper and Ashton 1° x 2° sheets were also begun. The background gamma-radiation study of the Cheyenne 1° x 2° was completed, but as reported last year, a geologic base map of the area is still not available from the U.S. Geological Survey.

Work continued on statewide studies of nonconformity-related uranium occurrences, of uranium in ground water, of radioactive mineral occurrences and uranium mines, of tantalum and Rare Earth Elements, of zeolites and of bentonite.

The Section was actively involved in securing a source of ballast in Wyoming for the Burlington Northern Railroad (near Guernsey); limestone and possibly gypsum resources for Mountain States Cement (Centex) at Laramie; and several construction material sources for road construction projects, including those related to the Peacekeeper missile construction project in southeastern Wyoming.

During FY 86, the Section was awarded and completed a grant to conduct geologic and geologic hazard assessment

studies related to reclamation work on the Colorado Fuel and Iron Company's (CF&I) Sunrise iron ore mine property. This project was funded by Western Water Consultants of Laramie from the Abandoned Mined Lands Reclamation Program (AML) of the Department of Environmental Quality. The Section's work on this grant was coordinated with the AML office and supported by CF&I.

Publications Program

The Publications Program, which is principally the sales arm of the Survey, provides the public with geological information collected and interpreted by Survey personnel or outside authors. Publications are an essential part of the Survey's overall service function as mandated by law (W.S. 9-2-805, part a, subsections iv and v).

Prices charged for individual items and quantities printed are based on actual publication costs and the nature of the item. Some publications are highly scientific or technical and have a limited market, others are specifically written for the general public. Some have an enduring market appeal, whereas others are timely, but sales are shorter term.

Part of the Publications Program is budgeted for "Purchases for Resale". In this way the Survey enhances the availability of special books and maps published by the U.S. Geological Survey or similar organizations, which have an appeal to Wyoming citizens or tourists. It is another type of information service. Topographic maps and the new *State geologic map* are two important items provided by this mechanism.

Through the years, the Publications budget has changed. It was designed to provide funds for printing and distributing the Agency's publications and for publications and maps purchased for resale. As the scope and volume of investigations and the style of reports and maps changed, the Publications budget

grew to accommodate the increased activity. Changes were also made in the budgeting procedure. New line items were added for other kinds of supplies and services that were more closely related to publications than to the Administrative Program. In FY 79, the salaries of two employees were shifted over from Administration to Publications. These two employees evolved into the Publication Sales Manager and the Editorial Assistant. Expenditures for the Publications Program in FY 86 were \$99,754.

In FY 86, the two employees in the Publications Program responded to 4,269 requests for publications (over-the-counter, phone or mail order), about the same as FY 85. The decline from the record 11,119 requests in FY 81 reflects the general economic decline that has characterized the minerals and petroleum industries in that period. A percentage breakdown of publication customers in FY 86 is:

Category	Percent of Customers	Percent of Sales Revenue
General Public	70%	50%
Business and Industry	18%	28%
Wyoming and Local Agencies	3%	10%
Federal, Other States and Foreign	2%	3%
Universities	7%	9%

Revenues generated from the sale of publications are deposited in the General Fund. Weekly tallies are reported to the State Geologist. Quarterly tally reports, which show monthly income totals and the number of each type of report or map sold, are submitted to the Geological Survey Advisory Board.

Biennial budget requests for printing funds are geared to revenue collected from the sale of publications during the two previous years. In other words, the funds requested of the Legislature for commercial printing costs are already on deposit in the General Fund. As a general rule, sales income had been increasing at the rate of \$6,500 per year until FY 81. Sales income in FY 81, however, increased a phenomenal \$51,799 over FY 80. With the subsequent recession, how-

ever, sales declined substantially, dropping to \$48,878 in FY 84. Late in 1984, the Legislature requested that the Survey try to increase its publications' revenues to 75 percent of the overall budget for the Publications Program (this equated to approximately \$74,800 in FY 86). To accomplish this goal prices were raised approximately 56 percent in late FY 85, and the preparation and publication of reports and maps were accelerated. Slumping sales were successfully turned around in FY 85 (\$63,029) and increased again in FY 86 (\$71,317).

Publications of the Geological Survey are also distributed free-of-charge to libraries and archives throughout the State. Limited numbers of each publication are also provided to other State

agencies and branches of government and to elected officials on request. In addition, the Survey participates in publication exchange programs with all other state geological surveys, numerous foreign geological surveys, the U.S. Geological Survey, the U.S. Department of Energy, the U.S. Bureau of Mines and other entities. These distributions do not add directly to sales revenue, but they provide an important service to the State and allow acquisition of publications from out-of-state agencies without charge. The publications acquired through the Survey's exchange agreements are subsequently donated to the University of Wyoming's Geology Library.

A complete listing of the 53 Survey reports and maps published in FY 86 is provided on pages 7 to 10).

PROBLEM AREAS AND RECOMMENDATIONS

1. Wyoming Statute 36-6-102 requires a company that drills an exploration hole on a State lease to submit copies of all subsurface log reports (electrical, gamma-ray, neutron, density, resistivity, etc.) to the State Geologist within three years after completion of drilling. Copies become the property of the State to be retained within the permanent files of the Geological Survey. These subsurface log reports are held "confidential" for a period of seven years after receipt by the State Geologist or until expiration of the lease, whichever is the lesser period of time. If a lease is being held by production, all reports will be held confidential until the lease is terminated.

Although many companies have complied with this law, the small amount of data turned in suggests that there are many companies that have not complied. Because there is currently no requirement for a company to notify the State Geologist that they are drilling or have drilled exploration holes, there is no way to verify the compliance with this law. Oil and gas companies pose no concern as their logs are routinely turned

into the Wyoming Oil and Gas Conservation Commission, thus meeting the provisions of this law since copies of these logs are forwarded to the State Geologist. Exploration logs for other minerals, however, present a problem.

Currently, when the State Geologist learns that subsurface drilling reports are available but not turned in, a letter to the delinquent companies, produces the reports. This procedure, however, only works when the State Geologist finds out holes were drilled and when he ascertains who to write to. Although at least a partial listing of exploration holes is now available in the Land Division of the Department of Environmental Quality, the Geological Survey lacked the funds to purchase this information in FY 86.

If this law is to be truly effective in gathering and preserving the valuable mineral resource information provided by subsurface drilling information, it needs revised. The revisions should provide some mechanism that will alert the Geological Survey to the drilling of holes on State lands so that the Agency

can monitor compliance with the law, i.e., follow-up letters can be written if the information is not received within three years of a drilling program. In addition, penalty provisions for non-compliance should be added. The law would also be more valuable if it required oil and gas companies to at least run gamma-ray logs to the surface in all wells drilled on State lands.

2. There is still a need for a State Minerals Supervisor. In essence, this Minerals Supervisor would be comparable to Wyoming's Oil and Gas Supervisor with responsibility for verifying production reports, preventing waste and promoting conservation of the State's mineral resources, exclusive of oil and gas. In particular, there is no State agency specifically assessing mining and exploration activities on State-owned lands.

It is recommended that the responsibility and authority for such a position be assigned to the Department of Public Lands. Alternatively, it appears that the Board of Land Commissioners may already have the authority to direct the State Geologist to make such appraisals at least on State or school lands through Wyoming Statutes 9-2-803, Paragraph (c), part (i). This alternative would require at least one additional full-time position in the Geological Survey.

3. With revenues from Wyoming's mineral industry leveling off or at least growing more slowly, forecasting of future tax revenues has become more important and more difficult. These forecasts, particularly on the short term, would be much more accurate and timely if the State were receiving monthly mineral production reports. Quarterly reports are less desirable, but certainly better than no reports at all. Although the Oil and Gas Conservation Commission already prepares monthly reports for oil and gas production, there is no similar requirement for any other minerals produced in Wyoming.

In the case of coal, the Survey has subscribed to a commercially available report that summarizes coal production reported to the Federal Energy Regulatory Commission (FERC) (derived from FERC Form 423). Similar monthly data for uranium and trona are not available from Federal agencies because they are "confidential". Although acquisition of this "confidential" data would undoubtedly require the support of both the Governor and Wyoming's Congressional Delegation, it would avoid duplication of effort.

In a similar vein, anyone needing production statistics for Wyoming's mineral industries realizes there is little agreement between the production reported by the Ad Valorem Tax Division, the Oil and Gas Conservation Commission and the State Inspector of Mines. There is even less agreement with similar production statistics for Wyoming published by the U.S. Department of Energy and the U.S. Bureau of Mines. This is because reporting requirements vary with the individual agencies. This problem will persist until the gathering of production data is relegated to one entity.

4. The Geologic Hazards Section of the Survey is not only responsible for compiling, mapping and interpreting information on existing and potential geologic hazards in the State, but also responds to hydrologic inquiries involving water wells and dam sites. Over the last two years, requests for maps and information on geologic hazards has more than tripled. In particular, the State's Emergency Management Agency has requested the Section's participation in preparing County Disaster Preparedness Plans. Similar requests have come from the counties that are involved. Responses to these requests have dominated the Section's activities and left little time for the equally important hydrologic inquiries, which have also increased in number.

The Geologic Hazards Section currently consists of one full-time Staff Geologist and one half-time

assistant. The Section staff only expands in size if contracts or grants are acquired. Unfortunately, the contracts and grants that the Section has had required a specific product only indirectly related to disaster preparedness, and personnel hired under those terms have specific duties that relate only to the project.

The existing staff could eventually address all the inquiries, however, the timetables requested by the Emergency Management Agency and the counties require much more accelerated responses if they are to be timely. Consequently, other important activities of the Section such as the assessment of naturally occurring toxic elements (selenium and radon), field examinations

of the geological suitability of various dam sites and requests for assistance in the siting of municipal water wells have been considerably scaled down.

In order to free the Geologic Hazards Geologist to meet all these increased demands for information on geologic hazards and to accelerate and increase responses for hydrologic information, another full-time Staff Geologist is needed. This new Staff Geologist should have extensive experience in geohydrology and would be put in charge of a new Ground Water Section of the Survey. In order to fill this position with a qualified person, a salary of \$29,000-\$30,000 is required. Supporting funds for this new position would require an additional \$7,000 each year.