

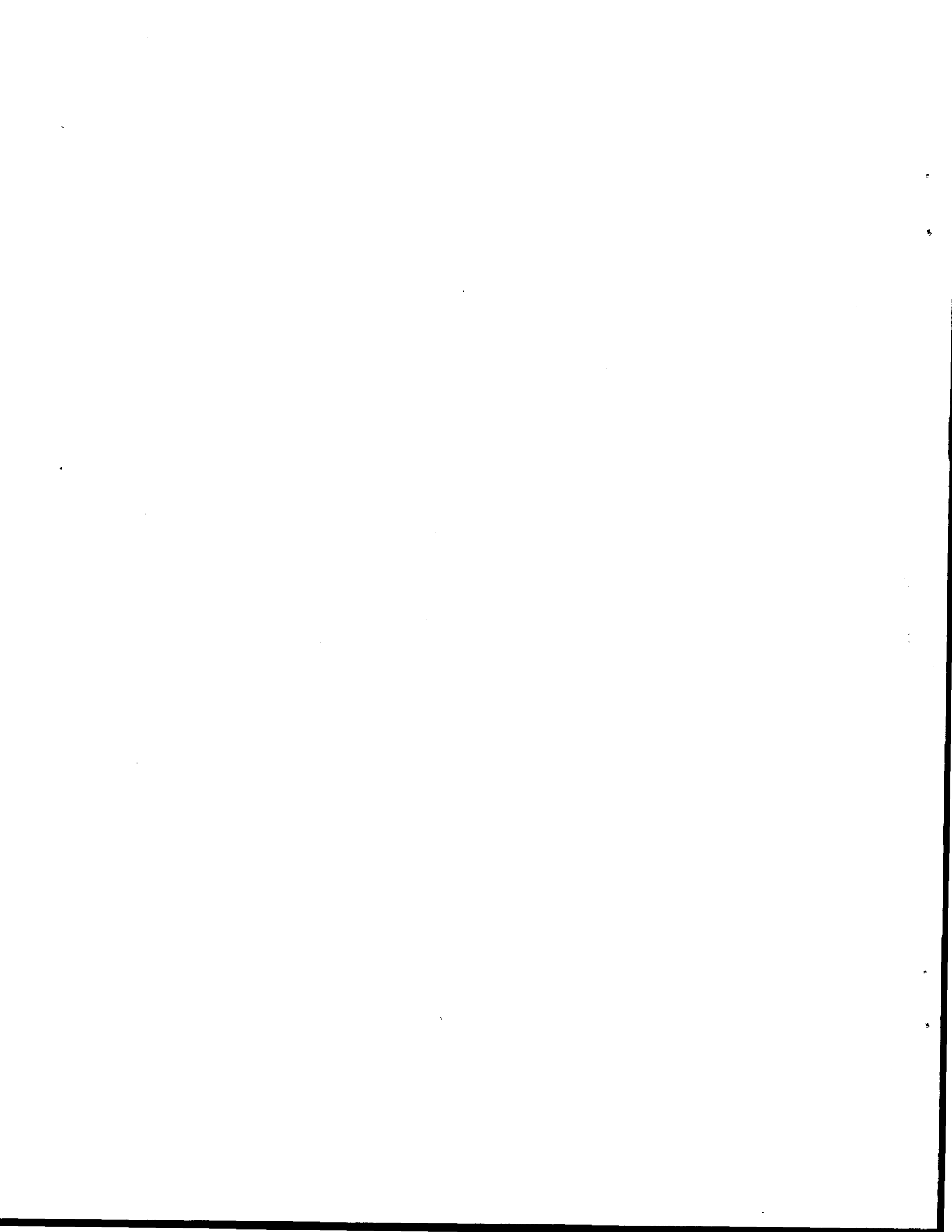
94th ANNUAL REPORT OF THE STATE GEOLOGIST

of

INDIANA GEOLOGICAL SURVEY
DEPARTMENT OF NATURAL RESOURCES

for

July 1, 1969 - June 30, 1970



GEOLOGICAL SURVEY
NINETY-FOURTH ANNUAL REPORT OF THE STATE GEOLOGIST

PERSONNEL

Permanent Personnel

Administration

John B. Patton State Geologist
Maurice E. Biggs Assistant State Geologist
Mary Beth Fox Mineral Statistician
Theodore H. Appleton Accountant
Marguerite Trisler Senior Account Clerk

Coal Section

Charles E. Wier Geologist and Head
Harold C. Hutchison Geologist
Richard L. Powell Geologist
Marvin T. Iverson Geological Assistant
Bonnie Burks Secretary

Drafting and Photography Section

William H. Moran Chief Draftsman and Head
Robert E. Judah Geological Artist-Draftsman
Muriel M. Malone Geological Draftsman
John E. Peace Senior Geological Draftsman
Roger L. Purcell Geological Draftsman
George R. Ringer Photographer

Educational Services

Reevan Dee Rarick Geologist

Geochemistry Section

R. K. Leininger Geochemist and Head
Maynard E. Collier Chemist
Elmer E. Craig Geochemical Assistant
Rosalie V. Easton Secretary
(Shared with Industrial Minerals Section)

Geochemistry Section (continued)

Margaret V. Golde Instrumental Analyst
Louis V. Miller Coal Chemist
Alfred E. White Geochemical Assistant

Geology Section

Robert H. Shaver Paleontologist and Head
Ned K. Bleuer Glacial Geologist
Henry H. Gray Head Stratigrapher
Alan S. Horowitz Curator of Paleontology
Carl B. Rexroad Paleontologist
Allan F. Schneider Glacial Geologist
Martha N. Smith Secretary

Geophysics Section

Maurice E. Biggs Geophysicist and Head
Robert F. Blakely Geophysicist
Galen Cramer Assistant Driller
Kathleen Hartley Secretary
(from July 21, 1969)
Clarence Haskins Driller
John R. Helms Geophysical Assistant
Charles Miller Instrument Maker
Joseph F. Whaley Geophysicist

Industrial Minerals Section

Lawrence F. Rooney Geologist and Head
Curtis H. Ault Geologist
Donald D. Carr Geologist
Rosalie V. Easton Secretary
Michael C. Moore Geologist
(from January 1, 1970)
William M. Webb Geologist
(to December 1, 1969)

Petroleum Section

T. A. Dawson Geologist and Head
Leroy Becker Geologist
M. Ruth Butcher Secretary and Curator of Records
G. L. Carpenter Geologist
James T. Cazee Geological Assistant
Andrew J. Hreha Geologist

Petroleum Section (continued)

Stanley Keller Geologist
Timothy L. Lawrence Geological Assistant
(from February 25, 1970)
Jan Alan Mayer Geological Assistant
(to January 30, 1970)
Vivian McGuire Senior Curator of Records
Howard Smith Geologist
(to November 19, 1969)
Dan M. Sullivan Geologist
James Thrasher Geological Assistant

Publications Section

Gerald S. Woodard Editor and Head
Linda K. May Secretary
(to March 13, 1970)
Donna C. Schultz Senior Sales and Records Clerk
M. Jane Tuke Secretary
(from March 2, 1970)

Seasonal Personnel

Coal Section

John Bassett Cave Research Assistant
(September 14, 1969 to May 23, 1970)
Thomas Hare Geologic Assistant
(July 1, 1969 to June 10, 1970)
David V. Lewis Geologic Research Assistant
(June 6, 1970 to June 30, 1970)
David Morton Laboratory Assistant
(June 21, 1970 to June 30, 1970)
Vance Pat Wiram Geologic Assistant
(September 14, 1969 to January 31, 1970)

Geochemistry Section

Stephen Eikenberry Laboratory Assistant
(January 19, 1970 to May 4, 1970)
Carrie Foley Laboratory Assistant
(September 16, 1969 to June 30, 1970)
Sally Lewis Laboratory Assistant
(June 9, 1969 to August 29, 1969)
Ted Petranoff Laboratory Assistant
(September 29, 1969 to June 4, 1970)

Geochemistry Section (continued)

Charles Roy Laboratory Assistant
(June 8, 1970 to June 30, 1970)
Bob Stout Laboratory Assistant
(April 13, 1970 to April 24, 1970)
John Thompson Laboratory Assistant
(February 11, 1970 to June 2, 1970)

Geology Section

David A. Darko Laboratory Assistant
(July 22, 1969 to August 29, 1969)
Carolyn J. Haase Laboratory Assistant
(January 9, 1970 to May 22, 1970)
James L. Hauser Laboratory Assistant
(April 6, 1970 to June 30, 1970)
Peggy Keller Laboratory Assistant
(June 22, 1970 to June 30, 1970)
Marion Lankston Geologist
(February 2, 1970 to May 22, 1970)
James P. McPhee Laboratory Assistant
(July 1, 1969 to August 17, 1969)
Inge Merkle Laboratory Assistant
(July 1, 1969 to June 30, 1970)
Robert S. Nicoll Geologist
(July 1, 1969 to August 29, 1969)
Linda M. Niles Laboratory Assistant
(June 8, 1970 to June 30, 1970)
Michael H. Peebles Laboratory Assistant
(July 1, 1970 to July 8, 1970)
Humberto Rostoworowski Laboratory Assistant
(October 13, 1969 to March 4, 1970)
Kathleen Roy Laboratory Assistant
(June 8, 1970 to June 30, 1970)
Jeffrey Rueble Laboratory Assistant
(September 15, 1969 to December 5, 1969)
Janet K. Sheets Laboratory Assistant
(July 1, 1969 to June 30, 1970)
W. Thomas Straw Geologist
(April 20, 1970 to June 30, 1970)
Robert Vote Laboratory Assistant
(September 20, 1969 to May 5, 1970)

Geophysics Section

Sondra Garrison Clerk-Typist
(September 15, 1969 to May 21, 1970)

Geophysics Section (continued)

Robert Lankston Laboratory Assistant
(March 16, 1970 to May 28, 1970)
James Lyons Geophysical Assistant
(July 1, 1969 to September 26, 1969)
Katy May Laboratory Assistant
(March 16, 1970 to May 1, 1970)
Sharon McGlothlin Key punch Operator
(July 1, 1969 to June 30, 1970)
Janice Nattier Laboratory Assistant
(June 8, 1970 to June 30, 1970)
Albert J. Rudman Geophysicist
(July 1, 1969 to August 31, 1969)
John Sexton Geophysics Field Party Chief
(June 8, 1970 to June 30, 1970)
Susan Zobel Clerk-Typist
(July 1, 1969 to July 31, 1969)

Industrial Minerals Section

Ann Feldman Laboratory Assistant
(July 1, 1969 to August 29, 1969)
Barry Jeffries Laboratory Assistant
(September 19, 1969 to May 22, 1970)
Linda Niles Laboratory Assistant
(September 16, 1969 to March 27, 1970)
Marion Lankston Laboratory Assistant
(February 2, 1970 to May 22, 1970)
Steve Wells Laboratory Assistant
(May 15, 1970 to June 30, 1970)

Petroleum Section

Larry G. Enochs Geological Assistant
(July 1, 1969 to August 29, 1969)

Publications Section

John V. Akard Clerk
(September 11, 1969 to January 30, 1970)
Herbert M. Hughes, Jr. Clerk
(January 26, 1970 to April 6, 1970)
Paul E. Prichard Clerk
(July 1, 1969 to September 10, 1969
April 20, 1970 to June 30, 1970)

FINANCIAL STATEMENT

FUNCTION OR ACTIVITY	EXPENDITURES 1969-70
1. PERSONAL SERVICES	
101. Full-time Salaries	\$437,872.43
101. Summer Field Work	2,226.80
101. Hourly	10,445.53
199. Work Study	214.61
TOTAL: PERSONAL SERVICES	450,759.37
2. SERVICES OTHER THAN PERSONAL	
201. Postage	13.00
204. Freight	74.98
206. Dues & Subscriptions	286.82
211. Gasoline	8,326.85
215. Travel	14,346.39
220. Telephone	4,998.40
TOTAL: SERVICES OTHER THAN PERSONAL	28,046.44
3. SERVICES BY CONTRACT	
302. Printing & Binding	17,863.40
329. Insurance	9,046.20
331. Repair to Buildings	1,850.27
332. Repair to Cars	3,054.73
339. Repair to Laboratory & Office Equipment	3,139.56
399. Contractual Services	3,206.53
TOTAL: SERVICES BY CONTRACT	38,160.69
4. MATERIALS, SUPPLIES & PARTS	
401. Office	906.87
404. Laboratory & Shop	15,183.78
TOTAL: MATERIALS, SUPPLIES & PARTS	16,090.65
5. EQUIPMENT	
501. Office	2,935.34
511. Motor Vehicle	5,015.86
521. Laboratory & Shop	2,436.47
TOTAL: EQUIPMENT	10,387.67
TOTAL: EXPENDITURES	\$543,444.82

INTRODUCTION

One measure of the activity and vigor of a geological survey is its output of published maps and reports and of memorandum reports. During the 1969-70 fiscal year the Indiana Geological Survey maintained the high level of publication that had begun during the preceding year. In all, five reports and three maps were published by the Survey and nineteen reports were published in scientific journals and elsewhere by Survey authors. In addition, a large number of memorandum reports were prepared in response to special projects.

This trend of an increased output of publications likely will continue into the next fiscal year. In contrast, during a period of several years relatively few reports were turned out by Survey authors. Although somewhat cyclic by nature, increases and decreases in the publishing program also reflect the Survey's financial situation, but with somewhat of a lag between the time of available funds and publications.

For the past several years the Geological Survey has operated under the handicap of an unpredictable budgetary situation. Because income from the Petroleum Severance Tax has been declining at a faster rate than the legislature has reacted to the change, the Survey has had an uncertain and shaky grip on its financial affairs. Expenditures have been held to the barest minimum in order not to be caught short at the end of a fiscal year.

Even the sources of funds have been uncertain at times. During the current fiscal year, for example, the Severance Tax was designated to provide \$211,000., the General Fund \$245,320., and through an emergency plan, the remainder of our operating budget was derived from funds that had been assigned to the Division of Water.

Because of these uncertainties the Survey has operated, but timidly. Routine work has been done, but no new projects have been undertaken, no reorganization of effort has been made, no new equipment has been sought, and the ideas for new projects and new concepts mainly have been stalled.

Under these conditions the Survey does its basic job, and quite well, but it does not show the vigor that at one time caused it to be ranked as one of the three best State geological organizations in the country. A stable and adequate system of financing the operation of the Geological Survey is desperately needed. Such a system is unlikely to be developed as long as our budget is tied to a severance tax on one declining commodity.

ORGANIZATION AND ADMINISTRATION

The Geological Survey is headed by the State Geologist, who is responsible to the Director of the Department of Natural Resources. The organizational framework consists of three commodity sections (Coal, Industrial Minerals, and Petroleum), three research and analytical sections (Geochemistry, Geology, and Geophysics) and two service sections (Drafting and Photography, and Publications). The sections differ widely in size, ranging from the Petroleum Section with 13 full-time employees and some seasonal personnel to the smallest section (Educational Services) which consists of one full-time geologist. In addition to the staff members of the sections enumerated, a few employees work directly with, or under the direction of the State Geologist.

Biennial budget requests are constructed by the State Geologist and submitted to the Director of the Department of Natural Resources, who in turn submits them to the State Budget Committee for action and transmittal to the Indiana General Assembly. Annual operating budgets of the Geological Survey also are constructed by the State Geologist and submitted to the Director for approval. Indiana University then acts as the fiscal agent for the Department of Natural Resources, and the appropriated funds are spent under the signature of the State Geologist. Records of all expenditures become part of the Accounting Department of Indiana University and are audited by the State Auditor's Office; monthly financial reports are sent to the Department of Natural Resources.

STATISTICAL SUMMARY OF ACTIVITIES FOR FISCAL 1969-70

Many of the activities of the Geological Survey can be most readily summarized by the statistical listing that follows:

Projects in progress	51
Projects completed	17
Conferences with visitors to the Survey	1,262
Man days of field work	1,149
Incoming letters	4,384
Outgoing letters	2,793
Telephone requests for information	10
Total number of vehicles	21
Total number of miles traveled in Survey vehicles	183,682
Thickness of stratigraphic sections	8,655
Public lectures	
Civic	15
Industrial	2
School	50
Other	10
Papers presented at professional meetings	4
Field trips	
In connection with conferences	53
Educational	50
News releases submitted	4
Mineral statistic questionnaires processed	850
Attendance at professional meetings	27
Exhibits prepared for special occasion	13
Samples received or collected	
Rocks, minerals	2,879
Coal	27
Fossils	924
Identification (rocks, minerals, fossils)	250
Special rock sets for teachers	23
Rocks and mineral sets sent	208
Gravity separations of coal	192
Polished blocks of coal made	24
Coal samples prepared	230
Coal analyses (determinations)	1,688
Samples analyzed instrumentally	795
Instrumental analyses (determinations)	4,826
Samples analyzed chemically	725
Chemical analyses (determinations)	2,200
Samples from cores and quarries received or collected	1,130
Rock analyses (magnetic, mineralogical, textural, and physical)	2,088
Physical tests on building stone	60
Physical tests on other stone	7
Seismic reflection shots	17
Feet of hole drilled	1,984

Feet of core recovered	860
Feet of hole augered	725
Feet of core collected other than by Survey	368
Feet of core described	1,586
Thickness of auger description (feet)	759
Gravity Station occupied	16
Oil wells field checked (current)	323
Well cutting sets catalogued and filed	144
Well cores catalogued and filed	26
Strip logs made	99
Feet represented on strip logs	105,000
Camera copies made	601
Field photographs	12
Black and white prints	1,022
Diazo prints	6,700
Film prints	412
Color slides	112
Black and white slides	19
Photo micrographs	214
Scribecoat prints	11
Stripping film prints	250
Memorandum reports on special projects	14
Reports completed for official publication (in editorial process)	
Geological Map of Indiana	1
Preliminary Coal Map	1
Regional geologic maps	3
Miscellaneous maps	1
Bulletins	1
Reports of Progress	2
Special Reports	2
Published reports	
Bulletins	3
Directories	1
Mineral Economic Series	1
Published maps	
Base maps	2
Miscellaneous maps	1
Petroleum Exploration Maps	
Revised	61
Checked without revision	45
Published reports sold	9,316
Published maps sold	6,030
Publications office customers	2,999
Announcement of publications sent	75
Outside publications	
Abstracts	8
Complete reports	2
Reports completed and sent to editors for outside publication	
Complete reports	7

COAL SECTION

Applied Activities

Requests for information during the year, whether in person, by phone, or by letter, have covered a multitude of topics. The largest number of requests concern the distribution of coal in Indiana. These range from requests by small land owners who want to know how much coal is under their land and how much it is worth to visits by geologists, or engineers from a large coal or investment company who are looking for blocks of uncommitted coal. The current thinking now seems to be that a company needs to tie up 50 million tons of coal or more in order to plan properly for a future operation. These large tonnages now are not available in coal that may be strip mined because much of any large block of coal already has been committed to a mining company. Thus most of these requests were for information about coal that might be mined by underground methods in an area centered about Gibson, Vanderburg, and Posey Counties -- counties that have had only a modest amount of activity in past years. Peabody Coal Company, Ayrshire Coal Co., Old Ben Coal Co., Consol Coal Co. and Carter Oil Co. have all acquired considerable coal rights in these three counties during the past year.

Because of the increased public interest and because of present or proposed legislation dealing with air and stream pollution there has been a great amount of interest in low sulfur coal (that is coal that may be cleaned to less than 2% sulfur). In general our information is not detailed enough to steer people into large areas of relatively low sulfur coal. We do point out that potential low sulfur coals are the two Block coals, Coal IV and Coal VII. Unfortunately much of the readily available high quality Block coal and Coal IV have been mined out and Coal VII is normally less than 3 feet thick. Thus, it requires an intensive search to find a suitable area for a mine in either of these three coals. Coal V is the most commonly mined coal in Indiana and has the most uniform distribution within the state, however, Coal V is normally classified as a high sulfur coal. We do know that there are fairly large areas in an east-west line across the center of Gibson County, where Coal V does contain about two percent sulfur. This coal area is being leased or has been leased by Old Ben and Ayrshire Coal Companies.

An increased interest in possible subsidence at the surface of underground mine workings was demonstrated during the year. Many land owners are more concerned about the danger of subsidence than they are about the value that they may obtain from their coal. Operating companies are just as concerned and we have answered a number of requests related to strength of the roof rock in underground mines. We ran a few modulus of rupture tests on the Baldwin press for selected samples of roof rock material. We usually are able to answer questions that commonly are asked by engineers or contractors; they like to know if

an underground mine workings extend beneath an area of construction. Our mine map file, although not quite complete, is the most nearly complete file in the state and provides answers to nearly all of these questions. Some requests during the year concerned potential pollution of the water or the soil of the spoil bank. Refuse dumps from underground mines and the spoil banks from strip mines may contain rocks that readily form acids when oxidized; this acid is then washed into the local streams as a result of rain water runoff. If a large percentage of rocks at the surface of spoil banks are acid forming, the pH of the overlying soil becomes so low that the area cannot successfully be planted in grass or trees as is required by Indiana law. We have been able to answer most of these requests about acidic conditions from knowledge of local geology and our file of chemical analyses of the coal bearing rocks. However, we need to do a great deal more work along this line.

Because one of the members of the Coal Section is the authority on caves and karst topography in Indiana we answer a large number of requests for information about caverns and other features of underground drainage.

Current Projects

Active Coal Mine Map. A map of southwestern Indiana showing the location of active coal mines (Misc. Map No. 7) was revised by Harold Hutchison during January and republished the following month. A few small mines were closed, a few opened, and a few of the stripping operations changed location, but the number of mines remain about the same. There are 50 active mines in the state -- 44 strip mines and 6 underground mines. Servicing these mines are 18 separate tipple and loading docks. Although the number of mines stayed the same as the previous year there is a marked trend to larger mines, especially strip mines, as is shown by the fact that the 1968 production was 18½ million tons and the 1969 production is 20 million tons of coal.

Preliminary Coal Map of Daviess County. The Preliminary Coal Map for Daviess County was completed to the manuscript stage in June. This map is the 15th of the series of county maps that are published at a scale of 1 inch equals 2 miles and that show the distribution of major coal beds and data related to the mining activities in each county. Manuscript copy of the map for Perry County also is completed, but not yet published. When the Perry and Daviess County maps are published all of the important mining areas in the state will be covered by printed maps. Three additional counties should be mapped in the future. A six-mile fringe in western Owen County has had a small amount of strip mining in the lower coals and does contain a small amount of coal reserves. Much of the coal mining area in the western half of Greene County is now covered by parts of the Coal Investigations Maps; this should be updated and the entire western area done at the same scale as the other county maps. Posey County has never had coal mining of

any significance and we had not planned a county map for that county, but with recent interest and activity in the county it also should be done as one of the county preliminary coal maps.

Distribution of Sulfur in Coal. Because of the increased interest by the general public and by industry in the amount of sulfur dioxide that is emitted into the air when coal is burned, the Indiana Geological Survey feels an obligation to learn more about the amount, kind, and distribution of sulfur in coal. An air pollution grant covering these studies was made by HEW in June of 1969. The stated purpose of this study on Indiana coals was "to collect data on the distribution of total sulfur and varieties of sulfur (organic sulfur, sulfide, and sulfate) and evaluate their relationship to other coal characteristics". In the total project, which will last about a year and a half, 15 one-ton samples will be collected from coal mines in the state. These will be selected to cover a wide geographic area and include most of the commercial coal beds in the state. Each one-ton sample is then crushed to $1\frac{1}{2}$ x 0, is split, and part of the split is run through $1\frac{1}{2}$ inch, 14 mesh, and 100 mesh screens. One split of the sample is crushed to $3/8$ inch x 0 and is sieved through the same screens. Each of these screen sizes are then separated into various specific gravity units, that is, 1.28, 1.32, 1.35, 1.4, and 1.6, float and 1.6 sink. Each of these gravity separations for each screen size is then analyzed for variety of sulfur, and a number of other chemical and physical tests are run. The results of these analyses should give an indication as to how each coal might be treated in a preparation plant (that is selective sizing, and gravity separations) in order to reduce the amount of sulfur in the final product. During the fiscal year 9 of the proposed 15 samples have been collected and 8 of these have been run through the crushing, screening, and gravity separation. Chemical analysis is proceeding much more slowly and only three of the samples have been completed.

Environmental Geology of the Evansville Area. Progress in a study of the environmental geology of the Evansville, Indiana area, which includes about 80 square miles in the southern two-thirds of Vanderburgh County and the Newburgh area in Warrick County, has been aided greatly by the completion of a geologic map of surficial materials by T. S. Straw. The major problems in the area are related to drainage, both of floodwaters and septic wastes in areas of glacial lake beds that form the plains in the Pigeon Creek watershed. The loess covered bedrock hills in the area also can present a septic waste problem. Alluvial valleys and sand hills or bars cover small portions of the area. Additional major aspects of the study include an evaluation of the hazards of construction over old workings of underground coal mines, danger to structures on the lake beds owing to potential earthquakes, and landslide hazards from overdevelopment of loess covered, steep slopes.

Caves and Karst. A special project on Caves of the U. S. that was funded by the National Park Service was completed, subject to review

by someone in the National Park Service. Extra funds were submitted to the Indiana Geological Survey to extend this study to include cave springs. By using a large amount of student help this project was essentially finished this fiscal year, but requires checking, indexing, and collating, typing the remaining mimeograph stencils, and the preparation of some additional illustrations for multilith printing. The major part of the project is a review of literature in order that a list can be made up of significant caverns under the general categories of geologic, hydrologic, scenic, historic, and biologic. This list will be used as a reference when a cave is proposed as a national monument or historical marker. About 100 of the more than 18,000 known caverns in the United States are described in the report, which also includes a review of theories concerning the origin of limestone caverns and an outline and discussion of the major cavernous areas of the United States.

Richard L. Powell also gave a half dozen talks on caves and karst areas at various clubs and submitted three short manuscripts to the Indiana Academy of Science, National Science of Teachers Association, and the Society of Indiana Pioneers. A special study of the karst area southwest of Bloomington relating this karst area to man's uses and needs, was made for the Monroe County Planning Commission.

DRAFTING AND PHOTOGRAPHY SECTION

The work performed in the Drafting and Photography Section during the past fiscal year consisted primarily of the final preparation of maps and illustrations for publication, drawings and slides for talks, and displays for exhibits.

Drafting work for the following Survey publications was completed: Bulletin 42A, Gypsum resources of Indiana; Bulletin 42B, High-calcium limestone and high-magnesium dolomite resources of Indiana; Bulletin 43, Compendium of rock-unit stratigraphy in Indiana; Bulletin 44, Stratigraphy of the New Albany Shale in Indiana; Mineral Economics Series 16, Oil development and production in Indiana during 1969; Regional Geologic Map 3, Geologic map of the 1° x 2° Vincennes Quadrangle and parts of adjoining quadrangles, Indiana and Illinois, showing bedrock and unconsolidated deposits; and Miscellaneous Map 16, Map of Indiana showing bedrock geology. Published maps which were revised include Miscellaneous Map 7, Map of southwestern Indiana showing locations of active coal mines; Base maps 26 and 65 (Gibson and Posey Counties); and 61 petroleum exploration maps of Indiana counties.

A display was completed for the State Fair. Planning and sketches were provided the Department of Natural Resources for their use at the State Fair. Illustrations were finished for seven outside publications and four talks.

ton. Collecting hikes were also conducted for Indianapolis Public Schools 28, 38, 39, 4, 45, 52, 64, 79, 84, 90, 106, 107, and 110 (school camp groups).

Articles submitted and published in OUTDOOR INDIANA include: "Hoosierland's Mineral Heritage--Glaciers Buried Ancient Waters," by R. Dee Rarick and W. J. Wayne (July-August 1969); "New Mineral Wealth Upstate," by Lawrence F. Rooney (November 1969); "Are We Celestial Twins?--Moon Rocks in Indiana," by R. Dee Rarick (December 1969-January 1970); "That Utile Mineral Coal," by Charles E. Wier (December 1969-January 1970); "The Nugget Fever Cycle--Hints for Hoosier Prospectors," by R. Dee Rarick (May 1970).

During the past fiscal year the geologist in charge of Educational Services submitted 2 news releases to Indiana's newspapers and aided in the preparation of others about the activities of the Geological Survey. Reports of the major news items of the Geological Survey were submitted to the editor of the State Geologists Journal, published semiannually by the Association of American State Geologists. Four issues of the Survey Newsletter were prepared and distributed among the personnel of the Survey during the past year.

Exhibits prepared by the Indiana Geological Survey for public display included a major exhibit for the Indiana State Fair; the Oilmen's Outing, held at Mt. Vernon, Illinois; the Jennings County Festival, Muscatatuck State Park; the annual rock show of the Three Rivers Gem and Mineral Society, Fort Wayne; the annual rock show of the Grant Geological Society, Marion, Indiana; and the annual rock swap of the Lawrence County Rock Club.

The geologist in charge of Educational Services participated in the 15th Annual High School Science Institute at Indiana University, aiding in the presentation of lectures about the field of geology, training for a career in geology, and career opportunities in geology. He also served as co-leader on the local geologic field trip held for the group.

During the 1969 4-H Fair season geology and weather exhibits were judged at the Decatur County 4-H Fair. Assistance was given to several 4-H geology exhibitors who submitted their displays at the Indiana State Fair.

GEOCHEMISTRY SECTION

The commodity and research sections of the Geological Survey rely on the Geochemistry Section to provide chemical analyses of Indiana's rocks and minerals. Because this work must include the determination

Several large projects were nearly completed. These include Circular 10, Geology of the Falls of the Ohio River; illustrations for an outside publication; Regional Geologic Maps 4 and 5 (Chicago and Muncie Sheets); and Preliminary Coal Map 14 (Perry County). Other major projects in progress are: Bulletin 42C, Dimension limestone resources of Indiana; Bulletin 42D, Sand and gravel resources of Indiana; Bulletin _____, Subsurface stratigraphy of the West Baden Group in Indiana; Bulletin _____, Conodonts from the Middle Devonian strata of the Michigan Basin; and a display for the State Fair.

Photographic items produced consist of 566 camera copies, 367 black and white prints, 412 film positives and duplicate negatives, approximately 250 stripping film prints of stickup type, 19 black and white slides, 112 color slides, 149 photomicrographs, 11 scribe-coat prints, 4 color proofs, 10 color transparencies, and 12 field and laboratory photographs.

Approximately 6,700 diazo prints were produced on the diazo printer.

EDUCATIONAL SERVICES

The Office of Educational Services was established by the State Geologist to coordinate the Geological Survey's efforts in providing information about Indiana geology and mineral resources to the public. This office aids in preparing materials for public schools, youth groups, adult groups, and all persons interested in rocks, minerals, fossils, and the earth. By means of news releases to Indiana's newspapers and articles sent to appropriate magazines, the Office of Educational Services not only aids in informing the public about activities of the Indiana Geological Survey but also aids in the distribution of educational information. In addition to giving public lectures and conducting special field trips when requested, the Educational Services geologist works directly with teachers, geology clubs, Scout groups, 4-H clubs, conservation clubs, civic groups, and with children throughout the school systems of the State on programs or projects concerning Indiana's geology and mineral resources. On occasion he serves as guest lecturer and field trip guide for college classes. The geologist in charge of Educational Services also aids in the preparation and installation of exhibits for fairs, for professional meetings, for amateur rock shows, and for displays in the Geology Building.

Activities of the Office of Educational Services for the past 12 months were very similar to those of preceding fiscal years. The most noticeable trend was a sharp increase in requests for field trips, the majority of which were with school groups during school

camp and day camp activities. Requests for tours through the Geology Building increased, mostly by Monroe County school groups. During the 1969-70 fiscal year the geologist in charge of Educational Services spent 48 days in the field and traveled 14,715 miles. In answer to requests received from the public, 56 public lectures were given and 46 special field trips and tours were conducted during the 12-month period.

Public lectures, laboratory demonstrations, and film showings were made to the following groups: Marion Lions Club, Grant County; Decatur County Home Demonstration Club members attending the 1969 annual achievement day; Teachers Inservice Workshop, North Central High School, Sullivan County; High School Science Institute, Indiana University, Bloomington; Decatur County 4-H club members taking geology projects; Kyana Geological Society, Louisville-New Albany area; Wabash Valley Gem and Mineral Society, Lafayette, Indiana; Peru YMCA Rock and Mineral Club, Peru, Indiana; Lawrence County Rock Club, Bedford; Education M-540 class (summer), Indiana University, Bloomington; Social Studies Methods class, Indiana University, Bloomington; Childs Elementary School Science Club, Bloomington; summer classes at Chesterton Jr. High School, Lake County; Earth Science classes, Emmerich Manual Training High School, Indianapolis; Jackson and Jennings County Rock and Mineral Club; 6th, 7th, and 8th grades, Fairbanks Elementary School, Sullivan County; 5th grade class, Meridian School, Kokomo, Howard County; 5th grade class, Grandview School, Monroe County; 4th grade class, Elm Heights School, Bloomington; 4th grade class, St. Charles School, Bloomington; 5th and 6th grade classes of Indianapolis Public Schools 28, 38, 39, 4, 45, 52, 64, 79, 84, 90, 106, 107, and 110; and two public lectures given at the Conservation Building during the 1969 Indiana State Fair. Three lectures covering geology in the summer class Forestry 580 at Purdue University, Lafayette, also were given.

Special field trips, collecting hikes, and tours were conducted for the following groups: Brown County Adult Education summer class; participants in the 1969 Lawrence County Rock Swap; members of the Education M-540 class, Indiana University, Bloomington; group of visiting Brazilian geologists; remedial reading class, Metropolitan School System, Bloomington; visiting adult group from Martinsville, Indiana; visiting group of junior high school students and teachers from Noblesville, Indiana; visiting group from Carmel, Indiana; 5th grade class, Grandview School, Monroe County; members of the Industrial Arts Class, Edgewood High School, Ellettsville, Indiana; 5th grade class, McCalla School, Bloomington; 5th and 6th grade classes of Kirksville School, Monroe County; members of the Jackson and Jennings County Rock and Mineral Club; group of Cub Scouts, Bloomington; 1st grade class from Arlington School, Monroe County; a group of elementary students from Fairview School, Monroe County; Lawrence and Orange County 4-H Club members and their adult leaders; members of the Forestry 580 summer class, Purdue University, Lafayette; and the members of the 1969 High School Science Institute, Indiana University, Bloomington.

of a large number of elements, a wide range of analytical techniques are utilized. These include wet chemical, spectrographic, X-ray, atomic absorption and other analytical procedures. A high degree of cooperation with the Department of Geology at Indiana University has evolved to supplement analytical instruments and techniques available in the Survey.

Most important of the day to day work of the Section is the analysis of samples collected by the commodity sections of the Survey. These samples are obtained from cores or from rock material collected at outcrops. The ultimate purpose of this work is to form a complete catalog of the chemical composition of the rocks that underlie our State. From this information we can answer questions about sources of raw materials for new industry, propose new and better uses for our natural resources, and relate rock units of similar ages for geologic mapping programs.

In accomplishing this work the analytical laboratories of the Geochemistry Section completed more than 6,000 determinations on about 800 samples of shale, gypsum, anhydrite, sand, limestone and dolomite from cores and other samples. In addition, approximately 100 samples of gypsum were analyzed for chloride content in an effort to aid in the processing of that mineral.

A major program in the Section has been the study of the composition of Indiana's coal deposits. In addition to providing the basic information from which judgements can be made for coal utilization, this program has the added value of acquiring data for air pollution studies. By means of the chemical determination of the content and form of sulfur in coal we hope to be able to suggest methods of removing the element before coal is burned, or in neutralizing the products of combustion. The coal analysis laboratory completed about 40% of the analytical work involved in the present study on sulfur during the year.

In other activities the Section started an investigation of the correlation between chloride and carbonate contents of gypsum. Identification of the mineral with which chloride exists in the State's gypsum deposits will help in developing aids to processing gypsum. The study of the causes, treatment, and prevention of stains on building limestone resulted in preliminary reports to the Indiana Limestone Institute.

In conjunction with the Department of Geology, seven radiocarbon dates were obtained for samples submitted by Survey personnel. A minor investigation was continued into the nature of subsoil materials of the unglaciated area of the State.

GEOLOGY SECTION

Introduction

Members of the Geology Section are proud of the year's accomplishments even while maintaining a guarded attitude about how well we can maintain the present magnitude of evidence of accomplishments in the next few years. Evidence for the year 1969-70 are summarized below in several ways. Overall, the information given below shows that reports submitted for publication and the backlog of reports decreased significantly for 1969-70, whereas the other categories were slightly to somewhat up. Members of the section:

I. Worked actively on 15 of 20 investigations having the status of projects and completing 5 of them.

II. Published 14 reports, of which 5 are entire reports and 9 are abstracts, these reports totaling 391 printed pages, 14 plates, 25 figures, and 9 tables.

III. Submitted for publication 1 map and 4 complete reports, these reports totaling 100 typescript pages, 6 plates, 11 figures, and 1 table.

IV. Prepared 13 other formal reports (not to be published) totaling 234 pages, 22 plates, 30 figures, and 13 tables.

V. Maintained a backlog of 7 reports and 1 map awaiting publication, the reports totaling 420 pages, 17 plates, 34 figures, and 6 tables.

VI. Engaged in scores of conferences, hundreds of letters, and in other media of information in answer to specific requests of several different kinds such as for landfills and waste disposal; from commercial, engineering, and resource (including water) interests; from planning interest; and from educational and research institutions.

Service and Applied Activities

The work described here was undertaken mostly in response to specific requests, to further the progress of older applied programs, and, most significantly, to embark upon a more vigorous applied program under the label of "environmental geology." The state-mapping part has employed some original investigation, so that assignment of this program to the heading above is somewhat arbitrary.

Activities Applied to Environmental Geology, Including Planning and Engineering Needs and Water. The year 1969-70 was actually the third

in which much of our function was discharged with deliberate consciousness under the label environmental or urban geology, "deliberate consciousness," we say because the Survey and the section has long done this kind of work under other title. Gray was asked to chair a committee to coordinate environmental activities in the several sections of the Survey, whereupon the committee outlined considerations for achieving some uniformity of publication or reports and also two basic kinds of studies: one kind to be topical, such as landfills, gas storage and physical properties of geologic units, and the other kind to be geographically designated.

I. Landfills. A project on "Geologic and ground water considerations in planning solid waste disposal sites in Indiana" was begun and completed. The project was designed to provide general information on the geology that affects the success and failure of landfills, this at a time shortly after new, state-ordered requirements were introduced in answer to a rapidly growing public problem. The project had multiple inspiration, however, including a June 1969 meeting with U. S. Soil Conservation Service and Purdue University personnel and later conferences with the Division of Water.

II. Physical properties of geologic units. A. A project on "Glacial lake deposits of southern Indiana--engineering problems and potential use" was begun and completed as a joint outgrowth of the environmental program, the project on quantitative geomorphology of southern Indiana, and of earlier studies on Perry County and on the Patoka River basin. B. Another project in this vein was undertaken to describe more generally the engineering and use characteristics of all the major bedrock and unconsolidated deposits of Indiana. Under the title "Supplemental chart: Regional Geologic Map series," the work neared completion at the end of the year. C. During the year the section notably advanced its laboratory program to determine engineering properties and textural and mineralogical characteristics of particularly unconsolidated deposits. Much of this was in a direct environmental emphasis, but the statistics shown in an earlier section of this report do not separate this emphasis from the research application.

III. Environmental projects designated geographically. A. Three projects designated by urban and county units were begun. Although each area has its peculiar geology and attendant problems for an expanding economy and population, there is some commonness of section purposes as perceived through these collective emphases: mineral resources including water, waste disposal, land use, general geology, and special planning consideration. Three separate projects are entitled: Environmental geology: (1) Alan County, (2) Floyd and Clark Counties, and (3) Lake and Porter Counties. Project no. 2 became well advanced, the field work being essentially completed by a summer employee, Thomas Straw. Older projects, especially for the Regional Geologic Map, are contributing materially to these areal studies, and

one old, inactive project, Pleistocene geology of the Calumet area, is to be merged with the Lake and Porter Counties work. B. The older project on "Urban geology of Madison County, Indiana" has been described in two earlier annual reports. The resulting manuscript remained in editorial preparation during 1969-70. It is: Wayne, W. J., Urban geology of Madison County, Indiana: Indiana Geol. Survey, 31 p., 6 pls., 1 fig., 3 tables. C. Other new, areally oriented projects, on the Evansville and Indianapolis areas, had some Geology Section input but are being left to other section's reporting.

IV. Planning and miscellaneous environmental and other applied activities. Through a series of conferences and reports, the section was instrumental in the elimination of one rather unfit site (in Orange County) and in the selection of a satisfactory site (in Jackson County) for the new camp site, White River Council, Boy Scouts of America. Two reports were filed.

Regional Geologic Map Series.

I. The regional mapping program has been described in several earlier annual reports. During the year it seemed to draw ever more gradually toward a close, "gradually" because little sectional effort was expended (most of its work having already been completed), because only one separate project was completed, and because no separate sheet was published. These two sheets, Chicago (RGM 4) and Vincennes (RGM 3) remained in editorial preparation and in press.

II. This sheet was submitted for publication: Burger, A. M., Forsyth, J. L., Nicoll, R. S., and Wayne, W. J., Geologic map of the 1° x 2° Muncie Quadrangle, Indiana and Ohio, showing bedrock and unconsolidated deposits: Indiana Geol. Survey Regional Geol. Map 5.

III. As for past years we record here the unusual number of separate byproduct reports and maps associated with the regional map. In other sections of this annual report, we have recorded both directly and indirectly many of the dividends afforded by this program in resource, environmental, educational, and other matters.

Research Activities

Although the reference below to several research projects and activities suggests considerable activity, much of it is cumulative and should not give us cause for complacency. The fact is that the year saw an accelerated rate of decrease in basic research effort. The environmental program is soaking up that effort, and we are not supporting nonemployee research in the degree to which we have in times past. We should endeavor to rebalance this matter at each opportunity having financial capability.

Biostratigraphy and Paleontology.

I. Middle Paleozoic geology of the southern part of the Michigan Basin. Described in earlier annual reports, this project was actively advanced especially in its paleontological aspects by continued collection, processing, and faunal assembly of many samples, particularly of Indiana and Michigan cores; also by the submission and publication of a few reports as both direct and indirect results (some originally under older, now-completed project titles). Less active was the stratigraphic part of the project, but several cored sections were described, and Indiana University personnel continued work on the Traverse (Devonian) part of the section.

II. Biostratigraphic studies of Kope (Cincinnatian) bryozoans. Described in two earlier reports, this project was considered to have been completed upon submission of this report as an Indiana University doctoral thesis: Anstey, R. L., 1970, The trepostome bryozoan fauna of the Eden Shale (Ordovician) in southeastern Indiana and adjacent areas in Kentucky and Ohio: Bloomington, Indiana Univ., 171 p., 22 pls., 15 figs., 11 tables. Because of difficulties in readying the manuscript (having also the name of T. G. Perry on it as a manuscript) for Survey publication, it was released for other publication as the authors saw fit.

III. Conodont biostratigraphy of the upper part of the Borden Group and of the Sanders Group (middle Mississippian). Described in two earlier annual reports, this project was advanced by the further collection of samples, measuring several sections, including two cored Indiana sections and four exposed Kentucky sections, and by the completion of laboratory processing of samples. Study of results is being done through auspices of a doctoral thesis (R. S. Nicoll), University of Iowa.

Stratigraphy and Areal Geology.

I. Program to study the glacial deposits and Pleistocene history of Indiana. This program was proposed on May 31, 1966, and described in earlier annual reports. It embraces a few, more specifically proposed projects. During 1969-70, 2,088 till and other materials analyses were made for textural, mineralogical, magnetic, and physical-properties characterizations, some of them being for specific projects mentioned below and some for environmental projects (see "Statistics").
A. Pleistocene stratigraphy of west-central Indiana. Described first in its purpose in the 1968-69 report, this project was furthered by additional field work to measure sections and acquire samples and by running of a few hundred determinations as noted above. The project is to clarify morainal and stratigraphic relationships associated with the Iroquois Moraine. B. Characteristics of Indiana tills. This new project was begun on November 20, 1969, its purpose being to authorize laboratory study on tills of the kind noted above for any part of the

state. Many of the till samples being acquired come from testing firms and from the State Highway Department, and this project takes advantage of their availability. Together with the project noted under A above, this project accounts for most of the remainder of mineralogical, textural, magnetic, and physical-properties analyses made during the year (see "Statistics"). C. Pleistocene geology of northern Indiana. Described in two earlier reports, this project saw some progress in the form of a few weeks of field work, collection of samples (including some for C14 dating), interpretation of soils and other maps, and in the preparation of assorted smaller reports. This project, as it has turned out, has served principally as authorization to continue investigation into stratigraphic and geomorphic questions that arose during Pleistocene mapping for the 1° x 2° map program. In fact, some of the reports listed above as part of the map program are joint results of a few different projects, including this one noted under C.

II. Discriminating tills and loesses, southeastern Indiana. This project was described in two earlier reports, its purpose being to apply its results (clay-mineral and heavy mineral profiles) to mapping for the Louisville and Cincinnati 1° x 2° maps. The results had limited practical application, as they turned out, although they had much other use as part of the general data being collected under the project title "Characterization of Indiana tills" (described above).

III. Quantitative aspects of geomorphology of southern Indiana. This project was begun during 1967-68 and described in earlier reports. Some progress was made by developing computer programs for the analyses of certain data (hypsothetic), which seemed to show that major geologic episodes of erosion and deposition for the unglaciated part of southern Indiana can be better interpreted. Cores from Salt Creek valley in Lawrence County were studied, which showed an alternation of lacustrine and alluvial episodes during the valley's geologic history. A manuscript on glacial lake sediments of southern Indiana resulted partly from this project and was submitted for Survey publication (see "Service and Applied Activities").

IV. Structural features of Indiana map. Although the section's responsibility for its part (text) of this map was completed in an earlier year, further intersectional planning during 1969-70 resulted in this Geology Section resubmission: Gray, H. H., Nomenclature of major structural features in Indiana: Indiana Geol. Survey Rept. Progress, 27 p., 1 pl., 4 figs.

V. Middle Paleozoic geology of the southern flank of the Michigan Basin. The stratigraphic aspects of this project are discussed under "Biostratigraphy."

Editorial, Committee, Educational, and other Assorted Activities.

I. Most members of the section belong to intra- or extra-Survey committees or otherwise perform editorial, report-reviewing, and chairmanship duties for the Survey and other organizations. A. In such capacities (1) the Geologic Names Committee handled 19 manuscripts and maps of record; and (2) its report for a long-standing project was published: Shaver, R. L., and others, Compendium of rock-unit stratigraphy in Indiana: Indiana Geol. Survey Bull. 43, 229 p., 1 pl., 1 fig., 8 tables. B. Gray served as chairman of the newly appointed committee to coordinate activities of the Survey's intersectional environmental program. C. Schneider served on the state and federally composed committee dealing with reservoir silting. D. Shaver assumed the chairmanship of the Publications Committee, Society of Economic Paleontologists and Mineralogists, served on an SEPM committee to study merger of Journal of Paleontology financial support provided by two societies, and he was assistant editor for that organization's special publication of Deltas: modern and ancient (submitted for publication).

II. The section disseminated educational and similarly informative knowledge through the media of several hundred letters, upward of 200 conferences, and several lectures, some described elsewhere in this report.

GEOPHYSICS SECTION

During the 1969-70 fiscal year the Geophysics Section worked on field surveys by seismic reflection, seismic refraction and gravity methods. In the laboratory the Section's continuing program to determine the physical properties of Indiana rock units utilized density, crushing strength, abrasion, radioactivity and other tests to determine the properties of rocks that influence their use. In order to handle the large quantity of data that is produced by geophysical measurements, the Geophysics Section utilized both analog and digital computers. The Section also was in charge of the operation of the Survey's Failing Model 1500-S drilling rig and a truck mounted auger capable of augering to depths of 100 feet.

Seismic Surveys

A large seismic refraction and two seismic reflection projects were worked on by a seismic crew during most of the field season. The seismic refraction project was in connection with a study of the mineral resources of northeastern Indiana. Measurements were made to determine the thickness of glacial material over bedrock across parts of several counties in northeastern Indiana.

The seismic reflection surveys covered traverses in southwestern Indiana and in the west central part of the State. Seismic shots were taken over parts of Indiana that are underlain by the Borden Group in an effort to detect changes in rock type from one locality to another. It was hoped that reflection character or changes in reflection quality would indicate changes of facies within the Borden. The project had the secondary purpose of adding to our knowledge about the thickness of the sedimentary section and the depth to the Pre-Cambrian basement in southern Indiana.

Laboratory Studies

As each core is received by the Survey's sample library sections are removed for laboratory tests of physical properties. Special samples also are received from industry groups and trade associations in order that we may assist in the development of tests on stone material for specific purposes.

During the year we were able to obtain access to the large computer that is located a few hundred feet from our building. By means of a teletypewriter and telephone lines we can communicate with the computer, submit programs, and have readily available the enormous power of the large facility. The Section continued to operate the small G-15 computer for problems that did not require the high speeds of the large machine. The program to encode data from all of the thousands of oil wells from which the Survey has records continued. By the end of the year well data from 87 counties had been punched onto cards. The remaining counties, however, contain a high proportion of the wells drilled in southwestern Indiana. When completed, this project will enable geologists to obtain rapid collections of data about particular areas, formations, rock types, production and other categories that have been encoded.

INDUSTRIAL MINERALS SECTION

The industrial rocks and minerals produced in Indiana include limestone, dolomite, sandstone, sand and gravel, cement, clay, peat, marl, and gypsum, all of which are commodities used principally as construction materials. Industrial rocks and minerals accounted for 60 percent of Indiana's mineral production in 1969 and were valued at over 160 million dollars. This value is a decrease of about 3 percent over the previous year and reflects a slow-down in construction projects probably resulting from a down-turn in the national economy.

Service

We received 252 service requests during 1969-70, down slightly from the record high of 260 the previous year. About 63 percent of these requests were from business corporations, 37 percent were from individuals and government or research organizations.

Probably each service request that we answer has value, but those requests that lead to the opening of a new quarry or pit are highly significant because they represent jobs for people and investment in Indiana's economy. We provided geologic information that is leading to new crushed stone quarries in Lake, Lawrence, and Putnam Counties and a new sand and gravel plant in Gibson County.

The Section's most active service request topic resulted from the Survey's discovery of a dolomite reef in Lake County. Seventeen corporations requested information on Survey Drill Hole 191, the drill hole that confirmed the presence of a thick bed of high-purity dolomite under a thin cover of drift near Lowell. At the present time, at least three companies have purchased land or hold land options in the area where the Survey core was taken. One company has started removing overburden and plans to begin quarrying before the end of the year.

A new directory of sand and gravel producers was issued.

The Industrial Minerals Section prepared three memorandum reports in 1969-70 and placed them on open file.

Lawrence F. Rooney, Donald D. Carr, Richard K. Leininger, and John B. Patton presented a half-day limestone seminar for the Indiana-Kentucky Geological Society in Evansville on December 16, 1969.

Research

A report on the crushed stone resources of the Blue River Group in Indiana is nearly complete except for some chemical analyses of Survey cores. Study of the limestone and dolomite resources along the Ohio River in Indiana continued. A new project to study the origin of the Lost River Chert Bed, an important marker bed in the Ste. Genevieve Limestone, was begun. A study of the rise and fall of Indiana's lime industry continued with the expectation to make it rise again. One hundred and twenty-eight abandoned quarries were located and field checked during the year. Members of the section investigated geologic factors that influence the environmental aspects of Allen and Marion Counties. A study of the chemical and physical properties of flyash was begun in hopes that useful products might be found for this ever-increasing waste product from power plants.

MINERAL STATISTICIAN

In 1969, the total reported value of materials produced by the mineral industries of Indiana amounted to \$266,157,460.00, an increase of .52 percent over the previous year.

Coal continued as the most economically important mineral produced in the state, and also showed the greatest percentage of increase in value.

Production of sand and gravel and dimension limestone increased in value 8.88 and 7.65 percent respectively, although the quantity of limestone sold by the dimension limestone companies declined almost 50 percent. This apparent discrepancy can be explained by the fact that shipments of breakwater and other relatively inexpensive types of stone dropped to approximately 15 percent of the previous level while shipments of quarry blocks from the state for processing elsewhere almost doubled.

Petroleum and the products manufactured from clay and shale continued to decline, 13.67 and 19.40 percent respectively.

Ten counties each reported production valued in excess of \$10,000,000.00, and accounted for 52.5 percent of the State's total mineral production exclusive of oil, natural gas, and peat. These counties, with commodities, are listed below:

\$20 million +

Warrick County	\$29,430,089.00	Coal, crushed limestone.
Lake County	\$25,246,774.00	Cement, clay products, sand and gravel.
Lawrence County	\$22,683,349.00	Cement, crushed limestone, dimension limestone, sand and gravel, dimension sandstone.

\$15 - \$20 million

Pike County	\$17,546,952.00	Coal, crushed limestone.
Sullivan County	\$16,204,085.00	Coal, crushed limestone, sand and gravel.
Clark County	\$15,529,302.00	Cement, crushed limestone, sand and gravel.

\$10 - \$15 million

Clay County	\$14,331,088.00	Clay products, coal.
Putnam County	\$13,457,856.00	Cement, crushed limestone, sand and gravel.
Monroe County	\$10,655,377.00	Crushed limestone, dimension limestone, sand and gravel.
Greene County	\$10,467,771.00	Clay products, coal, sand and gravel.

In addition to the ten counties listed above, twenty-four counties reported production in excess of \$1,000,000.00, accounting for 19.8 percent of the State total, exclusive of oil, natural gas, and peat.

From the fact that in 1968 thirty counties accounted for 92.6 percent by value of the minerals produced in the State as compared with thirty-four counties accounting for 72.3 percent in 1969, it is apparent that the greater percentage of increase was in those counties reporting less than \$1,000,000.00 worth of minerals produced and sold.

PETROLEUM SECTION

Work in the Petroleum Section has followed fixed patterns for years and consists of services, projects that are repeated annually, projects related to records improvement, subsurface study projects, and from time to time, significant special projects.

Services

A considerable part of total work consists of services, virtually all of which are directly related to the comprehensive well-data file in the Petroleum Section. It consists of correspondence and conferences about records in the file, continuous maintenance of the file and continuous expansion of the file.

Annual Projects

For many years, five projects have been carried out annually. Most of the work involved in carrying out these projects is of a calendar-year statistical nature.

Indiana Drilling Statistics. Indiana drilling statistics for 1969 were developed in accordance with the well classification format specified

	<u>1968</u>		<u>1969</u>		<u>% Inc. or Dec.</u>	
	<u>Quantity</u>	<u>Value</u>	<u>Quantity</u>	<u>Value</u>	<u>Quantity</u>	<u>Value</u>
Coal	18,475,046 tons	\$ 72,976,431.00	20,065,885 tons	\$ 81,467,493.00	+ 8.62	+ 11.64
Cement (portland and asonry)	17,391,707 bbls.	54,673,070.00	16,905,163 bbls.	51,716,546.00	- 2.80	- 5.41
Limestone, crushed	24,933,742 tons	35,132,373.00	25,515,510 tons	34,418,123.00	+ 2.33	- 2.03
Sand and Gravel	25,925,689 tons	25,994,576.00	27,027,829 tons	28,302,770.00	+ 4.25	+ 8.88
Petroleum	8,692,000 bbls.	28,249,000.00	7,841,468 bbls.	24,386,965.00	- 9.79	- 13.67
Limestone, dimension	10,481,634 cu.ft.	20,143,878.00	5,305,727 cu.ft.	21,685,474.00	- 49.38	+ 7.65
Clay and Shale						
Raw material	1,520,360 tons		1,139,080 tons		- 25.08	
Manufactured products		22,197,374.00		17,891,643.00		- 19.40
Peat	38,763 tons	557,000.00	38,214 tons	515,000.00	- 1.42	- 7.54
Natural Gas	233,995,000 cu.ft.	32,057.00	178,880,000 cu.ft.	25,632.00	- 26.97	- 20.04
Marl	54,339 cu.yd.	45,912.00	25,968 cu.yd.	19,629.00	- 52.21	- 57.24
Undistributed: Includes alumina cement, gypsum, dimension sandstone, whetstones		<u>7,391,116.00</u>		<u>8,607,852.00</u>		+ 16.46
TOTAL: adjusted to avoid duplication of clay, stone, and sand used in cement		\$264,775,054.00		\$266,157,460.00		+ .52

by the American Association of Petroleum Geologists' Committee on Statistics of Drilling. These statistics are published by the AAPG and by the American Petroleum Institute in statistical reviews covering drilling in the whole of the United States.

Indiana Exploration Developments. A summary of the results of exploratory drilling in Indiana during 1969 was prepared. It is published in a bulletin of the American Association of Petroleum Geologists.

Indiana Oil Production. The annual compilation on oil production in Indiana by fields was prepared for 1969. Publication is by the Indiana Geological Survey.

Indiana Oil Reserves. A compilation of the remaining producible oil in Indiana's oil fields, and attendant Indiana oil-recovery statistics, at the end of 1969 was effected. Data resulting from this compilation are incorporated in a publication of the American Petroleum Institute, the American Gas Association and the Canadian Petroleum Association on oil and gas reserves in the United States and Canada.

Petroleum Exploration Map Series. This map series consists of county well-location maps, scale 1 inch equals 1 mile, showing wells by the standard classes (dry hole, oil well, gas well, etc.) and total depths. All of the 92 maps in the series were reviewed, updated and re-issued as of December 31, 1969.

Records Improvement

The long-standing program of upgrading well records was continued during the year. Work on the program was restricted to Posey County.

Because Posey County is in the active oil-producing area of Indiana, data on the wells drilled in it are relatively good; and whereas past policy has called for field checking all wells when the well records of a county were reviewed, it is not deemed necessary to field check all wells in Posey County. Still, inasmuch as approximately 4,600 wells have been drilled in the county, a considerable amount of field work will be required.

Because of high well density, the Posey County upgrading project is divided into sub-projects on a congressional township basis. There are 18 congressional townships in Posey County in which wells have been drilled. Work on two townships, 4S-12W and 5S-12W, has been completed. In addition, work on 6S-12W, 7S-12W, 7S-13W, 6S-13W and 5S-13W is underway, progress on these sub-projects ranging from 20 to more than 90 percent completion.

Subsurface Studies

Only one subsurface study was made during the year. It involved a compilation of bottom hole temperature data from geophysical logs on Indiana wells.

The bottom-hole temperature data on Indiana wells was provided to the American Association of Petroleum Geologists' Research Committee which is collecting similar data for all parts of North America. From the temperature data collected, a map of North America showing temperature gradients in the crustal rocks will be compiled. Presumably this map will be published, with appropriate text, by the American Association of Petroleum Geologists.

Special Projects

National Petroleum Council. The National Petroleum Council project, initiated last year, was completed during the year. The objective of the project was to set down facts about oil and gas that has been found in the United States and opinions about areas and rock units in which oil and gas may be found in the United States in the future. The NPC project divided the United States into 11 districts. NPC District-9 consisted of the Illinois Basin, the Cincinnati Arch and the upper part of the Mississippi Embayment. Indiana lies almost wholly in the Illinois Basin and the Cincinnati Arch geologic provinces, and the Petroleum Section of the Indiana Survey made a major contribution to the NPC District-9 compilation.

The District-9 report has been submitted to the National Petroleum Council. Reportedly, it was well received by the NPC, and it is scheduled for publication, in total, by the American Association of Petroleum Geologists.

REPORTS AND MAPS PUBLISHED

Bulletins

French, K. R., and Rooney, L. F., 1969, Gypsum resources of Indiana: Bull. 42-A, 34 p., 20 figs., 2 tables.

Lineback, J. A., 1970, Stratigraphy of the New Albany Shale in Indiana: Bull. 44, 73 p., 1 pl., 18 figs.

Rexroad, C. B., 1969, Conodonts from the Jacobs Chapel Bed (Mississippian) of the New Albany Shale in southern Indiana: Bull. 41, 55 p., 9 pl., 2 figs., 1 table.

Directories

Indiana Geological Survey, June 1969, Directory of sand and gravel producers in Indiana: IBM printout, 48 p.

Mineral Economics Series

Carpenter, G. L., and Keller, S. J., 1969, Oil development and production in Indiana during 1968: Mineral Economics Ser. 15, 18 p., 2 figs., 4 tables.

Base Maps

Moran, W. H., and Peace, J. E., December 10, 1951, rev. September 1, 1969, Base Map of Gibson County, Indiana: Base Map 26.

Moran, W. H. and Peace, J. E., December 8, 1951, rev. September 1, 1969, Base Map of Posey County, Indiana: Base Map 65.

Miscellaneous Maps

Hutchison, H. C., 1962, rev. 1970, Map of southwestern Indiana showing locations of active coal mines: Misc. Map 7.

MEMORANDUM REPORTS

Ault, C. H., 1968 to present, Abandoned limestone and dolomite quarries in Indiana.

Bleuer, N. K., March 6, 1970, Geologic considerations for planning sanitary landfill sites in Greene County, Indiana, 5 p., 2 maps (for Representative Jack W. McIntyre, Bloomfield).

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Bleuer, N. K. and Schneider, A. F., July 7, 1969, Sanitary landfill sites in Camp Atterbury, 3 p. (for Division of Water).

Gray, H. H., July 10, 1969, Discrimination and age of tills in south central Indiana: 2 p., 8 figs.

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Schneider, A. F., The role of the Geological Survey in comprehensive planning (requested by the Department of Commerce).

Webb, W. M., 1969, Investigation of the New Providence Shale, Clark and Floyd Counties, Indiana, as a source of alumina.

Wier, C. E. and Powell, R. L., Distribution of West Franklin Limestone in southeastern Sullivan County.

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Bornea, C. R., Rexroad, C. B., and Miller, J. F., 1970, Lower Paleozoic conodont provincialism (abs.): Geol. Soc. America, Abs. with Programs, v. 2, p. 374.

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Nicoll, R. S. and Rexroad, C. B., 1960, Divergent or convergent evolution in conodonts (abs.): Geol. Soc. America, Special Paper 121, 1 p.

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Pollack, C. A., 1969, Fused Silurian conodont clusters from Indiana: Journal Paleontology, v. 43, p. 929-935, pls. 110-112.

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Powell, R. L., 1969, First there was water: Yearbook of the Society of Indiana Pioneers, p. 18-26, 2 figs.

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Rexroad, C. B., 1969, Conodont biostratigraphy: Silurian conodont faunas, North America (abs.): Geol. Soc. America, Abs. with Programs for 1969, pt. 6, p. 400.

Rooney, L. F., 1969, The industrial minerals geologist--or who killed Clem Kadiddlehopper! New Mexico Bureau of Mines, Circ. 101.

Rooney, L. F. and French, R. R., 1969, Allogenic quartz and origin of penemosaic texture in evaporites of the Detroit River Formation (middle Devonian) in northern Indiana: reply to a discussion by D. A. Holliday: Journal Sedimentary Petrology, v. 31, p. 1258.

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Schneider, A. F., 1969, A significant exposure of Pleistocene drift in south central Indiana (abs.): Indiana Acad. Sci. Proc., v. 78, p. 315-316.

Schneider, A. F. and Reshkin, Mark, 1970, Age and correlation of the Glenwood Stage of glacial Lake Chicago (abs.): Geol. Soc. America, Abs. with Programs, v. 2, p. 404.

Schneider, A. F. and Wayne, W. J., 1970, Segmentation of the upper Wabash River across Indiana (abs.): Geol. Soc. America, Special Paper 121, 1 p.

Wayne, W. J., 1969, Urban geology--a need and a challenge (presidential address): Indiana Acad. Sci. Proc., v. 78, p. 49-64, 4 figs.

Wier, C. E., 1970, That utile mineral coal: Outdoor Indiana, c. 34, no. 10, p. 30-33.

ACTIVITIES

Committee Service

Leroy Becker - Potential Gas Agency, Mineral Resources Institute:
Committee on Potential Supply of Natural Gas in the United States.

Jerry Carpenter - American Association of Petroleum Geologists:
Committee on Statistics of Drilling, Chairman, Indiana District.

Don Carr - Forum on Geology of Industrial Minerals: Steering Committee.

Tom Dawson - American Petroleum Institute: Committee on Reserves and Productive Capacity.

Richard Leininger - Indiana Limestone Institute: Restoration and Maintenance Subcommittee, ex officio.

Geochemical Society: Standards Committee.

Monroe County Soil and Water Conservation District, Treasurer.

Lou Miller - Indiana Mining and Technical Society, Secretary-Treasurer.

John Patton - Indiana Limestone Institute of America, Member Executive Advisory Committee.

Interstate Oil Compact Commission, Research Committee.

Association of American State Geologists, Liason Committee.

National Research Council, Division of Earth Sciences.

Richard Powell - Board of Geographic Names.

Lawrence F. Rooney - Great Lakes Basin Study Commission: Minerals Work Group.

American Institute of Mining and Metallurgical Engineers: Program Policy Committee.

Robert Shaver - Society of Economic Paleontologists and Mineralogists, Chairman of the Publications Committee, member of the committee to study merger of Journal of Paleontology financial support, Assistant Editor of the Society's special publication on Deltas: Modern and Ancient.

Dan Sullivan - American Association of Petroleum Geologists: Member, House of Delegates.

American Petroleum Institute: Committee on Reserves and Productive Capacity, Tri-State Subcommittee.

Charles Wier - Geological Society of America: Chairman, Carboniferous Stratigraphy Committee.

Indiana Academy of Science: Committee on Science and Society, Population and Environment Subcommittee.

Office of Emergency Planning: Director of Solid Fuels Task Force.

PUBLIC LECTURES

- Ned Bleuer on "Geology and its Relation to Sanitary Landfill Planning." to Southern Chapter, Indiana County Sanitarians Association, at Spring Mill State Park, May 21.
- Donald D. Carr, (paper co-authored by R. F. Blakely and R. R. French) Relationships between physical and chemical properties of the Brassfield Limestone (Silurian) in Indiana, Ohio and Kentucky, 6th Forum on Geology of Industrial Minerals, Ann Arbor, Michigan, April 3, 1970.
- Henry Gray on "Geology and Land Misuse in Monroe County" to Monroe County Community Council, April 22, 1970, Earth Day.
- John B. Patton presented paper "Geology, Resources, and Environment" at University of Michigan, Ann Arbor, February, 12, 1970.
- Presented paper "Man's Environment: The Geologic Concept" at Michigan State University, East Lansing, May 28, 1970.
- Addressed the Aurora, Indiana Rotary Club on the geology of that region.
- Gave talk on building limestone to visiting groups of architecture students from Ohio State University.
- Conducted geology training for guides at Indiana State Museum.
- Carl Rexroad on "Lower Paleozoic Conodont Provincialism" to North-Central Section, Geological Society of America, May 8, 1970.
- Lawrence F. Rooney, keynote address, The Party's over: A Rambling Discourse on Suspended Contempt, The Bittersweet Boom, and other Heresies, 6th Forum on Geology of Industrial Minerals, Ann Arbor, Michigan, April 2, 1970.
- Geology, Rogers School, Bloomington, Indiana, February 27, 1970.
- Lawrence F. Rooney, Donald D. Carr, Richard K. Leininger, and John B. Patton, Seminar on Limestone for the Indiana-Kentucky Geological Society in Evansville, Indiana on December 16, 1969.
- Allan Schneider on "Age and Correlation of the Glenwood Stage of Glacial Lake Chicago" to North-Central Section, Geological Society of America, May 8, 1970.
- "The Role of the Geological Survey in Comprehensive Planning" at a conference sponsored by the Department of Commerce with Indiana Chapter of Am. Inst. of Planners, September 18, 1969.

Tom Straw on "Geological History of the Ohio River" to meeting of agricultural limestone producers at Tell City, Indiana, June 19, 1970.