

U. S. DEPARTMENT OF THE INTERIOR  
BUREAU OF LAND MANAGEMENT  
EAST PITTSBURGH, PA.  
PITTSBURGH, PA.

**CANCELLED**

96th ANNUAL REPORT OF THE STATE GEOLOGIST

of

INDIANA GEOLOGICAL SURVEY  
DEPARTMENT OF NATURAL RESOURCES

for

July 1, 1971 - June 30, 1972

GEOLOGICAL SURVEY  
NINETY-SIXTH 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  
(To August 14, 1971)  
Marguerite Trisler . . . . . Senior Accounts Clerk  
(To July 3, 1971)

Coal Section

Charles E. Wier . . . . . Geologist and Head  
Harold C. Hutchison . . . . . Geologist  
Richard L. Powell . . . . . Geologist  
(On leave from Sept. 1, 1971 - June 15, 1972)  
Vance P. Wiram . . . . . Geologist  
(From Sept. 1, 1971)  
Marvin T. Iverson . . . . . Geological Assistant  
Bonnie Burks . . . . . Secretary

Drafting and Photography Section

William H. Moran . . . . . Chief Draftsman and Head  
Richard T. Hill . . . . . Geological Draftsman  
(From June 5, 1972)  
Robert E. Judah . . . . . Geological Artist-Draftsman  
Muriel M. Malone . . . . . Geological Draftsman  
(To May 19, 1972)  
John Peace . . . . . Senior Geological Draftsman  
Roger L. Purcell . . . . . Senior Geological Draftsman  
George R. Ringer . . . . . Photographer

Educational Services

Reevan Dee Rarick . . . . . Geologist

Geochemistry Section

Richard K. Leininger . . . . . Geochemist and Head  
Rosalie V. Easton . . . . . Secretary  
(Shared with Industrial Minerals Section)  
(To Sept. 24, 1971)  
Carrie Foley . . . . . Laboratory Technician  
Margaret V. Golde . . . . . Instrumental Analyst  
Gloria Hillenberg . . . . . Secretary  
(Shared with Industrial Minerals Section)  
(From November 29, 1971)  
Louis V. Miller . . . . . Coal Chemist  
Susan Wilson . . . . . Secretary  
(Shared with Industrial Minerals Section)  
(October 4 to November 26, 1971)

Geology Section

Robert Shaver . . . . . Paleontologist and Head  
Ned K. Bleuer . . . . . Glacial Geologist  
Henry H. Gray . . . . . Head Stratigrapher  
(On leave Aug. 1 - Sept. 30)  
Edwin J. Hartke . . . . . Environmental Geologist  
John R. Hill . . . . . Glacial Geologist  
Carl B. Rexroad . . . . . Paleontologist  
Martha N. Smith . . . . . Secretary

Geophysics Section

Maurice E. Biggs . . . . . Geophysicist and Head  
Robert F. Blakely . . . . . Geophysicist  
JoAnn Bullard . . . . . Secretary  
(From April 3, 1972)  
Galen Cramer . . . . . Assistant Driller  
Linda Dro . . . . . Secretary  
(To April 15, 1972)  
Clarence Haskins . . . . . Driller  
John R. Helms . . . . . Geophysical Assistant  
Joseph F. Whaley . . . . . Geophysicist

Industrial Minerals Section

Donald D. Carr . . . . . Geologist and Head  
Curtis H. Ault . . . . . Geologist  
George S. Austin . . . . . Geologist  
Rosalie V. Easton . . . . . Secretary  
(To September 24, 1971)

Industrial Minerals Section (continued)

Gloria J. Hillenberg . . . . . Secretary  
(From November 29, 1971)  
Michael C. Moore . . . . . Geologist  
Susan A. Wilson . . . . . Secretary  
(From October 4 to November 26, 1971)

Petroleum Section

T.A. Dawson . . . . . Geologist and Head  
Leroy E. Becker . . . . . Geologist  
M. Ruth Butcher . . . . . Secretary and Curator of Records  
Gerald L. Carpenter . . . . . Geologist  
James T. Caze . . . . . Geological Assistant  
William Hamm . . . . . Geological Assistant  
Andrew Hreha . . . . . Geologist  
Stanley J. Keller . . . . . Geologist  
Timothy L. Lawrence . . . . . Geological Assistant  
Vivian McGuire . . . . . Senior Curator of Records  
Dan M. Sullivan . . . . . Geologist  
James Thrasher . . . . . Geological Assistant

Publications Section

Gerald S. Woodard . . . . . Editor and Head  
Rebecca B. Gaidosz . . . . . Secretary  
Donna C. Schultz . . . . . Senior Sales and Records Clerk

Seasonal Personnel

Coal Section

Julio Alamos . . . . . Research Assistant  
(January 19, 1972 to June 30, 1972)  
Shafik Nasser . . . . . Research Assistant  
(September 16, 1971 to March 24, 1972)  
Ted Wilson . . . . . Geologic Research Assistant  
(August 1, 1971 to September 20, 1971)

Geochemistry Section

Greg Alumbaugh . . . . . Laboratory Assistant  
(October 26, 1971 to May 4, 1972)

Geochemistry Section (continued)

Murphy Dupler. . . . .Laboratory Assistant  
(September 1, 1971 to May 3, 1972)  
R. Timothy Hartsaw . . . . .Laboratory Assistant  
(May 26, 1972 to June 30, 1972)  
Jim Hauser . . . . .Laboratory Assistant  
(July 4, 1971 to August 28, 1971)  
Carole Houpperd. . . . .Laboratory Assistant  
(July 1, 1971 to August 27, 1971)  
Edward A. Stockey. . . . .Laboratory Assistant  
(August 30, 1971 to October 14, 1971)  
Christie York . . . . .Laboratory Assistant  
(July 1, 1971 to August 26, 1971)  
JoAnne Welch . . . . .Laboratory Assistant  
(November 9, 1971 to March 22, 1972)

Geology Section

Richard L. Asher . . . . .Laboratory Assistant  
(December 6, 1971 to May 12, 1972)  
Thomas Devine. . . . .Laboratory Assistant  
(August 31, 1971 to February 8, 1972)  
Marcia Engle . . . . .Laboratory Assistant  
(August 2, 1971 to November 16, 1971)  
Richard Hoffman. . . . .Laboratory Assistant  
(September 8, 1971 to October 21, 1971)  
Barry D. Jeffries. . . . .Laboratory Assistant  
(September 13, 1971 to April 22, 1972)  
Elizabeth Ann Lucas. . . . .Laboratory Assistant  
(June 15, 1972 to June 30, 1972)  
Edith A. Martin. . . . .Laboratory Assistant  
(June 9, 1972 to June 12, 1972)  
Inge Merkle. . . . .Laboratory Assistant  
(July 1, 1971 to November 5, 1971)  
Wesley C. Miller . . . . .Laboratory Assistant  
(June 27, 1972 to June 30, 1972)  
Robert S. Nicoll . . . . .Geologist  
(September 27, 1971 to October 8, 1971)  
Cathy Niles. . . . .Laboratory Assistant  
(July 1, 1971 to June 30, 1972)  
M. Jean Owen . . . . .Laboratory Assistant  
(May 26, 1972 to June 30, 1972)  
Humberto Rostworowski. . . . .Laboratory Assistant  
(July 1, 1971 to August 28, 1971)  
Janet Sheets . . . . .Laboratory Assistant  
(July 1, 1971 to November 20, 1971)  
Barbara Tully. . . . .Laboratory Assistant  
(December 7, 1971 to May 15, 1972)

Geology Section (continued)

Robert B. Vote . . . . .Laboratory Assistant  
(October 18, 1971 to June 30, 1972)

Geophysics Section

Melody Frye . . . . .Key Punch Operator  
(August 24, 1971 to April 28, 1972)

Nancy Hasenmueller . . . . .Geologist  
(July 1, 1971 to June 30, 1972)

Richard Hoffman . . . . .Geophysical Assistant  
(May 22, 1972 to June 30, 1972)

Linda Massey . . . . .Key Punch Operator  
(July 1, 1971 to July 31, 1971)

Albert Rudman . . . . .Geophysicist  
(July 1, 1971 to August 31, 1972)

Madan Varma . . . . .Geophysicist  
(September 7, 1971 to June 30, 1972)

Industrial Minerals Section

Tom Banta . . . . .Laboratory Assistant  
(September 30, 1971 to May 5, 1972)

Doug Baumgardt . . . . .Field Assistant  
(to August 27, 1971)

William Boyd . . . . .Laboratory Assistant  
(From June 26, 1972)

Richard Brown . . . . .Laboratory Assistant  
(January 24, 1972 to April 3, 1972)

Imogene Cooley . . . . .Laboratory Assistant  
(From June 5, 1972)

Linda Runkle . . . . .Laboratory Assistant  
(to July 16, 1971)(August 30, 1971 to December 4, 1971)

Michael Carpenter . . . . .Field Assistant  
(From June 27, 1972)  
(August 9, 1971 to September 1, 1971)

Petroleum Section

Larry Enochs . . . . .Geological Assistant  
(to August 20, 1971)

Publications Section

Anthony Polich . . . . .Clerk  
(to August 28, 1971)

John Robbins . . . . .Clerk  
(August 29, 1971 to June 3, 1972)

## INTRODUCTION

During a year when financing for the Geological Survey reached its most precarious stage, requests for service from the public and industry reached a new high level. Not only did the commodity sections receive more visitors and requests for information about mineral resources, but the Geology Section and specialists from all sections dealt with more questions about utilization of the land than at any time in the past.

The slowly increasing energy crisis, which also might be called a sulfur crisis, has resulted in a spectacular surge in interest in coal and petroleum resources. As a result both the Coal Section and Petroleum Section welcome a constant stream of visitors who are seeking help in finding new supplies of fossil fuels.

In terms of service to the public, both the Industrial Minerals Section and the Geology Section participated in their busiest year. During the fiscal year 411 requests for service were handled by the Industrial Minerals Section alone -- up from about 250 the preceding year, and fewer than 100 requests in 1962. The Geology Section held 194 conferences with the public to deal with all types of geologic questions, of which 17 dealt with landfills and 30 dealt with community planning. To support the information that was being supplied to communities, the section began a program to describe the engineering and use characteristics of all major bedrock and unconsolidated deposits throughout the State. More than 1,350 such tests were made during the year.

The Geological Survey has several noteworthy accomplishments to report for the year. An outstanding example is the award of a project to obtain and study imagery from the earth resources satellite, ERTS-A. Dr. Wier will use the remote sensing data to attempt to relate earth fractures to roof collapse in underground mines, a major cause of accidents in mines.

Final compilation was completed on the last three Regional Geologic Maps, the Ft. Wayne, Louisville, and Cincinnati Quadrangles, and drafting was completed on the Louisville and Cincinnati sheets. Even in preliminary form these maps have been a tremendous aid in dealing with environmental problems, and have pointed to numerous problems that need intensive study.

Several important discoveries were made by geologists of the Industrial Minerals Section. Among those related to mineral resources, potentially valuable stone deposits were mapped along the Ohio River, in Shelby County, and in the Indianapolis area. All of these were announced to interested persons by news reports and news letters.

In addition to handling a massive program of service to the public and to industry, Survey geologists produced an amazing quantity of basic research. The fruit of this work is represented by 10 reports and 4 maps published by the Geological Survey, 8 reports published in scientific journals, and 3 articles printed in Outdoor Indiana. In addition, 18 other reports were submitted for publication and were in editorial process at the end of the fiscal year.

In other activities eleven memorandum reports were prepared to cover specific geologic problems, six papers were presented at scientific meetings, sixteen public lectures were presented, and Survey geologists conducted 5 field trips. In addition members of our staff served on numerous committees of national professional organizations, and acted as chairmen of scientific sections at several meetings.

#### 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 12 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 1971-72

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

Projects in Progress . . . . .	153
Projects completed . . . . .	108
Conferences with visitors to the Survey . . . . .	1,205
Man days of field work . . . . .	1,352
Incoming letters . . . . .	4,503
Outgoing letters . . . . .	2,474
Total number of Survey vehicles . . . . .	21
Total number of miles traveled in Survey vehicles . . . . .	203,921
Thickness of stratigraphic sections measured . . . . .	6,578
Public lectures	
Civic . . . . .	7
Industrial . . . . .	4
School . . . . .	22
Other . . . . .	7
Papers presented at professional meetings . . . . .	13
Field trips for the public . . . . .	10
In connection with conferences . . . . .	2
Educational . . . . .	10
News releases submitted . . . . .	12
Mineral statistics questionnaires processed . . . . .	1
Attendance at professional meetings . . . . .	93
Exhibits prepared for special occasions . . . . .	8
Newsletters . . . . .	2
Samples received or collected . . . . .	2,402
Rocks, Minerals . . . . .	393
Fossils . . . . .	881
Identifications (rocks, minerals, fossils) . . . . .	161
Packets of geologic education material sent . . . . .	79
Special rock sets for teachers . . . . .	18
Rock and mineral sets sent . . . . .	167
Soil and sand samples sent . . . . .	5
Insoluble residues made . . . . .	63
Heavy mineral separations made . . . . .	16
Polished blocks of coal made . . . . .	122
Coal samples analyzed . . . . .	212
Coal analyses (determinations) . . . . .	2,974
Chemical analysis of samples . . . . .	607
Spectrographic analyses (qualitative) . . . . .	838
Spectrographic analyses (quantitative) . . . . .	4,059
Petrographic slides analyzed . . . . .	71
X-ray chemical analyses . . . . .	106
X-ray mineralogic analyses . . . . .	506
Coal thin sections made . . . . .	37

Rock analyses. . . . .	1,364
Number of stratigraphic sections measured . . . . .	25
Thickness of stratigraphic sections measured . . . . .	425
Physical tests on building stone . . . . .	38
Physical tests on other stone. . . . .	22
Seismic refraction shots . . . . .	504
Seismic reflection shots . . . . .	8
Electric Resistivity Stations. . . . .	77
Feet of hole drilled . . . . .	3,797
Feet of core recovered . . . . .	2,401
Feet of hole augered . . . . .	7,401
Feet of core collected other than by Survey. . . . .	4,673
Feet of core described . . . . .	5,693
Electric well logs run . . . . .	5
Oil wells field checked	
Current drilling . . . . .	434
Old drilling. . . . .	820
Well cutting sets catalogued & filed . . . . .	221
Well cores catalogued & filed. . . . .	16
Strip logs made (wells). . . . .	194
Feet represented on strip logs . . . . .	175,500
Camera copies made . . . . .	827
Field photographs. . . . .	300
Black and white prints . . . . .	810
Diazo prints . . . . .	4,000
Film prints. . . . .	364
Color slides . . . . .	224
Black and white slides . . . . .	201
Photomicrographs . . . . .	253
Scribecoat . . . . .	5
Color proofs of maps . . . . .	12
Memorandum reports on special projects . . . . .	11
Reports completed for official publication (in editorial process)	
Bulletins . . . . .	3
Regional Geologic Maps. . . . .	3
Miscellaneous Maps. . . . .	2
Reports of Progress . . . . .	1
Special Reports . . . . .	4
Mineral Economic Series . . . . .	1
Regional Geologic Map Supplement Chart. . . . .	1
State Park Guide. . . . .	1
Published Reports	
Bulletins . . . . .	6
Mineral Economic Series . . . . .	2
Guidebooks. . . . .	2
Special Reports . . . . .	1
Unnumbered Directories. . . . .	1
Publications last issued. . . . .	1

Published Maps . . . . .	1
Miscellaneous (new) . . . . .	1
Miscellaneous (revised) . . . . .	2
Regional Geologic Maps . . . . .	2
Published reports sold . . . . .	5,915
Published maps sold . . . . .	9,533
Publications Office customers . . . . .	3,998
General announcements sent . . . . .	1,717
Outside Publications . . . . .	8
Complete reports . . . . .	6
Reports completed & sent to editors . . . . .	6
for outside publication . . . . .	
Abstracts . . . . .	2
Complete reports . . . . .	5
Telephone conferences . . . . .	152
Total service requests . . . . .	411

## COAL SECTION

### Service Work and Applied Activities

A significant amount of time is utilized each year in answering requests for information concerning coal and coal-bearing rocks. The Coal Section had the usual requests from those who either want to buy or to sell coal and want to know the quality and quantity of coal in a specific area, but many visitors during the past year reflect the greater emphasis on the public concern for our ecology and environmental problems. Topics of these requests include: 1) air pollution, including problems related to the production of fly ash and SO<sub>2</sub> when coal is burned, and possible techniques and materials that might collect the solid particulate matter and the gases. These requests relate to analysis showing the percent of various kinds of sulfur, the percent of ash, and the heating value in the coal. 2) water pollution, including problems related to the location of abandoned gob piles and hullage roads that contain large concentrations of acid-forming materials. This work is based on geochemical analysis of the rocks and of the oxidized products. 3) reclamation, including problems caused by the acid-forming material in coal and the overburden material in strip mines. Answers to their questions depend on our background of information on the geochemistry and the petrology of the rocks, the location of abandoned and active strip mines, and a general knowledge as to the areas where reclamation has been properly done and where it has not. 4) conversion of coal, including methods of converting coal to gas, gasoline, or a low sulfur liquid or solid fuel. These problems relate to an anticipated shortage of gas and oil with an abundance of coal, and pollution problems related to high sulfur fuel. 5) location of mine areas, including location of strip mine area for possible future development and location of underground mined areas for possible use, or for areas to avoid. Our ability to answer these requests depends on our nearly complete inventory of both strip mine and underground mines.

### Current Projects

Evaluation of Sulfur in Coal.--Work continued on the distribution and the evaluation of sulfur in coal. A manuscript on "Pyrite in the Springfield Coal Member (V), Petersburg Formation, Sullivan County, Indiana" was revised and re-submitted for publication.

A project relating washability tests to the amount and distribution of varieties of sulfur in coal was brought to a conclusion. All physical separations and chemical tests were completed and a report was submitted to EPA, who financed part of the project. A manuscript "Reduction of Sulfur in Indiana Coal by Washability Techniques" was prepared for publication by the Indiana Geological Survey.

Results of this study show that coal now produced in Indiana contains from 1 to 6 percent sulfur. After the coals have been cleaned in the preparation plant the shipped coal averages about 3 percent sulfur. Using existing technology, it is impossible to reduce the sulfur content in most of the coal now being produced to the required approximate 1 percent sulfur. Pyritic sulfur and organic sulfur are both present in Indiana coals. Only part of the pyritic sulfur can now be removed from the coal by the mechanical washing process in use. Most of the coal sampled also contained more than 1 percent sulfur in the form of organic sulfur, which cannot be removed before burning except by dissolving the coal in a solvent. This is a much too expensive process for present economic conditions.

Distribution of Acid Forming Material in Overburden.--A small amount of work has been done in past years in an attempt to characterize the chemical composition of sandstones and shales that overlie the coal. In recent years there has been increased emphasis on evaluating acid-forming minerals in the overburden rocks that are in active strip mines. Not only does this material provide sulfuric acid that pollutes the run-off waters, but it also makes the spoil too acid to sustain normal growth when the area is planted in accordance with our regulations on the reclamation of abandoned strip mine lands. Preliminary work on this problem was described at a Geological Society of America meeting in a paper entitled "Evaluation of Sulfur in Overburden in Northwestern Greene County, Indiana." Additional work has been done during this fiscal year in relating the concentration of pyrite (iron-sulfide) to different kinds of sandstone and shale, and in relating concentration of pyrite to the position of sandstone channels in the overburden rock. Both unweathered and weathered rock materials have been studied and a variety of sulfates (the oxidized product from iron-sulfide), have been analyzed.

Preliminary Coal Maps.--During the year final revision was made on the Daviess County Preliminary Coal Map, which now has been published. Work is about 20 percent complete on the preparation of Preliminary Coal Maps for Greene, Owen and Putnam Counties. When work is done on these three counties, we will have maps of each coal producing county in the State, showing the area covered by each major coal seam, the area mined by both strip and underground mines, and a structure map on one of the coal beds.

Active Coal Mine Map.--In January 1972, Harold Hutchison revised the "Map of Southwestern Indiana showing the location of Active Coal Mines" (Misc. Map No. 7). There were a total of 60 active mining operations -- 5 underground mines and 55 strip mines -- and 16 coal preparation plants. Fifteen new strip mines were opened. This reflects the recent situation wherein the price of coal was increased significantly, and the fact that the demand for coal was greater than the production last year.

Underground Mine Maps.--During the past 20 years the Coal Section has been accumulating copies or photographs of maps of underground mines. Unlike strip mines mined areas underground cannot be determined at the

surface; these maps of the underground workings, therefore, are the only source of such information. The Geological Survey now has a file of nearly 600 such underground mine maps. We have numerous requests for location and area of certain old and abandoned underground mines. Accurate mine maps are required to show where coal reserves have been depleted. These maps have a broad interest now because mined areas have a potential for subsidence at the surface and must be considered before public buildings, grain elevators, water towers, dams, spillways, etc. are built.

Some part-time help is now being utilized in up-dating our records on these maps and plotting them on 7½' quadrangles.

Environmental Geology of the Evansville Area. --A first draft manuscript and maps of the Evansville Area was completed and copies were made available to city officials and planners in the Evansville area. The project has been dormant for about 10 months, awaiting some feedback from users. Work on this project will be continued during July and August 1972, when the manuscript will be prepared for publication by the Geological Survey.

Wyandotte Cave. --During the 1965-66 fiscal year and before the State purchased the Wyandotte Cave property, the Geological Survey mapped the cave passages and prepared a report for the use of the Natural Resources Commission. Since that time, additional information gradually has been accumulated on the cave and some smaller adjacent caves. Because of the large amount of information available on the origin and development of this particular cavernous area, and because Wyandotte Cave is visited by a large number of people each year, we decided to complete a report on Wyandotte Cave, using it as an example of the origin and development of the thousands of caves along the karst area in Indiana. The final report is nearly complete and will be finished in the summer of 1973.

#### DRAFTING AND PHOTOGRAPHY SECTION

The primary function of the Drafting and Photography Section is to provide service to the commodity and research sections of the Geological Survey. The services offered consist mainly of the final preparation of maps and illustrations for publication and talks, preparation and illustration of geology related displays, diazo printing, map and photograph mounting, film developing and printing, copying, color-proofing, photomicrography, field photography, and complete lantern slide preparation.

The most significant accomplishment during the year was the completion of the final three sheets, Fort Wayne, Cincinnati, and Louisville, of the Regional Geologic Map series. Other Survey publications completed include: Preliminary Coal Map 15, Distribution, structure and mined areas of coals in Daviess County, Indiana; Bulletin 46, Applied geology of industrial limestone and dolomite; Special Report 7, Lithostratigraphy of the Maquoketa Group (Ordovician) in Indiana; and Guidebook 13, A field guide to the Mt. Carmel Fault of southern Indiana. Published maps that were revised during the year are: Misc. Map 7, Map of southwestern Indiana showing locations of active coal mines; and Misc. Map 14, Locations of clay and shale operations in Indiana.

Illustrations were completed for seven outside publications and for fifteen talks. Also finished were three displays and illustrations for a legislative committee meeting.

Other projects in progress are: Bull. 42-I, Coal resources of Indiana; Bull. 47, Subsurface stratigraphy of the West Baden Group in Indiana; Bull. 48, Geometry and origin of the Ste. Genevieve Limestone (Mississippian) in the Illinois Basin; Bull. \_\_\_\_\_, Silurian and Devonian rocks in Indiana south of the Cincinnati Arch; Special Report 6, Coal strip-mined land in Indiana; Mineral Economics Series 18, Oil development and production in Indiana during 1971; a display of the 1<sup>o</sup> x 2<sup>o</sup> Regional Geologic Maps for a meeting of the International Geological Congress; and a limestone display for the 1972 Indiana State Fair.

Photographic items produced during the year consisted of 827 camera copies, 666 black and white prints, 24 tinted prints (mural-type), 364 film positives and duplicate negatives, 161 stripping film prints of stickup type, 201 black and white slides, 224 color slides, 21 photomicrographs, 5 scribesheets, 12 color proofs of maps, and 300 field photographs.

#### 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 newspapers, magazines, public schools, youth groups, adult groups, and for 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 in public schools, geology clubs, Scout groups, 4-H clubs, conservation clubs, civic groups, and 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 conducts field trips for college classes. The geologist in charge of the Office 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.

During the 1971-72 fiscal year the geologist in charge of Educational Services spent 39½ days in the field and traveled more than 11,000 miles. In answer to requests received from the public, 23 public lectures were given and 10 special field trips and 10 tours of the Geology Building were conducted during the 12-month period.

Public lectures, laboratory demonstrations, and film showings were made to the following groups: Decatur County 4-H club members (workshop at Decatur Co. 4-H Fairgrounds); Indiana Gem and Mineral Society, Indianapolis; Meridian School, Kokomo (5th grade); Grandview School, Bloomington (4th & 5th grades); Rogers School, Bloomington (4th grade); Geology-516, I.U. class; Jackson and Jennings County Rock and Mineral Club, Seymour; Y.M.C.A. Rock and Mineral Club, Peru; Brownie Scout Troop 89, Bloomington; pre-school camp session for participating teachers of the Indianapolis Metropolitan School System, Bradford Woods; Happy Day Summer Camp, Cascades Park, Bloomington; Education-540, I.U. summer class in Conservation Education; University School, Bloomington (remedial reading summer class); Decatur County 4-H club members attending their summer camp at Hassmer Hill, Ripley County; and Hunter School, Bloomington.

Special field trips, collecting hikes, and tours were conducted for the following groups: a Girl Scout Troop, Indianapolis, Patricksburg Elementary School (5th grade); Clinton W. Young Elementary School, Indianapolis (5th grade); Binford Jr. High School, Bloomington (7th grade); Grandview School, Bloomington (5th grade); Grandview School, Bloomington (4th grade); Rogers School, Bloomington (4th grade); McCalla School, Bloomington (2nd grade); Stony Creek Elementary School, Noblesville (6th grade); Fort Wayne North Side High School, Fort Wayne (Juniors and Seniors, Science Club); group of adults attending the 1971 Lawrence County Rock Swap; and the classmembers of I.U. Education-540, class in Conservation Education.

Articles submitted and published in OUTDOOR INDIANA included: "Sand Bodies in Indiana," by R. Dee Rarick and W.D. Thornbury (Dec. 1971-Jan. 1972); "Apollo Flights Reveal Lunar Secrets," by R. Dee Rarick (February 1972); and "Ostracoderms: Ancestral Vertebrates," by R. Dee Rarick (June 1972).



During the past fiscal year the geologist in charge of Educational Services submitted 10 news releases to Indiana's newspapers and aided in the preparation of others about 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. Three issues of the Survey Newsletter were prepared and distributed among the personnel of the Survey and the I.U. Department of Geology during the past year.

Exhibits prepared by the Indiana Geological Survey for public display included a major exhibit for the Indiana State Fair and a substantial amount of preliminary planning and work on an exhibit to be taken to the International Geological Congress to be held in Montreal, Canada, in August 1972. The Geologist in charge of Educational Services assisted in the preparation of these exhibits. Other Survey exhibits were installed at the annual rock show of the Grant Geological Society, Marion, Indiana; the Glendale Shopping Center, Indianapolis; the College Mall Shopping Center, Bloomington, and the I.U. Health Center, Bloomington.

The geologist in charge of Educational Services participated in the 17th Annual High School Science Institute conducted by 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 conducted for the group.

Professional meetings attended included the Oilmen's Outing, held in Centralia, Illinois; the annual meeting of the Outdoor Education Section of the Indiana State Teacher's Association, Indianapolis; and the annual meeting of Nature Conservancy, held at Spring Mill State Park.

During the 1971 4-H Fair season geology and weather exhibits were judged at the Decatur County 4-H Fair and at the Sullivan County 4-H Fair. Assistance was given to several 4-H geology exhibitors who submitted their displays at the 1971 Indiana State Fair.

#### GEOCHEMISTRY SECTION

The Geochemistry Section is referred to as one of the three research sections of the Geological Survey. Although a strong research role is important to maintain a competent and vigorous geochemical program, a skeleton staff and the pressures of supplying analytical data to supplement investigations by the commodity sections have resulted in research being held to a minimal level.

Samples collected by all of the sections of the Geological Survey usually must be analyzed to determine their chemical composition. Chemical procedures used to complete these analyses involve spectrographic, x-ray, atomic absorption, and wet chemical methods. This work makes up the continuing routine program of the Geochemistry Section. The purpose of this work is to learn what elements make up Indiana's rocks and minerals, what uses might be made of these materials, and what potentially dangerous substances such as mercury or other heavy metals may serve as contaminants in the geological formations of the State.

Another important segment of the work of the Geochemistry Section involves the analysis of coal in order to learn its composition, heat content and contaminants. During the past several years the emphasis of this work has been on the amount and form of sulfur that is present in Indiana coals. The geochemists reason that if the different types of sulfur present in coal can be determined, then methods can be developed to remove at least part of this material during the preparation process.

Because chemical technology is changing at a rapid pace, a significant amount of time must be spent in developing new methods of analyzing particular elements and in calibrating standards. Chemical analysis of geologic materials is among the most challenging in the science because the constituents of rocks can include all elements in an enormous variety of combinations.

Some work was done by members of the section on a continuing project to develop methods to remove stains from building stone. Under certain special conditions of installation and use, a variety of stains have been found to mar the appearance of building stone. Because the quarrying and milling of Indiana limestone is an important mineral industry, geochemists have assisted in analyzing the materials that cause stains, and in removing them chemically.

## GEOLOGY SECTION

### Introduction

Through the years this annual report seems to have grown longer because the same kind of information, once reported, tends to be reported thereafter whereas little is dropped. The sober tone above is not intended to signify lack of pride in our accomplishments, however. The Regional Geologic Map program was completed (as far as this section's involvement is concerned) after approximately 20 years of conception and 15 years of production. The environmental program had continued emphasis and saw reports and maps submitted for the Jeffersonville, New Albany, and Evansville areas, as well as a few reports on nongeographically designated projects.

Our accomplishments are further summarized:

I. Working actively on 13 investigations having the status of projects and completing 3 of them.

II. Having 9 reports published. Two of these are abstracts, and altogether they total 243 pages and 60 illustrations and other exhibitions.

III. Having one Regional Geologic Map published.

IV. Submitting for publication (remaining unpublished at year's end) 14 reports and 5 maps and charts, some with text. Of these reports 1 is an abstract, and they total 207 pages and 59 illustrations and other exhibitions. One report has nothing to do with a Survey project.

V. Preparing 9 formal reports (not for publication) in answer to specific requests. These reports total 33 pages and 23 illustrations.

VI. Maintaining a backlog of 19 reports, totaling 523 pages and 116 illustrations and other exhibitions, and 5 maps and charts that await publication. Two of these reports have nothing to do with Survey projects.

VII. A tabulation of the kinds of conferences has been made, both by subject matter and by requestor and beneficiary:

Number of conferences by subject matter

General geologic information	40	Landfills	17
Water, drainage, soils, pollution, disease, general environment	35	Fossils and paleontology	
Planning needs	30	Economic deposits and energy sources	8
General educational	24	Legal problems	2
Engineering and natural damage problems	24		
<u>Requestors and (or) beneficiaries of conferences (several organizations counted more than once)</u>			
Universities and colleges or their personnel	55	Indiana counties	14
		Indiana cities	8
Federal offices	37		

State offices	32	Professional and other organizations	6
Businesses, utilities, and industries	31	Planning and other consultants	5
Private individuals	26	Foreign offices	4
		Office of another state	1

The items designated I-VI are down slightly from the same items for 1970-71

### Service and Applied Activities

Most of the work described here may be classified into three broad categories: (1) specific projects in the coordinated environmental program, (2) work in response to specific requests, mostly from outside the Survey, and (3) regional geologic mapping.

Environmental geology, including waste disposal, planning, engineering, soils, and water considerations. --The year 1971-72 was the fifth in which much of our function was carried on under the designation environmental and(or) urban geology. It is the third year of operation, however, of the first well-organized Survey environmental effort that is coordinated by Henry Gray and that has had several deliberate projects begun and finished. (See earlier reports.)

I. Landfills. Although our activity in this area was significant, it decreased some during the year ending, one index being 17 conferences and requests of record vs. 42 for the preceding year.

A project in cooperation with the Indiana University Water Resources Research Center to study the effects of leachates on groundwater quality near landfills was continued in small measure. Our contribution was drilling and examining the geologic sections at sites in Bartholomew, Lawrence, and Monroe Counties; also, some physical tests and water quality analyses.

II. Physical properties of geologic units. The project that was begun during 1969-70 to describe the engineering and use characteristics of all the major bedrock and unconsolidated deposits throughout the state was completed. Activities in the sedimentation laboratory were mostly devoted to determination of physical properties, including textural and mineralogical aspects, such determinations also being applicable to basic research projects described elsewhere. Some 1,364 tests were made, this figure representing only 40 percent of the number of tests made in the preceding year.

III. Environmental projects designated geographically. Two of four projects designated by urban and county units were completed, but overall progress has not been as rapid as had been hoped. The completed projects are represented by items submitted for publication.

Urban geology of Madison County. The report and manuscript (Wayne, W.J., Urban Geology of Madison County, 31 p., 6 pls., 1 fig., 3 tables) has been completely inactive for the past two years because of failure to obtain the remaining revision from Wayne.

IV. Planning, engineering, and other miscellaneous applied activities. Judging from the numbers of conferences on environmental matters in general during the past two years, our activities increased in particularly these special categories: Water, drainage, soils, disease, pollution -- from 21 to 35; engineering and natural damage matters -- from 13 to 24; planning needs -- from 7 to 30.

#### Research Activities

Our research activity was probably maintained at a level near that of the preceding year, but that is only modest comfort because it had been down for a few years. The reasons for decrease during the last few years include our increasing environmental efforts and the loss of summer personnel. A further decrease this year was in the laboratory work for the analysis of unconsolidated materials, particularly tills. Nevertheless, activity in biostratigraphy, paleontology, and stratigraphy, both bedrock and Pleistocene, is notable.

Bedrock stratigraphy, biostratigraphy, and paleontology.--Middle Paleozoic geology of the southern part of the Michigan Basin. This project, described in earlier reports and once having National Science Foundation support, saw much progress during the year. A manuscript on the basic stratigraphy of the Detroit River Formation of northern Indiana was all but completed. A great deal of laboratory work and study was accomplished for the portion of this project dealing with Silurian conodont biostratigraphy. The next biostratigraphic report to appear will be on conodonts of the type Liston Creek, Kenneth, and Kokomo members (Silurian).

The project on upper Chesterian stratigraphy (reported several earlier years) was mostly inactive, but some plans were made to revitalize and reschedule the project, including plans for computerized mapping to show shifting patterns of environments of deposition.

The project on conodont biostratigraphy of the upper part of the Borden Group and of the Sanders Group (Mississippian) has been described in earlier reports. It has remained too long in progress, but during the past year the project and its preliminary report were reviewed and some final work was planned and partly carried out to assure completion of the project during 1972-73.

Pleistocene biostratigraphy, stratigraphy, and till studies.--Much of our work on Pleistocene and other unconsolidated materials has been applied, so that one principal product has been, especially in the immediately preceding years, the Regional Geologic Map series and another product is, increasingly, in the environmental reports. This kind of activity has been reported under the applied heading above even though isolated segments of that activity could have been referred to as rather basic research.

During the past three years we have undertaken a kind of Pleistocene research in which we had had little previous concentrated effort. This consists of detailed analyses of tills and other sediments for texture, chemical composition, mineralogy, and other physical characters, including engineering properties. These analyses have been listed mainly as statistics without separation as to environmental or research application. The level of this activity, however, whether for research or other purposes, was considerably down for 1971-72, from 3,355 to 1,364. A number of shallow borings were made and other Pleistocene samples collected.

#### Editorial, Committee, Educational, and Other

Most of our personnel belong to intra- or extra-Survey committees or otherwise perform educational, editorial, reviewing, field trip, and officerial duties for the Survey and other organizations.

Geologic Names Committee. Work of the committee was routine during the year. Fifteen manuscripts, 6 maps and charts, and 4 abstracts of record were processed. As one index of Survey productivity, these numbers of manuscripts and maps for eight successive years may be noted: 30, 24, 15, 30, 18, 19, 16, and 21.

Miscellaneous. Gray and others conducted two field trips on Indiana geology for the benefit of particularly the newer employees of the Survey. Shaver conducted a Silurian field trip in northern Indiana and portions of adjoining states for Shell Oil Company geologists. Gray continued to serve as chairman of the committee that coordinates activities of the Survey's environmental program.

An intersectional Committee to Review the Geological Survey was formed late in 1970-71, and during 1971-72 the subcommittees that involved this section's personnel and that filed reports were: (1) Subcommittee on Stratigraphy, Gray, chairman, Bleuer and Rexroad, members; (2) Subcommittee on Environmental Geology, Hartke, chairman; and (3) Subcommittee on Quantitative Geology, Hill, member.

Members of the section seemed to have critically reviewed a large number of reports that had been published or had been submitted for publication, both by Survey and non-Survey personnel and for both Survey and non-Survey publication. The count is 39 separate jobs (represents some duplication of items).

Members of the section collectively gave or conducted nine papers or talks and field trips to or for professional, industrial, and amateur groups.

#### GEOPHYSICS SECTION

During the 1971-72 fiscal year the Geophysics Section maintained a program of field work, laboratory measurements, and development of computer programs to assist the interpretation of geophysical data. The greatest effort and coordination was required for field surveys because geophysical field work had to be done by crews which operated a wide assortment of complex equipment.

Seismic refraction surveys.--A major part of the section's field work involved seismic refraction shots to measure the thickness of overburden above bedrock. This information is needed to supplement drilling data in connection with many geologic problems. The most extensive seismic survey during the year was requested by the Coal Section for mapping in Greene, Owen, and Putnam Counties. The purpose of this work was to determine the thickness of overburden above bedrock in order to permit calculations of coal reserves remaining in the ground. Seismic surveys were designed to trace the extent of buried valleys which cut through rocks that contain coal. By mapping the width and depth of the hidden valleys a calculation of the amount of coal that had been removed could be made.

Other seismic surveys also were made in Lake County in an effort to locate buried reefs. These reefs were formed by marine organisms many millions of years ago, were covered by glacial deposits, and represent valuable sources of limestone and dolomite. Because the stone in one of these reefs may be harder and more resistant to erosion than surrounding bedrock, it was hoped that they might be found at a shallower depth than most rock in the area.

In all, 504 seismic refraction measurements were made during the year.

Electrical resistivity measurements.--Electrical resistivity surveys are made by measuring the ease with which electrical currents flow through the ground at different depths. Because this "ease" or resistivity is an indirect indication of the type of materials through which the current is flowing, electrical surveys are important methods of determining what the unconsolidated materials are at a given locality. Interpretation of the resistivity data helps in the search for gravel, clay, or fresh water, or to trace salt water contamination.

A resistivity survey was made in conjunction with seismic surveys in the search for reefs, and in LaPorte County to assist in a search for ground water. A total of 77 electrical resistivity stations were occupied during this work.

Drilling Program.--The Geophysics Section also is in charge of the Survey's drilling program. During 1971-72, 3,797 feet of hole were drilled, 2,401 feet of core were recovered, and 4,628 feet of hole were augered at locations throughout Indiana.

#### INDUSTRIAL MINERALS SECTION

The principal function of the Industrial Minerals Section is to gather, organize, and store geologic information about the industrial rocks and minerals so that it can be readily distributed to the general public. A subordinate function, but one of almost equal importance, is to conduct research that will increase our overall understanding of the geology of the industrial rocks and minerals in Indiana.

During 1971-72, the staff of the Industrial Minerals Section handled 411 service requests, an increase of 23 percent over the previous fiscal year. In addition, notable increases were made in number of papers presented at professional meetings, number of man-days in the field, and the amount of geologic information added to file.

Environmental studies occupied a greater part of the section's time than ever before. More than one man-year was spent in pursuit of this aspect of industrial minerals research. The clay and shale research program reinstated in June 1971 had its first full year of operation. Research projects on carbonate rocks, sand and gravel, and gypsum resources continued at a high level.

#### Research Projects in Progress

Borden Group of Indiana -- Austin

Data on Abandoned Quarries -- Ault,

Environmental Geology of Allen County -- Bleuer and Moore

Environmental Geology of Marion County -- Ault, Austin, and Moore

Kankakee Valley Duné Sands -- Moore

Limestone and Dolomite Chapter for AIME's 4th Edition of "Industrial Minerals and Rocks" -- Carr

Limestone Resources in the Ohio River Valley in Indiana -- Ault, Carr, French, and Rooney

Origin of the Lost River Chert -- Carr, Moore, and Leininger

Resources of the Big Blue River Valley -- Ault and Moore

Utilization of Fly Ash -- Moore



Research Projects Completed

Gypsum Resources in Southwestern Indiana -- Carr & Jorgensen

MINERAL STATISTICIAN

The year 1971 marks a change in the manner in which mineral production is reported. The following table includes only the actual mineral commodities, with values reported at first stage of salability. Values for products manufactured from these commodities are reported in the text when available.

	<u>Quantity</u>	<u>Value</u>
Coal	21,439,814 tons	\$101,839,117.00
Crushed Limestone	23,057,045 tons	34,104,712.00
Sand and Gravel	22,078,934 tons	26,176,355.00
Petroleum	6,657,745 bbls	22,769,488.00
Dimension Limestone	4,481,232 cu.ft.	8,062,200.00
Clay and Shale	1,314,669 tons	1,720,483.00
Peat	54,285 tons	516,213.00
Natural Gas	537,000,000 cu.ft.	88,000.00
Undistributed - includes dimension sandstone, gypsum, marl, and whetstones		<u>3,517,480.00</u>
TOTAL		\$198,794,048.00

The fuels -- coal, petroleum, and natural gas -- accounted for 62.8 percent of the total value of minerals produced in Indiana. Although an extended strike caused a decrease of 4.1 percent in the quantity of coal mined, a greater unit price resulted in a 1.2 percent increase in total value. Petroleum production declined slightly more than 11 percent in volume and almost 5 percent in value, continuing a trend of the past several years. The substantial increase (126.6 percent in volume and 155.8 percent in value) in reported natural gas production is due primarily to the start of production in the Fort Wayne Field, which had been shut down since 1962, and to increased production from the Plainville and Odon East Fields.

With the exceptions of clay and shale, which increased in volume of production by 5 percent and in value 13.7 percent, and gypsum, which increased 8.4 percent in volume and 13 percent in value, all building materials declined in volume, and only sand and gravel showed a slight increase in value.

Processing of limestone from rough blocks into sawed slabs, cut stone, and veneer added an additional \$13,579,664.00 to the value of dimension stone reported in the table above. The reported value of tile (drain, structural, and sewer), common and face brick, pottery, and other products made from Indiana clays and shales was \$26,427,696.00, an increase of 6.2 percent over the previous year. The cement plants in the state produced a total of 18,409,843 barrels, valued at \$58,614,320.00, an increase of 22.13 percent in quantity and 22.57 percent in value.

The following counties led in production of minerals (excluding oil and gas) and products manufactured from minerals of Indiana origin:

County	Mineral Commodities	Value-Raw Materials	Value-Including Manufactured Products
<u>\$20 million +</u>			
Warrick	Coal	\$33,073,224.00	-----
Sullivan	Coal, crushed limestone sand and gravel	23,903,932.00	-----
Pike	Coal, crushed limestone	21,658,027.00	-----
Lake	Clay & shale, sand & gravel, recovered sulfur, cement, clay products	584,171.00	\$24,024,380.00
<u>\$10 - 20 million</u>			
Lawrence	Clay & shale, crushed limestone, dimension limestone, cement	6,661,580.00	18,069,488.00
Clay	Clay & shale, coal, clay products	5,932,858.00	17,409,368.00
Clark	Clay & shale, crushed limestone, sand & gravel, cement	2,835,989.00	18,452,161.00

<u>County</u>	<u>Mineral Commodities</u>	<u>Value-Raw Materials</u>	<u>Value-Including Manufactured Products</u>
<u>\$5 - 10 million</u>			
Vermillion	Clay & shale, coal, sand & gravel, clay products	\$ 6,803,983.00	\$ 7,489,233.00
Lawrence	Clay & shale, crushed limestone, dimension limestone, cement	6,661,580.00	18,069,488.00
Greene	Clay & shale, coal, sand & gravel, clay products	6,434,129.00	6,733,904.00
Monroe	Crushed limestone, dimension limestone, dimension sandstone	6,273,421.00	9,195,297.00
Clay	Clay & shale, coal, clay products	5,932,858.00	17,409,368.00
Putnam	Crushed limestone, sand & gravel, cement, clay products	3,507,481.00	9,754,934.00
Cass	Clay & shale, crushed limestone, sand & gravel, cement	939,087.00	7,626,468.00
Montgomery	Clay & shale, sand & gravel, clay products	C	6,077,435.00

In 20 counties, including 10 listed above, products manufactured from mineral resources added substantially to the total value of annual production.

#### PETROLEUM SECTION

Work in the Petroleum Section has followed the same pattern for many years. It consists of services, projects that are repeated annually, projects related to records improvement and subsurface study projects; in addition, from time to time, special projects are undertaken.

## Services

The Petroleum Section maintains a comprehensive, continuously-expanding file of data on Indiana wells. Services rendered by it, for the most part, are related to, and dependent upon, this file. Services consist of correspondence and conferences about samples, cores, geophysical logs, scout data, drillers logs, drilling-time logs, well locations and elevations, etc., and interpretations made from these data.

## Annual Projects

Five projects, undertaken annually for many years, were completed during the year. These projects are primarily of a statistical nature.

Indiana Drilling Statistics.--Indiana drilling statistics for 1971 were compiled in accordance with the well classification format specified by the American Association of Petroleum Geologists' Committee on Statistics of Drilling; these statistics are utilized by the AAPG and the American Petroleum Institute in compilation of statistical summaries covering drilling in the whole of the United States. Indiana drilling statistics were compiled, also, in accordance with the well classification format employed by the Geological Survey for many years; these statistics are published by the Geological Survey in the annual volume of its Mineral Economic Series.

Indiana Exploration Developments.--A review of the results of exploratory drilling in Indiana during 1971 was compiled. It is published in a bulletin of the American Association of Petroleum Geologists, as a part of a national review of exploration results.

Indiana Oil Production.--Indiana oil production statistics, by fields, for 1971 were prepared. Publication of these statistics is by the Geological Survey in its Mineral Economic Series; the volume for 1971 will be the eighteenth of the series. Although the Mineral Economic Series consists primarily of oil production statistics, reviews of drilling, and drilling results, are presented in it.

Indiana Oil Reserves.--The Petroleum Section participates annually in the American Petroleum Institute's program of formulating statistics on remaining oil reserves and developing attendant oil-recovery data. The section's statistical contributions to the API reserves program pertain mainly to Indiana. Reserves and attendant data for Indiana are incorporated in a publication of the American Petroleum Institute, the American Gas Association, and the Canadian Petroleum Association. Only state-total figures are published.

The Petroleum Section's participation in the API reserves program has been continuous for more than 20 years.

Review of 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, etc.) and total depths. All of the 92 maps in the series were maintained on an up-to-date basis throughout the year.

In the past, the maps of the Petroleum Exploration Map Series have been revised and re-issued on an annual basis. In the future, they will be re-issued on a biennial basis. The next published revision of the maps of the Series will be as of December 31, 1972.

#### Records Improvement

Posey County.--Upgrading well records, by counties, has been a continuing program for more than 20 years. The program encompasses all of Indiana's 92 counties except the seven in which the oil reservoirs of the Trenton Field are located, where vintage of drilling precludes upgrading. Of the 85 counties included in the program, 83 have been completed. The two remaining counties are Posey and Gibson. These are the most densely drilled counties of the 85, and thus a large amount of work remains to complete the program. Work currently is restricted to Posey County.

Because of high well density, the Posey County project is divided into sub-projects on a congressional township basis. Two townships were completed in 1969-70, four were completed in 1970-71, and four were completed during the current year. Work is well underway on all of the remaining nine townships, progress on them ranging from 75 to 90 percent completion. All townships will be completed during the coming year, and publication of a new Posey County petroleum exploration map is expected by December 31, 1972.

Survey Drill Hole Records.--No systematic procedure of incorporating records of the Geological Survey's drill holes into the Petroleum Section's master file of well records has been followed through the years. To incorporate these records in the master file, a separate project was initiated on June 15, 1972. The project will not require a great amount of time, and probably will be completed within a couple of months. It consists of collecting all data for all holes (drillers logs, geophysical logs and sample studies, etc.), cataloguing them and filing them.

## Subsurface Studies

Study of the thick Cambrian clastic section in Indiana, started last year, was continued throughout the current year. It is now 50 percent complete. It will add significantly to understanding of Indiana subsurface strata and will be published by the Geological Survey, probably as a bulletin.

## Special Projects

Compilation of a new pipeline map of Indiana, started last year, was completed during the year. The Geological Survey published a detailed pipeline map of Indiana in 1960, which is now out-of-date inasmuch as many pipelines, mostly for gas, have been built in Indiana in the past 12 years. The new Indiana pipeline map is currently being edited. It will be published as a Miscellaneous Map.

## Miscellaneous Notes

Technical Programs.--One member of the Petroleum Section participated in the Geological Survey's Mineral Industries Conference held on December 15, 1971. Participation consisted of presenting a paper on subsurface occurrence of Silurian reefs, and associated petroleum accumulations, in the Illinois Basin portion of Indiana.

Technical Committees.--One member of the Petroleum Section is a member of the American Petroleum Institute's Subcommittee on crude oil reserves data for the Tri-States area of Illinois, Indiana and Kentucky. His contribution to the Subcommittee's work consists of reserves data for Indiana oil fields. He participated, at St. Louis in January, 1972, in the meeting of the Subcommittee dealing with 1971 reserves data.

One member of the Petroleum Section is a member of API's National Committee on crude oil reserves. He is the Committee's representative for the Tri-States and Michigan. Relative to 1971 crude oil reserves statistics, he participated in the Tri-States and Michigan Subcommittee meetings in January, 1972 and in the National Committee meeting, at Palm Springs, California, in March, 1972.

A third member of the Petroleum Section belongs to the American Association of Petroleum Geologists Committee on Statistics of Drilling. His Committee obligation pertains to oil and gas drilling in Indiana. He attended the Committee's annual meeting, at Washington, D.C., in October, 1971.

Professional Societies.--Five members of the Section are active participants in the Indiana-Kentucky Geological Society and one member is an active participant in the meetings of the Indiana Geologists organiza-

tion. Four are long-standing members of the American Association of Petroleum Geologists and two hold membership in the Geological Society of America.

#### PUBLICATIONS SECTION

During the past fiscal year the Publications Section sold 5,915 reports and 9,533 maps. The section sent 1,504 reports and 394 maps on exchange to institutions in the United States and in foreign countries. It also distributed without charge 2,112 reports and 1,506 maps to members of its own organization and to individuals, libraries, and companies in the United States and abroad. The Publications Section served 3,998 office customers, handled 2,145 letters pertaining to geologic reports and maps, and sent out 1,717 announcements of new publications.

As in past years, bestsellers among reports are numbers in the Circular series. The biggest seller is Circular 5, "Let's Look at Some Rocks" (published 1958, 29,000 copies in print). It is followed by Circular 6, "Adventures with fossils" (published 1959, 12,000 copies in print); Circular 4, "Guide to Some Minerals and Rocks in Indiana" (published 1958, 10,000 copies in print); Circular 7, "Fossils: Pre-historic Animals in Hoosier Rocks" (published 1960, 9,000 copies in print); and Circular 8, "Caves of Indiana" (published 1962, 7,000 copies in print). Among maps, U.S. Geological Survey topographic maps (scale 1:24,000 and 1:250,000) are by far the bestsellers.

REPORTS AND MAPS PUBLISHED BY THE GEOLOGICAL SURVEY

Bulletins

Carr, Donald D., 1971, Specialty sand resources of Indiana: Bulletin 42-F, 30 p., 2 pls., 7 figs., 13 tables.

Carr, Donald D., French, Robert R., and Ault, Curtis H., 1971, Crushed stone aggregate resources of Indiana: Bulletin 42-H, 38 p., 2 pls., 7 figs., 3 tables.

Orr, R.W., 1971, Condonts from middle Devonian strata of the Michigan Basin: Bulletin 45, 110 p., 6 pls., 4 figs.

Rooney, Lawrence F., and Carr, Donald D., 1971, Applied geology of industrial limestone and Dolomite: Bulletin 46, 59 p., 16 figs., 12 tables.

Wayne, W.J., 1971, Marl resources of Indiana: Bulletin 42-G, 16 p., 4 figs., 1 table.

Directories

Austin, George S., 1972, Directory of clay and shale producers and ceramic plants in Indiana, 28 p.

Carr, Donald D., and Ault, Curtis H., 1971, Directory of Dimension Stone Quarriers in Indiana, 18 p.

Guidebooks

Shaver, Robert H., and Austin, George S., 1972, A field guide to the Mt. Carmel Fault of southern Indiana, Geological Survey Guidebook 13, 25 p., 10 figs.

Mineral Economic Series

Carpenter, G.L., and Keller, S.J., 1972, Oil development and production in Indiana during 1970: Mineral Economics Ser. 17, 20 p., 3 figs., 5 tables.



### Special Reports

Bleuer, N.K., and Hartke, E.J., 1971, Diagrammatic cross sections of Indiana geology in relation to solid waste disposal sites: Indiana State Board of Health: Suppl. Indiana Geol. Survey Special Rept. 5, 21 p., 16 figs.

### Miscellaneous Maps

Hutchison, H.C., 1962, rev. 1972, Map of southwestern Indiana showing locations of active coal mines: Misc. Map 7.

Webb, W.M., 1967 rev. 1972 by G.S. Austin, Locations of clay and shale operations in Indiana: Misc. Map 14.

### Preliminary Coal Maps

Hutchison, Harold, Preliminary Coal Map 15, 1972, Distribution, structure, and mined areas of coals in Daviess County, Indiana.

### Regional Geologic Maps

Burger, A.M., Forsyth, J.L., Nicoll, R.S., and Wayne, W.J., 1971, Geologic map of the 1° x 2° Muncie Quadrangle, Indiana and Ohio, showing bedrock and unconsolidated deposits: Regional Geol. Map 5. Part A and Part B.

PAPERS PUBLISHED IN SCIENTIFIC JOURNALS

AMERICAN GEOLOGICAL SOCIETY

Bleuer, N.K., and Moore, N.C., 1972, Glacial stratigraphy, buried landforms and early drainage at Fort Wayne, Indiana (abs.): Geol. Soc. America, Abstracts with Programs, North-Central Section, 1 p.

Collinson, Charles, Rexroad, C.B., and Thompson, T.L., 1971, Conodont zonation of the North American Mississippian: Geol. Soc. America Mem. 127, p. 353-394, 8 figs., 1 table.

Powell R.L., 1972, Karst ground water (abstract): Program of 6th Annual Meeting, North-Central Section, GSA, p. 344-345.

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Rexroad, C.B., and Craig, W.W., 1972, Restudy of conodonts from the Bainbridge Formation (Silurian) at Lithium, Missouri: Jour. Paleontology, v. 45, p. 684-703, pls. 79-82, 2 figs.

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Rexroad, C.B., and Nicoll, R.S., 1972, Summary of conodont biostratigraphy of the Silurian System of North America: Geol. Soc. America Mem. 127, p. 207-225, 2 pls., 2 figs.

Wier, C.E., Wiram, V.P., and Mitchell, J.R., 1972, Evaluation of sulfur in overburden in northwestern Greene County, Indiana, (Abstract): Program of 6th Annual Meeting, North-Central Section, GSA, p. 356.

#### REPORTS PUBLISHED IN OUTDOOR INDIANA

Rarick, R. Dee, February, 1972, Apollo Flights Reveal Lunar Secrets, Outdoor Indiana.

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Rarick, R. Dee, and Thornbury, W.D., December, 1971-January, 1972, Sand Bodies in Indiana, Outdoor Indiana.

#### MAPS PUBLISHED OUTSIDE THE INDIANA GEOLOGICAL SURVEY

Amos, D.H., Geologic Map of the New Amsterdam Quadrangle Kentucky-Indiana and Part of the Mauckport Quadrangle Kentucky (Indiana part by Donald D. Carr and Richard L. Fowell), U.S. Geological Survey GQ 990, June, 1972.

#### SUBMITTED FOR PUBLICATION

##### Bulletins

Ault, Curtis H., Rooney, Lawrence F., and Palmer, Margaret V., The lime industry in Indiana.

Carr, Donald D., Crushed stone resources of the Blue River Group of Indiana.

Carr, Donald D., Geometry and origin of Oolite bodies in the Ste. Genevieve Limestone (Mississippian) in the Illinois Basin.

Gooding, A.M., Characteristics of late Wisconsinan tills in eastern Indiana: Indiana Geol. Survey Bull., 28 p., 8 figs.

##### Guidebooks

Austin, George, Paleozoic lithostratigraphy of southeastern Minnesota, Fieldtrip 3 Guidebook for the 1972 annual GSA meeting.

Austin, George, Precambrian Sioux quartzite and cretaceous rocks of southern Minnesota, Fieldtrip 3 Guidebook for the 1972 annual GSA meeting.

Bleuer, N.K., The geologic history of Pokagon State Park, Indiana's Ice Age legacy: Indiana Geol. Survey State Park Guide 1 (new series proposed), 7 p., 8 figs.

#### Special Reports

Bleuer, N.K., Distribution and significance of some ice-disintegration features in west-central Indiana: Indiana Geol. Survey Special Rept., 18 p., 7 figs.

Droste, J.B., and Orr, R.W., The age of the Detroit River Formation in Indiana: Indiana Geol. Survey Special Rept., 11 p., 1 fig.

Gray, H.H., Glacial Lake sediments in Salt Creek valley near Bedford, Indiana: Indiana Geol. Survey Special Rept., 21 p., 7 figs.

Gray, H.H., Lithostratigraphy of the Mawuketa Group (Ordovician) in Indiana: Indiana Geol. Survey Special Rept., 87 p., 12 figs., 3 tables.

Maroney, D.G., and Orr, R.W., A population of the new species Ctenoconularida delphiensis from the New Albany Shale (upper Devonian) at Delphi, Indiana: Indiana Geol. Survey Special Rept., 16 p., 1 pl., 1 fig.

Moore, M.C., and Rexroad, C.B., Age and origin of stone quarried near Fort Wayne in the late 1800's: Indiana Geol. Survey Special Rept., 12 p., 2 figs.

Shaver, R.H., The Muscatatuck Group (new middle Devonian name) in Indiana: Indiana Geol. Survey Special Rept., 19 p., 1 fig.

#### Miscellaneous Maps

Gray, H.H., Environmental geology of the Jeffersonville area, Indiana: Indiana Geol. Survey Misc. Map.

Gray, H.H., Environmental geology of the New Albany area, Indiana: Indiana Geol. Survey Misc. Map.

Gray, H.H., Geology map of the 1° x 2° Louisville Quadrangle, etc., no. 6.

Gray, H.H., Forsyth, J.L., Schneider, A.F., and Gooding, A.M., Geologic map of the 1° x 2° Cincinnati Quadrangle, etc., no. 7.

Johnson, G.H., and Keller, S.J., Geologic map of the 1° x 2° Fort Wayne Quadrangle, etc., no. 8

#### Regional Geologic Maps

Gray, H.H., Properties and uses of geologic materials of Indiana: Regional Geol. Map Suppl. Chart 1.

#### Reports of Progress

Shaver, R.H., and Smith S.G., Early and early middle Pennsylvanian kirkbyacean ostracods of Indiana in relation to fusulinid zones and Midcontinent series terminology: Indiana Geol. Survey Rept. Progress, 118 p., 3 pls., 5 figs.

#### Contributions to Outside Publications

Austin, George, three chapters for "Geology of Minnesota," for the Minnesota Geological Survey: Cretaceous rocks in Minnesota, Sioux quartzite, and Paleozoic lithostratigraphy of southeastern Minnesota.

#### Papers Submitted for Publication in Scientific Journals

Barnes, C.A., Rexroad, C.B., and Miller, J.F., Lower Paleozoic conodont provincialism: Geol. Soc. America Mem. 134, 52 p., 16 figs.

Bleuer, N.K., and Moore, M.C., Glacial stratigraphy of the Fort Wayne area and the draining of glacial Lake Maumee: Indiana Acad. Sci., 16 p., 9 figs., 1 table.

Horowitz, A.S., and Rexroad, C.B., Conodont biostratigraphy of some United States Mississippian sites: Jour. Paleontology, 19 p., 3 figs.

Rexroad, C.B., with three others, as a secondary contributor, Geology of the Gazelle-Callahan region, Klamath Mountains, California: Preliminary report: Geol. Soc. America Bull., 31 p., 4 figs.

MEMORANDUM REPORTS

Ault, C.H., Gray, H.H., and Wier, C.E., Field trip itineraries, SE and SW Indiana, April 28 and May 5, 1972, IMS 62.

Bleuer, N.K., October 7, 1971, Glacial geology of the South Bend area: 3 p., 1 fig. (requested by State Senator Frick).

Gray, H.H., July 12, 1971, Preliminary report on the geology of the Mt. Vernon, Indiana port site: 8 p., 1 map (requested in connection with Corps of Engineers project).

Gray, H.H., December 15, 1971, Origin of sliding materials at Hidden Valley (Dearborn County): 1 p., (requested by Div. Water).

Gray, H.H., Powell, R.L., and Straw, W.T., Environmental geology of the Evansville area: Chart and text, 7 maps, 1 table.

Hartke, E.J., December 21, 1971, Geologic considerations for General Electric's waste disposal well no. 2: 3 p., 1 fig. (requested by Wm. Andrews).

Hartke, E.J., March 30, 1972, A preliminary geologic evaluation of seven proposed power plant sites in Indiana: 3 p., 8 maps (requested by Dept. Nat. Resources).

Hill, J.R.V., February 22, 1972, Geologic interpretation of the unconsolidated deposits in Lake and Porter Counties, Indiana: 4 p., 1 fig. (Requested by Lake-Porter County Regional Transportation and Planning Commission).

Horowitz, A.S., July 25, 1971, Curating the paleontological collections no. 14: 2 p.

Moore, Michael C., Southern Indiana Karst field trip guide, March, 1972, 20 p., IMS 61.

Rexroad, C.B., July 12, 1971, Selected geologic information on the proposed Clifty Creek Reservoir area: 6 p., 1 map (requested by Dept. Nat. Resources).

PAPERS PRESENTED AT PROFESSIONAL MEETINGS

Austin, George S., and Patton, John B., The history of brick manufacture in Indiana, at the Indiana Academy of Science meeting, Earlham College, October 29, 1971.

Austin, George S., Stratigraphy of the Shakopee Formation (early Ordovician) of Minnesota, at the GSA Meeting, DeKalb, Illinois, May 11, 1972.

Austin, George S., Petrology of the Shakopee Formation (early Ordovician) of Minnesota, at the GSA Meeting, DeKalb, Illinois, May 12, 1972.

Bleuer, N.K., and Moore M.C., Glacial geology of the Fort Wayne, Indiana Area and the History of Glacial Lake Maumee, at the Indiana Academy of Science Meeting, Earlham College, October 29, 1971.

Bleuer, N.K., and Moore, M.C., Glacial stratigraphy, buried landforms, and early drainage at Fort Wayne, Indiana, at the GSA Meeting, DeKalb, Illinois, May 11, 1972.

Jorgensen, D.B., and Carr, D.D., Influence of cyclic deposition, structural features, and hydrologic controls on evaporite deposits in St. Louis Limestone in southwestern Indiana and adjacent states, at the Eighth Forum on Geology of Industrial Minerals, Iowa City, Iowa, April 13, 1972.

PUBLIC LECTURES

Ault, C.H., A talk on rocks, minerals, and fossils, October, 1971, to a fourth grade class at Marlin Elementary School in Bloomington.

Austin G.S., On the Mt. Carmel Fault, May, 1972, at a meeting of the Indiana-Kentucky Geological Society in Bloomington.

Carr, D.D., "There is gold in Indiana if you can find it," August, 1971, Bloomington Toastmasters Club.

Carr, D.D., Ault, C.H., and Moore, M.C., "A trilogy: lime, limestone, and the lonesome limestone ledge," December, 1971, Geological Survey Mineral Industries Conference.

Moore, M.C., A slide talk on caves, October, 1971, the Bloomington Park and Recreation Board cave club.

Patton, J.B., A talk on uses of stone in architecture at annual meeting of Hillforest Foundation, Aurora, Indiana, November 18, 1971.

Wier, C.E., "Reduction of sulfur in Indiana coal by washability techniques," October 5, 1971, to EPA conference in Denver on sulfur in coal and air pollution.

Wier, C.E., "Mineral resources of Indiana," October 27, 1971 to Optimist Club at Martinsville.

Wier, C.E., "Washability and distribution of sulfur in Indiana coal," December 15, 1971, to Indiana Geological Survey Advisory Group.

Wier, C.E., "On the proposed project using ERTS-A imagery to map fracture patterns in the coal mine area," March 29, 1972, IGS Colloquium.

Wier, C.E., "Distribution of sulfur in Indiana coal," March 23, 1972, to Indiana Mining and Technical Society at Linton.

Wier, C.E., "Formation of karst topography and relationship to soils," April 26, 1972, to members of Bloomington Common Council and Planning Commission at airport west of Bloomington.

Wier, C.E., "Evaluation of sulfur in overburden in northeastern Greene County, Indiana," May 11-12, 1972, North-Central Section, GSA, DeKalb, Illinois.

Wier, C.E., "Distribution of sulfur in overburden at the Latta Mine, Greene County, Indiana," May 24, 1972, at IGS Colloquium.

Wiram, V.P., "A sulfur problem with our Indiana coals and associated overburden material," December 30, 1971, Kiwanis in Brazil.

Wiram, V.P., "A sulfur problem with our Indiana coals and associated overburden material," January 8, 1972, Lawrence County Rock Club.

#### PUBLIC FIELD TRIPS

Moore, M.C., conducted a field trip for the Youth Conservation Corps in July, 1971.

Moore, M.C., conducted a field trip for the Boone County 4-H Clubs in July, 1971.

Moore, M.C., conducted a field trip for the Mid-Illinois Grotto, Champaign, Illinois in March, 1972.



Austin, G.S., and Shaver, R.H., conducted a field trip for the Indiana Kentucky Geological Society in May, 1972.

Ault, C.H., conducted a field trip for an I.U. sponsored science workshop for elementary school teachers in June, 1972.

#### ACTIVITIES

George Austin -- Member of Task Force 6 (Land Resources), Kankakee-Elkhart River Basin Study Group and of General Geology, Physiography and Minerals Subgroup of that task force.

Leroy Becker -- Society of Economic Paleontologists and Mineralogists: Potential Gas Committee.

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

Industrial Minerals Division of AIME: Member of Program Policy Committee.

Industrial Minerals Division of AIME: Vice-chairman of the North Central Midcontinent Region.

Great Lakes Basin Study Commission: Committee on Mineral Resources.

Thomas Dawson -- American Petroleum Institute: Committee on Crude Oil Reserves & Productive Capacity.

Richard Leininger -- Clay Mineral Society: Counselor.

Monroe County Soil & Water Conservation District: Treasurer

Louis Miller -- Indiana Mining Technical Society: Secretary-Treasurer.

Indiana Geologists: Vice President.

Michael Moore -- 1973 National Speleological Society Convention: Chairman, general sessions, August, 1972 - June, 1973.

John B. Patton -- Representative of the Association of American State Geologists, in the Division of Earth Sciences, National Research Council.

Member of a National Research Council ad hoc Organizing Group to make recommendations to the Governing Board of NRC on organization, membership, and procedures for a U.S. National Committee on Tunneling Technology, which will represent the United States in the International Tunneling Association.

On the Society of Economic Geologists' newly-established Committee for Information on Mineral Problems, which is to provide technical information to various policy-making agencies of government.

Chairman of the Bloomington Environmental Quality and Conservation Commission.

Chaired one session at the first annual meeting (at Columbus, Ohio) of the newly-formed Eastern Section, American Association of Petroleum Geologists.

On the advisory screening committee for geology, Committee on International Exchange of Persons (Senior Fulbright-Hays Program).

Representative of the Society of Economic Geologists to the American Geological Institute.

Served on the Research Grants Committee and the Science and Society Committee of the Indiana Academy of Science.

Member of the Nominating Committee of the Association of American State Geologists.

Public Relations subcommittee member in the American Society for Testing and Materials, Committee C-18 -- Natural Building Stone.

Served on the committee on underground injection of liquid wastes of the Ohio River Valley Water Sanitation Committee.

Member of the Research Committee, Interstate Oil Compact Commission, and served as chairman of a subcommittee for data on underground disposal of liquid wastes.

Chairman of the Historic Preservation Conference held on the campus of Indiana University last fall.

Robert Shaver -- Paleontological Society: Great Lakes Section  
Vice President elect.

Charles Wier -- Geological Society of America: Chairman, Carboniferous Stratigraphy Committee and co-chairman of session on coal geology.

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

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

Monroe County Soil and Water Conservation District: Secretary

Bloomington Land Use Committee: Chairman.