91st ANNUAL REPORT OF THE STATE GEOLOGIST

of

INDIANA GEOLOGICAL SURVEY
DEPARTMENT OF NATURAL RESOURCES

for

July 1, 1966 - June 30, 1967

GEOLOGICAL SURVEY
NINETY-FIRST 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
	(On leave from Survey June 10-30, 1967)
S. A. Friedman	Geologist
Harold Hutchison	Geologist
Marvin T. Iverson	Geological Assistant
Sharon Kirkman	Secretary
Richard L. Powell	Geologist

Drafting and Photography Section

William H. Moran	Chief Draftsman and Head
Robert E. Judah	Geological Artist-Draftsman
John E. Peace	Senior Geological Draftsman
Roger L. Purcell	Geological Draftsman
George E. Ringer	Photographer
Sharon Turpin	Geological Draftsman
	(From October 14, 1966 to January 10, 1967)

Educational Services

Reevan Dee Rarick	Geologist

Geochemistry Section

R. K. Leininger	Geochemist and Head
Maynard Coller	Chemist
Elmer M. Craig	Geochemical Assistant
Rebecca Dexter	Secretary
	(To January 12, 1967; shared with Industrial Minerals)
Rosalie Easton	Secretary
	(From December 19, 1966; shared with Industrial Minerals)
Jack L. Harrison	X-ray Mineralogist
	(To September 22, 1966)
Ronald W. Klusman	Instrumental Analyst
Louis V. Miller	Coal Chemist
Alfred E. White	Geochemical Assistant

Geology Section

Robert H. Shaver. . . . . Paleontologist and Head
Ann Burger. . . . . Geologist
(To July 29, 1966)
Henry H. Gray . . . . . Head Stratigrapher
Alan S. Horowitz. . . . . Curator of Paleontology
Carl B. Rexroad . . . . . Paleontologist
Allan F. Schneider. . . . . Glacial Geologist
Martha N. Smith . . . . . Secretary
William J. Wayne . . . . . Head Glacial Geologist
(On leave September 16, 1966 to June 23, 1967)

Geophysics Section

Maurice E. Biggs. . . . . Geophysicist and Head
Robert F. Blakely . . . . . Geophysicist
Ruth Fulk (half-time appointment) . . . . . Secretary
(July 1 to September 16, 1966)
Linda Harris. . . . . Secretary
(From September 12, 1966)
Clarence Haskins. . . . . Driller
John R. Helms . . . . . Geophysical Assistant
Glenn Johnson . . . . . Assistant Driller
Joan Justus . . . . . Secretary
(To August 10, 1966)
Charles S. Miller . . . . . Instrument Maker
Joseph F. Whaley. . . . . Geophysicist

Industrial Minerals Section

Lawrence F. Rooney. . . . . Geologist and Head
Donald D. Carr. . . . . Geologist
Rebecca A. Dexter . . . . . Secretary
(To January 12, 1967; shared with Geochemistry)
Rosalie Easton. . . . . Secretary
(From December 19, 1966; shared with Geochemistry)
Robert R. French. . . . . Geologist
William M. Webb . . . . . Geologist
Margaret Palmer . . . . . Geologist
(September 15, 1966 to June 6, 1967)

Petroleum Section

Thomas A. Dawson. . . . . Geologist and Head
Leroy E. Becker . . . . . Geologist
M. Ruth Butcher . . . . . Secretary and Curator of Records
Gerald L. Carpenter . . . . . Geologist
James T. Cazee. . . . . Geological Assistant
(To May 28, 1967)
Jr. Draftsman
(From May 29, 1967)

Petroleum Section (continued)

Lois Chaney . . . . . Jr. Draftsman
(November 28, 1966 to May 5, 1967)
Larry Enochs. . . . . Geological Assistant
(February 6 to June 30, 1967)
Darry Don Hayes . . . . . Geological Assistant
(From May 1, 1967)
Andrew J. Hreha . . . . . Geologist
Stanley Keller. . . . . Geologist
Leon Ledson . . . . . Geological Assistant
(May 29 to June 9, 1967)
Jan Mayer . . . . . Geological Assistant
(From June 19, 1967)
Vivian McGuire. . . . . Senior Curator of Records
Allen H. Pruett . . . . . Geological Assistant
(On Military Leave of Absence January 12 to June 5,1967)
Howard Smith . . . . . Geologist
Dan M. Sullivan . . . . . Geologist
James Thrasher. . . . . Geological Assistant
(To April 28, 1967)
Sharon A. Turpin. . . . . Geological Assistant
(To January 12, 1967)

Publications Section

Gerald S. Woodard . . . . . Editor and Head
Carol B. Bland . . . . . Secretary
(To August 12, 1966)
Lewis W. Nellinger. . . . . Sales and Record Clerk
(To March 31, 1967)
Donna Schultz . . . . . Secretary
(From September 9, 1966 to March 31, 1967)
Sales and Record Clerk
(From April 1, 1967)
Linda K. Ruble. . . . . Secretary
(From May 2, 1967)

Seasonal Personnel

Coal Section

Michael Fowler. . . . . Research Assistant
(July 1 to August 31, 1966)
Suzanne Penz. . . . . Research Assistant
(July 1, 1966 to January 31, 1967)
Ikram Khawaja . . . . . Research Assistant
(July 1 to August 31, 1966)

Drafting and Photography

Ruth Brown	Print Trimmer (March 9 to April 13, 1967)
Patricia M. Buckley	Typist and Drafting Assistant (March 16 to June 30, 1967)
Michael C. Carpenter	Print Trimmer (March 10 to April 10, 1967)
Robert L. Methot	Print Trimmer (September 1 to 9, 1966)
Nancy A. North	Typist and Drafting Assistant (September 19, 1966 to May 6, 1967)
Richard N. Passero	Drafting Assistant (July 18, 1966)
Sheila K. Rawlins	Drafting Assistant (June 1 to 30, 1967)
Gail N. Stern	Draftsman (September 26 to October 4, 1966)

Educational Services

Mary Beth Jones	Geologic Assistant (September 20, 1966 to April 30, 1967)
Susan Shrigley	Geologic Assistant (July 1 to August 15, 1966)

Geochemistry Section

Douglas R. Baumgardt	Laboratory Assistant (June 19 to 30, 1967)
Robert Berry	Laboratory Assistant (July 1 to August 8, 1966)
Donald L. Burton	Laboratory Assistant (September 21, 1966 to June 30, 1967)
Richard Overmyer	Laboratory Assistant (May 10 to June 20, 1967)

Geology Section

John P. Ford	Field Geologist (July 1 to August 31, 1966)
Gerald H. Johnson	Geologist (July 1 to August 15, 1966)
Robert S. Nicoll	Geological Assistant (July 1 to August 15, 1966)
	Geologist (June 15 to July 1, 1967)
Mark Reshkin	Field Geologist (July 1 to August 26, 1966)
Kenneth W. Ashby	Laboratory Assistant (July 1, 1966 to January 19, 1967)

Geology Section (continued)

Betty Brugger	Laboratory Assistant (July 1 to September 15, 1966)
Mary Ann Brezina	Clerk-Typist (July 21 to August 25, 1966)
Michael Dutton	Laboratory Assistant (July 17, 1966)
Stephen W. Henderson	Laboratory Assistant (January 5 to May 20, 1967)
Stanley C. Kent	Laboratory Assistant (September 23 to November 22, 1966)
Alex Klishevich	Laboratory Assistant (February 17 to June 30, 1967)
Jaci Leach	Laboratory Assistant (July 18 to August 25, 1966)
Randall Marmouze	Laboratory Assistant (January 11 to May 25, 1967)
Kenneth L. Potts	Laboratory Assistant (November 1 to December 15, 1966)
Michael A. Retherford	Laboratory Assistant (September 17, 1966 to June 30, 1967)
Nancy Sheets	Clerk-Typist and Laboratory Assistant (October 20, 1966 to June 30, 1967)
Katharine Sommer	Geological Assistant (February 6 to June 30, 1967)
Mary Jane Weddle	Laboratory Assistant (January 18 to March 28, 1967)

Geophysics Section

Harry Allen	Field Assistant (July 1 to August 26, 1966) (June 26 to 30, 1967)
Wendell Allison	Field Assistant (September 23 to October 7, 1966)
Carl Campbell	Field Assistant (July 1 to September 2, 1966)
David Collins	Lab Technician (July 1 to August 8, 1966)
Abraham H. Dizraj	Laboratory Assistant (June 7 to 30, 1967)
Herman Dyck	Field Assistant (July 1 to August 31, 1966)
Mark Hahn	Geophysical Technician (June 12 to 30, 1967)
Robert G. Marvin	Field Assistant (July 1 to September 30, 1966) (June 1 to 15, 1967)
Helen Moreland	IBM Keypunch Operator and Typist (July 1, 1966 to June 30, 1967)

Geophysics Section (continued)

Dennis Murphy	Field Assistant (January 25, 1967)
Albert J. Rudman	Geophysicist (July 1 to 15, 1966)
Jerry Lynn York	Field Assistant (September 24 to 29, 1966)

Industrial Minerals Section

Deborah Allen	Laboratory Assistant (June 26 to 30, 1967)
David C. Herrick	Laboratory Assistant (July 1 to September 17, 1966)
James Keith	Laboratory Assistant (June 13 to 30, 1967)
John McIntosh	Laboratory Assistant (July 1 to August 20, 1966)

Petroleum Section

David Denton	Geological Assistant (February 20 to July 1, 1967)
Kathleen Hancock	Typist (November 1 to December 23, 1966)
John F. Hemmer	Geological Assistant (July 1 to August 26, 1966)
John Ravenscroft	Geological Assistant (July 1 to August 19, 1966)

Publications Section

Wayne T. Morden	Clerk (September 16, 1966 to January 13, 1967)
Roger A. Norris	Clerk (February 14 to May 25, 1967)
Robert M. Goldstein	Clerk (June 8 to 30, 1967)

FINANCIAL STATEMENT

FUNCTION OR ACTIVITY		EXPENDITURES 1966-67
1. PERSONAL SERVICES		
101.	Full-time Salaries.	$405,406.
101.	Part-time-Summer.	13,738.
101.	Hourly.	9,900.
199.	Fellowships and Research Assistants	10,000.
	TOTAL PERSONAL SERVICES	439,044.
2. SERVICES OTHER THAN PERSONAL		
201.	Postage	500.
202.	Telephone and Telegraph	4,300.
204.	Freight and Express	400.
205.	Travel.	16,678.
206.	Dues and Subscriptions.	200.
211.	Gasoline Credit Cards	7,580.
	TOTAL SERVICES OTHER THAN PERSONAL. . . .	29,658.
3. SERVICES BY CONTRACT		
302.	Printing and Binding.	12,000.
329.	Insurance	2,510.
331.	Repairs to Buildings.	500.
332.	Repairs to Motor Vehicles	4,400.
339.	Repairs to Laboratory and Office Equipment. .	5,125.
399.	Contractual Services N.O.C.	4,500.
	TOTAL SERVICES BY CONTRACT.	29,035
4. MATERIALS, SUPPLIES AND PARTS		
401.	Office Supplies	1,470.
404.	Laboratory and Field Supplies	18,150.
	TOTAL MATERIALS, SUPPLIES AND PARTS . . .	19,620.
5. EQUIPMENT		
501.	Office Equipment.	1,000.
511.	Motor Vehicle Equipment	6,500.
521.	Laboratory, Field and Shop Equipment.	9,793.
522.	Educational Equipment	350.
	TOTAL EQUIPMENT	17,643.
	TOTAL EXPENDITURES.	$535,000.

INTRODUCTION

During the past 20 years the Indiana Geological Survey has grown in stature more than any other state geological organization in the country. This growth has been brought about by support of the legislature and the Department of Natural Resources, by generous and effective cooperation by Indiana University, by the counsel of representatives of the mineral industry, and by the accumulation of a highly professional geologic staff. That the staff has the respect of the scientific community is attested by the honors awarded to various of its members and by the number of papers presented to national professional organizations.

Among the honors may be included the election of Dr. John B. Patton, State Geologist, to the presidency of the Assocition of American State Geologists; Dr. Lawrence Rooney, head of the Industrial Minerals Section, to be vice-chairman of the Mid Continent Region, Industrial Minerals Division of the American Institute of Mining and Metallurgical Engineers; Dr. Robert Shaver, head of the Geology Section, to continue as one of two editors of the Journal of Paleontology; and Mr. Robert F. Blakely of the Geophysics Section was elected president of a computer user's organization.

That these men and their colleagues on the Geological Survey staff contribute a practical and effective role in helping maintain a healthy mineral industry in Indiana is demonstrated by the number of representatives of the mineral industries and governmental agencies that visit our offices and laboratories to seek their advice and to acquire basic geologic information. Partly as a result of their years of careful scientific investigation so that we have had the geologic data to answer these questions, in 1966 the mineral industries showed their greatest gain. The value to minerals produced in 1966 amounted to $283,091,950.00 or 12.4 per cent more than the previous year. Because most of these minerals were the raw materials for finished products, the 283 million dollars represents just a fraction of the income and taxes generated within the State by the production of mineral resources. This amount in turn may be just a fraction of the mineral resources needed by the end of the next 20 years. The work that the Geological Survey is doing now and will be doing in the next few years will continue to be the foundation on which this growth can be built.

Because funds available for the operation of the Geological Survey have remained at essentially the same level for the past several years and because the cost of maintaining the Survey has increased at a rate of approximately five per cent per year, the level of operations has steadily declined. This decline has been reflected in a reduction of summer field programs and in research programs undertaken by graduate students of geology and in the necessary postponement of refilling positions in the Coal, Geochemistry, and Geophysics Section that have been vacant for some time as a result of resignations. A loss of these personnel and a reduction of functions for lack of supplies and equipment takes away proportionately from the vigor of our program.

For these reasons we should continue to maintain a strong resourceful organization. To accomplish this, funds should be provided to increase staff salaries which have lagged somewhat in the past few years, unfilled positions should be staffed, ancient analytical equipment in the Geochemistry Section should be updated or replaced and a program in environmental or urban geology should be instituted to meet the increasing complexity of man's existence on the earth.

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 1966-67

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

Projects in Progress	50
Projects Completed	16
Conferences with visitors to the Survey	969
Man Day of field work	1,771
Incoming letters	4,473
Outgoing letters	2,863
Total number of Survey vehicles	22
Total number of miles traveled in Survey vehicles	226,187
Area mapped (geologically)	6,360 Sq. Mi.
Thickness of stratigraphic sections measured (feet)	5,967
Public lectures	104
Special field trips	87
News releases submitted	8
Mineral statistics questionnaires processed	1,140
Samples of rocks, minerals, fossils received or collected	4,175
Samples of oil received or collected	12
Samples of brine received or collected	39
Identifications (rocks, minerals, fossils)	434
Packets of geologic education material sent	262
Special rock sets for teachers	6
Rock and mineral sets sent	329
Soil and sand samples sent	15
Insoluble residues made	75
Heavy mineral separations made	12
Polished blocks of coal made	12
Coal samples analyzed	444
Samples prepared for analysis (by crushing)	1,656
Chemical analysis of samples	4,413
Spectrographic analyses (qualitative)	1,135
Spectrographic analyses (quantitative)	2,114
X-ray chemical analyses	789
X-ray mineralogic analyses	192
Measurements of specific gravity & viscosity (brine & oil)	150
Physical tests on building stone	228
Physical tests on other stone	241
Seismic refraction shots	745
Seismic reflection shots	182
Gravity stations measured	2,481
Feet of hole drilled	5,698
Feet of core recovered	4,014
Feet of hole augered	3,016
Oil wells field checked (current drilling)	492
Well cutting sets catalogued and filed	338
Well cores catalogued and filed	77
Strip logs made (wells)	294
Feet represented on strip logs	200,000

Statistical Summary of Activities for Fiscal 1966 continued--

Camera copies made	645
Field photographs	130
Black and white prints	1,011
Diazo prints	6,178
Color transparencies	4
Film prints	256
Color slides	281
Black and white slides	79
Photomicrographs	369
Memorandum reports on special projects	14
Reports completed for official publication (in editorial process)	
Bulletins	5
Regional Geologic Maps	1
Miscellaneous Maps	1
Published Reports	
Bulletins	1
Mineral Economic Series	1
Special Reports	1
Published Maps	
Miscellaneous (new)	3
Miscellaneous (revised)	1
Petroleum Exploration Maps	
New	2
Revised	71
Checked without revision	130
Regional Geologic Maps	1
Published reports sold	7,880
Published maps sold	6,842
Publications office customers	2,431
Outside Publications	
Complete reports	18
Reports completed and sent to editors for outside publication	
Abstracts	3
Complete reports	2
Maps	1

COAL SECTION

The Coal Section is responsible for information concerning location, quantity and quality of coal and information on the adjacent coal-bearing rocks.

Service Projects

Active Coal Mine Map.--The map of southwestern Indiana showing locations of active mines (Miscellaneous Map No. 7) was revised February 1, 1967, and republished. There are now 15 underground mines, 42 strip mines, and 19 separate tipples and loading docks in Indiana.

Vincennes $1^{\circ} \times 2^{\circ}$ Regional Geologic Map.--The Coal Section is responsible for the western half of the Vincennes sheet, including the data from the Illinois Geological Survey. Scribing, checking and final compilation was completed during the year.

Survey of strip mined areas.--Approximately 3,000 acres of land in Indiana were disturbed by stripping coal in 1966 and nearly 100,000 acres have been disturbed by strip mining since mining began. This area is shown on a map completed in June at the scale four miles to an inch. It will be published as a miscellaneous map.

Strippable coal resources.--Work on the evaluation of strippable coal resources in Indiana is nearly complete. Mined areas and drilling and outcrop data have been plotted for each major coal in all counties except Daviess County. Coal reserves are listed under one of three different reliability categories by thickness of coal and thickness of overburden (up to 150 feet).

Wyandotte Cave.--Before the Wyandotte Cave area was purchased by the State all of the readily accessable passages in the cave were mapped by members of the Coal Section assisted by graduate students from Indiana University. This project was essentially completed in 1967 when 5.1 miles of passage had been mapped. Several reports have been compiled and instructions have been prepared for guides at both Wyandotte and Little Wyandotte Caves.

Miscellaneous cave studies.--Some time has been spent by one member of the Coal Section on the study of caves and karst topography. This includes working with members of the U. S. Soil Conservation Service in tracing by means of fluorescein dye the route of underground drainage that will affect reservoirs in the Lost River area.

Guidebook and meeting of the North-Central Section, G.S.A.--Members of the Coal Section helped plan and conduct the first annual meeting of the North-Central Section of the Geological Society of America which was held in Bloomington. Parts of the guidebook on karst topography and geomorphology and on coal mining areas were written by members of the section.

Geologic names of Pennsylvanian age.--Members of the section completed descriptions of geologic names of Pennsylvanian age that will be included with those on other ages and published in a compendium for the State.

Research Projects

Coal quadrangle mapping.--Work was continued on the completion of two sets of quadrangles that contain coal. Work on the Catlin-Mansfield area in southern Parke County was suspended last year after all of the field work and primary compilation was done. Work on a text and supplementary tables and illustrations was resumed recently.

The Clinton area includes six $7\frac{1}{2}$ minute quadrangles in northern Vigo, southern Vermillion, and southwestern Parke Counties. Final revision of this manuscript was completed during the year.

County coal maps.--Field work and compilation of data for a preliminary coal map of Daviess County was begun during the year. The mapping is 80 per cent done and the compilation is 40 per cent complete.

Stratigraphy, petrology, and economic potential of the Busseron Sandstone. --Thickness data have been compiled from information from coal test holes, water wells and oil and gas drillings. Isopach maps have been completed for southern Vermillion, Vigo, Sullivan, Knox, Gibson, Vanderburgh, and Posey Counties, concluding the stratigraphic phase and 45 per cent of the project.

Meetings and Conferences Attended

One or more members of the Coal Section attended many of the monthly meetings of Indiana Mining and Technical Society, Indiana Geologists, and Indiana Board on Geographic Names, and attended annual meetings of Indiana Coal Mining Institute, Geological Society of America, North-Central Section of G.S.A., American Coal Petrographers, American Mining Congress, and Illinois Academy of Science.

Members of the section also participated in the Western Resources Conference at Golden, Colorado (WRRC); a tour of Indiana surface mines for the Appalachian Study Committee for surface mines, Committee for the National Park Service; and a test exercise of the Indiana Emergency Resources Management Plan for Solid Fuels.

Papers Presented and Talks Given

S. A. Friedman presented a paper entitled "Effect of lithofacies variation on coal reserves" at the first annual meeting of the North-Central Section, G.S.A. and the annual meeting of the Illinois Academy of Science. He also gave five other informal talks.

R. L. Powell presented a paper entitled "Geomorphic interpretation of unconsolidated deposits on the Mitchell Plain of Indiana" at the first annual meeting of the North-Central Section, G.S.A. and gave 13 other talks during the year. Eight of these were on caves and karst topography; the remainder were on cartography and coal geology.

C. E. Wier gave two lectures on coal to an economic geology class, a lecture on preservation of plant fossils to a palentology class and two other informal talks on coal mining.

Published by the Indiana Geological Survey

Hutchison, H. C., 1967, Map of southwestern Indiana showing locations of active coal mines: Miscellaneous Map No. 7 (1967 revision).

Published by outside organizations

Friedman, S. A., 1967, Stratigraphic analysis of key beds in cyclothems in the Staunton Formation (Middle Pennsylvanian) in the Clinton area, west-central Indiana: Jour. Sed. Petrol. v. 37, p. 175-183, 5 figs.

Powell, R. L., 1966, Caves--speleology and karst hydrology: Indiana Acad. Sci. Sesqui. Vol., p. 116-130, figs. 29-33.

Powell, R. L., 1966, Groundwater movement and cavern development in the Chester Series: Indiana Acad. Sci. v. 75, p. 210-215, 2 figs.

Powell, R. L., 1967, Wyandotte Cave purchased by State of Indiana: National Speleologic Society News v. 25, no. 3.

Powell, R. L., and Thornbury, W. D., 1967, Field Trip No. 1, Karst geomorphology of south-central Indiana: A field trip guidebook prepared for the First Annual Meeting of the North-Central Section of The Geological Society of America.

Rooney, L. F., French, R. R., and Hutchison, H. C., 1967, Field Trip No. 4, Nonmetallic mineral resources of southwestern Indiana: A field trip guidebook prepared for the First Annual Meeting of the North-Central Section of the Geological Society of America.

Wier, C. E., and Patton, J. B., 1966, Mineral resources: Indiana Acad. Sci. Sesqui. Vol, p. 131-155, figs. 34-42.

Completed for publication by the Indiana Geological Survey

Powell, R. L., Map of southwestern Indiana showing strip mine land. Completed June 9, 1967, in Misc. Map Series.

Friedman, S. A., Geology and coal deposits of the Clinton area, west-central Indiana. Completed June 30, 1967 as a Bulletin.

DRAFTING AND PHOTOGRAPHY SECTION

The section provides drafting and photographic services to the sections and offices of the Geological Survey. Drafting service consists primarily of the final preparation of maps and other illustrations for use in publications,

talks, and displays. Photographic service consists mainly of preparing lantern slides, prints, photomicrographs, color proofs of maps, and guide copy for negative scribing. Diazo printing and dry mounting of maps and photographs are among other services offered.

During the year drafting of the following publications was completed: Bulletin 36, Stratigraphy and conodont paleontology of the Brassfield (Silurian) in the Cincinnati Arch area; Bulletin 38, Arenaceous foraminiferida and zonation of the Silurian rocks of northern Indiana; Mineral Economics Series 13, Oil development and production in Indiana during 1966; Regional Geologic Map 2, Danville Sheet; Petroleum Exploration Map 96A (Shelby County); Petroleum Exploration Map 97A (Rush County); Misc. Map 12, Map showing bedrock topography of northern Indiana; Misc. Map 13, Map of Bedford-Bloomington dimension limestone belt showing mills, quarries, and outcrop of Salem Limestone; and Misc. 14, Locations of clay and shale operations in Indiana. Included among published maps revised are seventy-one petroleum exploration maps; Misc. Map 7, Map of southwestern Indiana showing locations of active coal mines; and Misc. Map 11, Locations of crushed stone operations in Indiana. Also completed were illustration for twelve outside publications, slide drawings for ten talks, a display for the Indiana State Fair, and a base for a geologic map of the Chicago Quadrangle.

Significant projects started include: illustrations for Bulletin 37, Crushed stone resources of the Devonian and Silurian carbonate rocks of Indiana; Regional Geologic Map 3, Vincennes Sheet; preparation of base detail for geologic maps of the Louisville and Cincinnati Quadrangles; a mural for a museum room, and a display for the State Fair.

A total of 6,178 diazo prints were produced.

Photographic work completed included 645 camera copies, 130 field photographs, 725 black and white prints, 4 color transparencies, 256 film prints, 79 black and white slides, 281 color slides, and 48 photomicrographs.

EDUCATIONAL SERVICES

The office of Educational Services, established by the State Geologist in 1958, coordinates the Geological Survey's efforts in geologic information for the public. This office aids in preparing materials for public schools, youth groups, and lay readers. By means of news releases sent to Indiana's newspapers and articles sent to appropriate magazines, the Office of Educational Services not only informs 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 geology clubs, Scout groups, 4-H clubs, conservation clubs, civic and service clubs, teachers in public schools, and children throughout the school systems of the State on projects concerning Indiana's geology and mineral resources. The geologist in charge of Educations Services also aids in the preparation and installation of exhibits and displays for fairs, for amateur rock shows, for professional meetings, and for display spaces in the Geology Building.

During the fiscal year 1966-67 the geologist in charge of Educational Services spent 54 days in the field and traveled 13,312 miles. In answer to requests received from the public, 48 public lectures were given and 30 special field trips were conducted during the 12-month period.

Public lectures, laboratory demonstrations, and film showings were made to the following groups: Hartford City Jr. High School summer classes; Warrick County 4-H Camp; Dectur County 4-H group (geology projects); Kosciusko County Boys Conservation Camp (McClure Lake); I. U. School of Education class in methods of teaching social studies; Vigo County Boys Conservation Camp (Shakamak State Park); I. U. Education 540, "Methods of Teaching Conservation"; 5th grade class, Meridian School, Kokomo; Princeton Kiwanis Club; Outdoor Education Section of ISTA; 7th grade class, Ellettsville Jr. High School; Hartford City High School Science Club; I. U. Education 540 class, Madison Extension; 4th grade class, Elm Heights Elementary School, Bloomington; Jackson & Jennings Rock and Mineral Club, Seymour; Vigo Rock and Gem Club, Terre Haute; Kyana Geology Society, Louisville, Kentucky; members of the Bloomington Metropolitan School System School Camp, Bradford Woods; Conservation and Outdoor Education Workshop, Bradford Woods; Indianapolis Metropolitan School System School Camp, Camp Gallahue, Brown County; 9th grade class, Ossian Jr. High School; Lawrence County 4-H group (geology projects) and their leaders; 3rd grade class, Ellettsville Elementary School; Decatur County 4-H group (geology projects) and their leaders; and the members of the 1967 High School Science Institute, Indiana University.

Special field trips, tours, and collecting hikes were conducted for the following groups: Schools 1, 20, 34, 35, 44, 51, 69, 73, and 99 of the Indianapolis Public School System; summer school science classes, Hartford City Jr. High School; Decatur County 4-H group (geology projects); Education 540, "Methods of Teaching Conservation" class; elementary students from Columbus, Indiana; Cub Scout Pack 228, Franklin, Indiana; Outdoor Education Section of ISTA; members of the Bloomington Metropolitan School System's School Camp, Bradford Woods; Conservation and Outdoor Education Workshop, Bradford Woods; members of the Indianapolis School System's School Camp, Camp Gallahue, Brown County; Lawrence County 4-H group (geology projects); Decatur County 4-H group (geology projects); and the members of the 1967 I. U. High School Science Institute.

One major exhibit was prepared by the Indiana Geological Survey during the fiscal year and was installed at the 1966 Indiana State Fair. Pre-existing displays were refurbished and installed at the Peru Rock Show; the meeting of the North-Central Section of G.S.A. at Indiana University; and the 1967 Oilmen's Outing held at Robinson, Illinois. Materials for geologic exhibits were prepared and taken to the Indiana State Museum in Indianapolis for installation.

During the past 12 months the Office of Educational Services submitted eight news releases to Indiana's newspapers about the activities and accomplishments of the Geological Survey. Reports of the major news items concerning Geological Survey activities were submitted to the editor of the State Geologists Journal, published semi-annually by the Association of American State Geologists. Three magazine articles were written and submitted to Outdoor Indiana. Four issues of the Survey Newsletter were prepared and distributed among the personnel of the Geological Survey during the past year.

A guidebook was prepared by the Office of Educational Services for the 12th annual Indiana University High School Science Institute field trip. The geologist in charge of Educational Services aided in the presentation of lectures to the group about the field of geology, training in geology, and career opportunities in geology and also served as co-leader on the geologic field trip.

During the 1966 county fair season 4-H geology exhibits were judged at the Decatur County 4-H Fair by the Educational Services geologist. Earlier in the summer assistance in the form of demonstration lectures and collecting field trips were conducted for the members of 4-H clubs in Lawrence County, Jennings County, Owen County, Decatur County, and Warrick County.

The Educational Services geologist and the Survey's staff artist visited the Field Museum, the Museum of Science and Industry, and the Chicago Academy of Science in December 1966, seeking ideas and techniques for developing geologic exhibits and obtaining advice on display cases for the Geological Survey museum.

GEOCHEMISTRY SECTION

The Geochemistry Section performs chemical and mineralogic analyses of samples collected by the geologists of the Geological Survey for their investigations. Analyses also are made of samples taken from cores drilled by or donated to the Survey. During the past year especially, the Geochemistry Section assisted paleontologic and stratigraphic work of the Survey by sampling, and describing cores and by crushing the samples. All analyses are maintained in open file for use by the public and the staff of the Survey. These data provide for evaluation of the State's materials for both economic purposes and geologic interpretations.

In addition to analyzing samples the staff of the section provides advice to the public and to the geologists of the Survey concerning various geochemical problems. The staff also maintains the equipment of the six laboratories--preparation, x-ray analysis, chemical analysis, emission spectrographic analysis, routine chemical analysis, and coal analysis. New methods of analysis are investigated to provide for more accurate and less time-consuming determinations.

Besides the major efforts of preparation and analysis of samples, the section is carrying out the following projects:

Analysis of Brines

Oil-field brine samples collected by the Petroleum Section are analyzed for the major components and several trace constituents. Collection of samples for this project, and thereby the analytical work, is nearing completion because of the scarcity of sampleable wells.

Waste Products of the Coal Industry

Additional samples of sludge or refuse from the washing of coal were collected, separated into size fractions, and analyzed. Variability of material

in the disposal areas, from the various raw coals and from the different processing plants has proven to cause concern about the adequacy of sampling. In broad terms, however, the present waste products have been found to contain considerable useful and therefore valuable material. Separation of this material to provide a marketable product may not be economical under today's conditions.

Compilation of Analyses Performed in Survey Laboratories

The collection of geographic and geologic data concerning samples and the analyses of samples is to result in one or a series of publications to make such data more readily available to the public. A compilation of such data including analyses performed in other laboratories has been started.

Study of the Chemical Gradient in a Weathering Profile

This research project required additional analyses and interpretation of results for completion. Essentially it is a study of the chemical processes of weathering of a glacial till and the composition of the resulting soil.

Artificial Weathering of an Illinois Till

This research is related to the previous one but is less advanced. An attempt is being made to produce in the laboratory the same changes in clay mineral content of a till that take place in natural weathering.

Analysis of a Pennsylvanian Core

An attempt is being made, through analysis, to differentiate those sediments that were formed in marine environments from those formed in continental environments.

Analysis of Precambrian Cores

All available samples of basement rocks are being routinely analyzed to provide data to assist in interpretation of geophysical data and in an effort to study the history of the oldest rocks available from beneath the surface of the State.

During 1966-67 additional equipment to improve the X-ray analytical laboratory was ordered. Updating of the equipment will need to be continued in future years to insure efficient operation. An increased backlog of samples for which analyses are necessary points to the increased reliance by geologists on quantitative data and industry's increased preference for analytical data in addition to geologic information about our natural resources. Fortunately space is adequate for an increased program of analyses, but loss of personnel and partial improvement of equipment do not provide the means for providing the data requested.

GEOLOGY SECTION

The greatest single effort of the section continued to be the Regional Geologic Map program, and as this work neared its end we were able both to reduce the temporary work force helping with this program and to free time of permanent personnel for attention to other matters. Thus, a number of new research projects were planned by permanent employees, most of which will be reported upon in the 1967-68 report, and we are encouraged by the thought that we are making some progress with the ideal of having basic information gathered in advance of specific needs and of keeping morale and professional acumen high through the satisfaction of conducting personally interesting research.

Service and Applied Activities

The work described here was undertaken mostly in response to specific requests and to further the progress of standing applied programs. Particularly the State-mapping part employs some original investigation, so that assignment of this program to the heading above is somewhat arbitrary.

Regional Geologic Map Series. The past year has seen the beginning of tapering off of the very large sectional effort that has been expended, only the Pleistocene mapping for the Michigan part of the Fort Wayne Quadrangle is outstanding.

1. The Danville map was published in bedrock, surficial, and combined editions: Wayne, W. J., Johnson, G. H., and Keller, Stanley, 1966, Geologic map of the Danville 1° x 2° Quadrangle, Indiana and Illinois, showing bedrock and unconsolidated deposits: Regional Geol. Map.

2. The Vincennes map was completed and transmitted for publication: Gray, H. H., Wayne, W. J., and Wier, C. E., title as above except for "Vincennes."

3. The Chicago sheet was brought to within one month of completion and submission for publication.

4. The Fort Wayne sheet remained in a more or less static condition but very nearly all the scribing and base preparation was completed for Indiana and Ohio and in part for Michigan. Only the Michigan Pleistocene mapping remains as an outstanding contribution, last scheduled for completion during August 1967, and this remains as the last problem on which we may yet have to make adjustment.

5. Muncie sheet. About half the Indiana surficial mapping for this sheet represents the year's progress, so that only the completion of that phase and final assembly, including scribing, into one map remain for overall completion.

6. Cincinnati and Louisville sheets. The second year of work on these last-to-be scheduled sheets saw about one-third of the required total effort expended, leaving a third yet to be expended. Field work is essentially completed, but both bedrock and surficial mapping are in part outstanding as are base preparation and scribing.

7. An important by-product map of the Regional Geologic Map project was published: Burger, A. M., Keller, S. J., and Wayne, W. J., Map showing bedrock topography of northern Indiana, 1966, Indiana Geol. Survey Misc. Map 12.

Other reports which resulted from studies in direct or related support of the mapping program are (a) Gray, H. H., in press, Geomorphic significance of stability of southern Indiana landscapes (abs.): Geol. Soc. America Special Paper; (b) Schneider, A. F., in press, History of a morainal gap at Valparaiso, Indiana (abs.): Ibid.; (c) Schneider, A. F., and Johnson, G. H., in press, Late Wisconsin glacial history of the area around Lake Maxinkuckee: Indiana Acad. Sci., Proc., v. 76; (d) Wayne, W. J., 1966, The reversal of Raccoon Creek at Atherton Island, west-central Indiana: Ibid., v. 75, p. 167-174, 2 figs.; (e) Wayne, W. J., and Jacobs, Alan, in press, The origin of Chestnut Ridge, Jackson County, Indiana (abs.): Geol. Soc. America Special Paper.

In addition (f), Gray turned in to the USGS-Kentucky mapping program the Indiana portion of the Rock Haven Quadrangle map (15-minute), thus completing our part of an agreement of some years' standing.

Field conferences and Indiana Sesquicentennial: 1. As final commentary on the field conferences and the Indiana celebration that were reported upon last year, these reports were published: (a) Shaver, R. H., 1966 or 1967, Excursions in Indiana geology (abs.): Geoscience Abstracts, v. 8 or 9; (b) Schneider, A. F., 1966, Physiography, in Lindsey, A. A. (ed.), Natural features of Indiana: Indiana Acad. Sci. Sesquicentennial Volume, p. 40-56, figs, 15, 16; (c) Wayne, W. J., 1966, Ice and land, a review of Tertiary and Pleistocene history of Indiana, in Lindsey, A. A. (ed.), Ibid., p. 21-39, figs. 8-13; and (d) Wayne, W. J., in press, Periglacial climatic gradient in the Till Plains Section of the Central Lowlands of the United States, in Cushing, E. J., and Wright, H. E. (eds.), Quaternary paleoecology: New Haven, Yale Univ. Press, Internat. Assoc. Quaternary Res., 7th Congr., v. 7, p. 393-414, 6 figs.

2. Primary responsibility for planning and conducting the field trips for the first annual meeting of the North-Central Section, Geological Society of America, was lodged with the section. These separate reports further document the section's effort: (a) Rexroad, C. B., and Orr, R. W., 1967, Silurian and Devonian stratigraphy of southeastern Indiana, in Schneider, A. F. (ed.), Geologic tales along Hoosier trails: Geol. Soc. America, First annual meeting field trip guidebook, North-Central Section, April 19-22, 1967, p. 39-74, 5 figs.; (b) Schneider, A. F., and Wayne, W. J., 1967, Pleistocene stratigraphy of west-central Indiana, in Schneider, A. F. (ed.), Geologic tales along Hoosier trails: Ibid., p. 75-104, 6 figs.

Studies applied to water resources and miscellaneous applied studies: The section continued to maintain a significant level of applied activity, particularly on the geology of water in relation to resources and engineering aspects. Many calls and conferences were consumated, and 11 reports were prepared and one was published:

1. The report for the East Fork (reported in earlier years) was published: Schneider, A. F., and Gray, H. H., 1966, Geology of the Upper East Fork drainage basin: Indiana Geol. Survey Special Report 3, 55 p., 12 figs., 4 tables.

2. The section continued to be represented on the Joint Water Resources Task Committee for State and federal coordination, two memorandum reports resulting: (a) Gray, H. H., and others (J. M. Heckard, chairman), September 1, 1966, Report of ground-water task committee: Indiana Div. Water, Geol. Survey, and State Board of Health and U. S. Geological Survey: 44 p.; (b) Gray, H. H., and others (J. M. Heckard, chairman), January 1967, A plan for study of the water resources availability in the upper White River basin above Martinsville, Indiana: Ibid., iv + 14 p.

3. Other water related memorandum reports filed are: (a) Reshkin, Mark, August 15, 1966, Report on a Blackford County dam-site project: 4 p., 4 figs.; (b) Wayne, W. J., July 1, 1966, Water supply problem for Indiana University Ecology Field Station: 6 p.; and (c) Wayne, W. J., August 24, 1966, Geologic conditions at site proposed for Bloomington sewage treatment lagoons: 5 p.

4. Miscellaneous applied studies resulted in these memorandum reports: (a) Gray, H. H., March 17, 1967, A brief summary of the geology of the Ninth Congressional District, Indiana: 3 p., 1 map; (b) Gray, H. H., May 23, 1967, Weimer Acres cyclotron site (Bloomington, Indiana Univ.): 1 p.; (c and d) Horowitz, A. S., December 19, 1966, and June 7, 1967, Curating the paleontological collections, No. 5, 9 p., and No. 6, 3 p.; (e) Schneider, A. F., June 9, 1967, Descriptions or explanations of some unusual, interesting, and significant geologic features in part of northwestern Indiana: 6 p.; and (f) Wayne, W. J., August 11, 1966, Geology of a mastodon site in Posey County, Indiana: 3 p.

Research Activities

Stratigraphy and areal geology: 1. Stratigraphy of upper Chester rocks: This new project (Gray) was proposed to complete the remaining unrealized objectives in the earlier described and now abandoned project on the "Geology and mined areas of Perry County." It is to result in basic study and presentation of upper Chester, surface and subsurface stratigraphy, including up-to-date nomenclature, of southwestern Indiana and was begun by assimilating subsurface data from well records.

2. Middle Paleozoic geology of the southern part of the Michigan Basin. This project, also supported by the National Science Foundation and through Indiana University, was described in the 1965-66 report. Much new data of sedimentologic, petrologic, and stratigraphic aspect was gathered for Silurian and Devonian sections. This report reached a preliminary state of completion: Doheny, E. J., 1967, Petrology and subsurface stratigraphy of the Detroit River Formation (middle Devonian) in northern Indiana (Ph.D. thesis): Bloomington, Indiana University, vii + 120 p., 8 pls., 13 figs., 11 tables; this memorandum was filed: Shaver, R. H., February 1, 1967, Re GP 5629, Middle Paleozoic geology of the northern flank of the Michigan Basin: 2 p.; and see the section on biostratigraphy for other information on this project.

3. Stratigraphy of Cincinnatian rocks in Indiana: Described in two earlier reports, this project was advanced from 40 percent to more than 50 percent completion through insoluble residue studies and collection of subsurface data.

4. Pleistocene geology of the Calumet region: This project, described in the 1965-66 report, was advanced, particularly in its field work, to about 25 percent completion.

5. Structural features of Indiana: The section's work on this earlier described project is essentially finished.

Biostratigraphy, paleontology, and paleoecology: 1. Biostratigraphic studies of Kope (Cincinnatian) bryozoans: This new project was proposed in order to attain a better understanding of the morphology and interrelationships among Kope (early late Ordovician) fossil bryozoans and to develop a better biostratigraphic zonation of the Kope Formation in southeastern Indiana and adjacent areas. Most of the field work was completed during the year and half the laboratory preparation and study, which is conducted by Indiana University personnel, Robert L. Anstey and T. G. Perry.

2. Devonian conodont biostratigraphy of northern Indiana: This project, described in the 1965-66 report and conducted through the Survey's fellowship program and through cooperation with Indiana University and the NSF project mentioned under "Stratigraphy and areal geology," was carried to a well-advanced state. This report was produced: Orr, R. W., 1967, Conodonts from middle Devonian strata of the Michigan Basin (Ph.D. thesis): Bloomington, Indiana University, v + 169 p., 6 pls., 4 figs. In addition, a memorandum report of November 2, 1966, was filed but is now replaced by the cited report.

3. Conodonts from the Jacobs Chapel Shale: This project, described in two earlier reports, was very nearly completed, and only typing of the manuscript remained.

4. Status of reports for projects completed in earlier years: These two reports were published: (a) Rexroad, C. B., 1967, Stratigraphy and conodont paleontology of the Brassfield (Silurian) of the Cincinnati Arch area: Indiana Geol. Survey Bull. 36, 64 p., 4 pls., 4 figs. and (b) Rexroad, C. B., and Lane, H. R., 1966, Clarification of Cavusgnathus alta, type species of Cavusgnathus: Jour. Paleontology, v. 40, p. 1391-1392; these two reports remained in an editorial state: (c) Mound, M. C., Arenaceous Foraminiferida and zonation of the Silurian rocks of northern Indiana: Indiana Geol. Survey Bull. and (d) Rexroad, C. B., An outline of Silurian conodont zones in the Illinois Basin and Cincinnati Arch area, in Berry, W. B. N., and Boucot, A. J., Silurian of North America: Geol. Soc. America.

Editorial, committee, and miscellaneous activities: Most permanent members of the section belong to intra- or extra-Survey committees or perform editorial and report-reviewing duties for the Survey or other organizations. Thus, (a) Gray represented the Survey on the Joint Water Resources Task Committee for State and federal coordination, two memorandum reports resulting--see section on "Studies applied to water resources;" (b) Schneider continued his role on the Interagency Committee on Reservoir Silting (State and federal membership); (c) the Geologic Names Committee handled 15 items of record and brought the long-standing compendium on Indiana stratigraphy to within three months of submission for publication; (d) Shaver continued as one of two editors of the Journal of Paleontology for the Society of Economic Paleontologists and Mineralogists.

The members of the section disseminated educational and similar information through the media of hundreds of letters, 149 conferences of record, several memorandum and published reports, and 29 lectures of record. Two examples are (a) W. J. Wayne's "Old-time ironworks" (1967, Outdoor Indiana, v. 32, no. 7, p. 4-9, illus., and (b) Wayne's adult class on "Geology of the human environment," offered through Indiana University during the spring of 1967.

GEOPHYSICS SECTION

During the past year the Geophysics Section worked on field surveys by seismic refraction, seismic reflection, gravity and electrical methods. In the laboratory measurements were made of optical characteristics, density, resistance to abrasion, crushing strength, and other properties of rocks that influence their uses and serve as guides to their location. In order to assimilate and make meaningful the large volume of data that was obtained from field and laboratory projects, the Geophysics Section operated both digital and analog computers. The Geophysics Section also operated a Failing Model 1500-S rig capable of drilling and coring to depths of 1,000 ft. and a truck-mounted mobile auger capable of augering to depths of 100 ft.

Seismic Surveys

Five major seismic refraction projects were worked on by the Geophysics Section during the year. Of the five projects four were completed and the fifth was terminated because of lack of time. All of the seismic refraction work was done to measure the thickness of unconsolidated materials at specific locations. One of the projects was done in connection with studies of groundwater resources, three were done in conjunction with the regional geologic mapping program and one project provided data for a study of coal reserves.

Seismic refraction profiles were shot over most of Vanderburgh County to attempt to locate buried valleys which might serve as major reservoirs of groundwater. Most of the seismic refraction work during the year was done at the request of the Geology Section. The regional geologic mapping program must deal with large areas in which the nature of bedrock geology is hidden by thick glacial deposits. Surveys were made in north-central Indiana, in Carroll County, and in Henry County to measure the thickness of glacial deposits, to map bedrock topography and to obtain general information about the stratigraphy of bedrock from the velocity of the seismic waves through the rock layers.

Other Geophysical Field Surveys

An intensive geophysical study was made at the geologically disturbed area near Kentland during the year. In all, 2,481 gravity stations were occupied and 182 seismic reflection shots were made to help interpret the complexly folded rocks. Not only does this area have great scientific interest because it may represent the site of a meteoritic impact, but also the area is economically important because of the limestone brought to the surface at that location.

The section also worked in the area of the gypsum mine in Martin County. An attempt was made through the use of gravity measurements to deliniate the edge of the gypsum deposit. A second phase of this project is to attempt to locate the zones within the enclosing rocks where solution has left water filled cavities that when encountered in mining cause flooding in the mine.

Laboratory Studies

During the year work was continued on the use of remote sensing techniques, principally side-looking radar and photographic techniques using other than the visible portion of the spectrum. Radar films were made of Johnson County and the Kentland area by NASA test flights. We now are analyzing these for geologic significance.

Routine testing of rock samples for resistance to abrasion, crushing strength, absorption, specific gravity, and elastic properties continued during the year.

Industrial Minerals Section

Industrial minerals accounted for 65 percent of Indiana's mineral production in 1966 and were valued at 183 million dollars, an increase of 15 percent over 1965. Most of this production is in the hands of small business, without large research or exploration capacities. The industrial minerals themselves (which include limestone and dolomite, sandstone, clay and shale, gypsum, sand and gravel, peat and marl as well as processed products such as cement, lime, and lightweight aggregate) are found in many parts of the state and are of direct interest to many citizens. They are of equally vital interest to Indiana in general, which consumes enormous quantities of raw material each year. It is the responsibility of the Industrial Minerals Section to apply geology to the discovery and development of these minerals and to provide service to citizens and industry who desire information on Indiana's mineral deposits.

Services

We received 181 service requests during 1966-67. More than half of these were from corporations, some actively searching for mineral deposits. Some of these service requests required as much as a man-week to answer.

The following Industrial Minerals Section Memorandum Reports were prepared as a result of service requests:

French, R. R., July 1966, Mineral beneficiation of optical color sorting. IMS 43, 5 pages, 4 figures.

Carr, D. D., French, R. R., and Rooney, L. F., September 1967, List of some historic sources of building stone in Indiana (excluding Salem Limestone). IMS 44, 13 pages, 1 map.

Research Projects

In addition to answering numerous inquiries concerning the state's crushed stone resources, members of the section continued research on two major rock units: the Blue River Group and Devonian and Silurian rocks. Beneficiation of gypsum ore by electronic color sorting was investigated. Research on the relationship between the physical and chemical properties of Brassfield Limestone and the geology of the formation was nearly completed. Study of the sand and gravel deposits along the Ohio River between Lawrenceburg and New Albany also continued. Members of the Section tested samples of Salem Limestone that had been treated chemically to improve its resistance to abrasion and weathering. A study of the cost of transportation of crushed stone was begun.

Directories

A clay and shale directory and a dimension stone directory were issued during the year.

National Committees

Lawrence F. Rooney was elected vice-chairman of the north-central mid-continent region Industrial Minerals Division of AIME. He was also appointed representative of the Industrial Minerals Division to the Editorial Board of Mining Engineering. He was re-elected as a member of the steering committee of the Forum on Geology of Industrial Minerals. Members of the section helped host the first regional meeting of the North-Central Section of the Geological Society of America.

Publications

Carr, D. D., French, R. R., (Sedimentation Seminar with others, 1966) Cross-bedding in the Salem Limestone of Central Indiana: Sedimentology, v. 6, p. 95-114.

Carr, D. D., Webb, W. M., 1966 (with others) Stratigraphic sections, bedding sequences, and random processes: Science, v. 154, p. 1162-1164.

Carr, D. D., and Rooney, L. F., 1967, Map of Bedford-Bloomington Dimension Limestone belt showing mills, quarries, and outcrop of Salem Limestone: Indiana Geological Survey Misc. Map 13.

French, R. R., 1967, Geology and Mining of gypsum in southwestern Indiana: Indiana Academy of Sci. Proc. 1966, v. 76.

French, R. R., 1967, Indiana's Crushed Stone Industry: 1947-65, Indiana Business Review, v. 42, p. 7-11.

Rooney, L. F., 1967, Geology of cement raw materials in Indiana: Proceedings 2nd Forum on the Geology of Industrial Minerals, Indiana University, p. 13-21.

Rooney, L. F., French, R. R., and Hutchison, H. C., 1967, Nonmetallic resources of southwestern Indiana, Field Trip No. 4, 1967 North-Central Section Geological Society of America, p. 107-133.

Webb, W. M., 1967, Locations of clay and shale operations in Indiana: Indiana Geol. Survey Misc. Map No. 14.

Webb, W. M., Briggs, L. I., 1966, The Use of Principal Component Analysis to Screen Mineralogical Data: Journal of Geology, v. 74, no. 5, part 2.

Papers Presented at National Meetings

Carr, D. D., and Webb, W. M., April, 1967. Sand and Gravel Exploration by Thermal Sensing of Soil at the third Forum on Geology of Industrial Minerals, Lawrence, Kansas.

French, R. R., and Carr, D. D., 1967, Geologic factors affecting the production of aggregates in the Indianapolis area, 18th Annual Highway Geological Symposium at Purdue University.

MINERAL STATISTICIAN

In 1966 the mineral industries showed their greatest gain in an upward trend that began in 1962. The value of minerals produced in 1966 amounted to $283,091,950.00, or 12.3 percent more than the previous year.

The fuels -- coal, petroleum, and natural gas -- account for slightly more than 34 percent of the value of minerals produced. An increase in coal production more than offset decreases in the other two commodities, so that the total value for fuels increased 7.2 percent.

Building materials -- cement, clay and shale, dimension and crushed limestone, sand and gravel, gypsum, and dimension sandstone -- comprise 65.5 percent of the value of mineral production. Although a little less crushed limestone was quarried in 1966 than in 1965, total production of materials for construction purposes increased 14.4 percent.

The figure shown in the table for products manufactured from clay and shale includes china plumbing fixtures, art products, and some pottery for which substantial amounts of clay are brought in from other states, but the increase in raw clay mined in Indiana reflects the demand for more building brick and tile which are made from local materials.

Although the amount of limestone crushed for agricultural, chemical, and other nonconstruction purposes was greater in 1966 than in the previous year, the increase did not compensate for a decline of 4.63 percent in the use of crushed stone for construction purposes, including concrete and road building.

The use of sand and gravel for construction, paving, fill, and railroad ballast continued to increase, as it has each year since 1962.

The cement industry, after suffering a decline in production in 1965, continued its general upward trend.

Although the volume of dimension limestone produced was slightly less than in 1965, the value increased 6 percent.

Two new quarries were opened during the year for production of crushed limestone, ground was being cleared and equipment installed in preparation for opening three others, and several companies were investigating potential sites for new operations. A large and and gravel operation began production during the year. Four quarries which had not been operated for several years were re-opened for production of building limestone.

An industry, new in that no similar one has existed in Indiana since 1953, began during the year when the Marblehead Lime Company started lime production using imported limestone brought in by Great Lakes freighters. The total output went to the steel mills in the Gary region.

Thirty-five counties, an increase of five in the past year, now report mineral production in excess of $1 million, exclusive of oil and gas. Of these, nine (Clark, Clay, Lake, Lawrence, Monroe, Pike, Putnam, Sullivan, and Warrick) report more than $10 million, and five (Cass, Howard, Jackson, Madison, and Marion) reported between $5-$10 million. Twenty-one counties have production valued between $1-$5 million, and fourteen counties between $500,000 and $1 million.

Figure 1 -- Mineral Production in Indiana in 1965 and 1966

	1965		1966		Percent Inc. or Dec. Amount	Value
Coal	15,386,238 tons	$58,467,701	17,072,941 tons	$65,730,823	+10.96	+12.42
Cement (portland and masonry)	15,145,060 Bbls.	49,134,308	17,879,171 Bbls.	57,771,141	+18.05	+17.58
Clay and shale (Raw materials) (manufactured products)	1,344,910 tons	37,029,129	1,500,931 tons	48,186,723	+11.60	+30.13
Limestone, crushed	24,770,753 tons	31,489,244	23,873,448 tons	30,396,591	- 3.62	- 3.47
Petroleum	11,428,802 Bbls.	32,457,798	10,616,748 Bbls.	31,850,244	- 7.11	- 1.87
Sand and Gravel	25,408,905 tons	22,301,646	26,526,056 tons	24,545,268	+ 4.40	+10.06
Limestone, dimension	5,488,759 cu. ft.	15,839,223	5,406,734 cu. ft.	16,792,091	- 1.49	+ 6.02
Peat	53,873 tons	511,000	38,111 tons	436,444	-29.26	-10.68
Marl	60,207 cu. yds.	42,375	72,580 cu. yds.	49,605	+20.55	+17.06
Natural Gas	137,778,320 cu. ft.	22,828	115,245,230 cu. ft.	18,439	-16.35	-19.23
Undistributed - includes Alumina Cement, Crushed Quartz, Crude Gypsum, Dimension Sandstone, Recovered Sulfur, Whetstones, and Lime (1966 only)		6,809,734		9,338,180		
TOTAL (adjusted to eliminate duplication of stone and sand used for cement)		251,952,579		283,091,950		+12.36

PETROLEUM SECTION

The long-established work pattern of the Petroleum Section continued throughout the year. Work accomplished falls under the general headings of services and special projects.

Service work consists of providing information to individuals and companies by correspondence and conference and continuously maintaining and expanding the voluminous well-record files of the Geological Survey. Special-projects work accomplished during the year is summarized below; it is divided into recurrent projects (projects that recur annually) and non-recurrent projects.

Recurrent Projects

Indiana exploratory drilling statistics. Statistics were compiled to cover exploratory drilling in Indiana during 1966. These data have been published in the Bulletin of the American Association of Petroleum Geologists as part of an annual statistical summary of exploratory drilling in the United States. Each exploratory well is given a pre-drilling classification, and if successful, a post-drilling classification according to the stratigraphic position of the newly discovered petroleum.

Indiana exploration developments. Each year a project is required to collect information on the results of oil and gas exploration in Indiana. A report resulting from this work is published by the American Association of Petroleum Geologists.

Indiana oil production. Statistics on oil production in Indiana by fields for the year must be collected and assembled. The results are published in a report on oil development and production in Indiana during 1966.

Indiana oil reserves. Crude oil reserves data, and associated statistics, published by the American Petroleum Institute are developed by committee effort. Two members of the Petroleum Section participate in the API reserves program. One serves on the national committee and one serves on the Illinois-Indiana-Kentucky subcommittee.

Revision of petroleum exploration maps. All of the county well location maps in the Petroleum Exploration Map series were updated during the year. Maps in the series total 89, two of which were newly published during the year.

Non-Recurrent Projects

Upgrading well records. The long-term program of upgrading the well record files of the Geological Survey continues unabated. The work of this program consists of field-checking well locations and elevations and reviewing all well records (samples, cores, electric logs, drillers logs, scout tickets, etc.). Segments of the program completed or initiated during the year involved Rush, Shelby, Hamilton, Madison, and Tipton Counties. Work on Rush and Shelby Counties was completed, and work on Hamilton, Madison, and Tipton Counties was initiated. Hamilton is 50 percent completed, Madison is 30 percent completed and Tipton is 5 percent completed.

Subsurface studies. The subsurface study of the Bethel, Paint Creek, and Cypress rock section was completed last year, and the resulting manuscript is being readied for publication. The subsurface study of the Devonian-Silurian carbonate section was advanced during the year although not as rapidly as planned; progress was retarded somewhat by other work receiving priority over it. The Devonian-Silurian study is estimated to be 85 percent completed.

Indiana brines. This long-term project, which consists of collecting and analyzing brines from Indiana oil fields, is advanced as opportunity permits. Thirty-three samples were collected and analyzed during the year, bringing the total number of samples processed to date to 220.

PUBLICATIONS SECTION

The Indiana Geological Survey publishes maps and reports to inform the public of the results of field and laboratory investigations. Geologic reports are issued currently as Bulletins, Circulars, Guidebooks, Mineral Economics Series, Reports of Progress, and Special Reports. Maps are issued currently as Atlas of Mineral Resources of Indiana Maps, Petroleum Exploration Maps, Base Maps, Preliminary Coal Maps, Miscellaneous Maps, and Regional Geologic Maps.

The Publications Section conducts the publishing program of the Indiana Geological Survey. This section, in cooperation with the Drafting and Photography Section, prepares maps and reports for printing. The Publications Section informs the public of new reports and maps as they are issued and handles all matters pertaining to the sale and distribution of publications. This section works with the Geology Library of Indiana University in carrying on an exchange program with geologic institutions in the United States and in foreign countries.

The Publications Section also handles the sale and distribution of maps published by the U. S. Geological Survey in cooperation with the Department of Natural Resources and the Indiana Geological Survey, such as topographic quadrangle maps and total intensity aeromagnetic maps; supervises the operation and maintenance of a Xerox 720 copier for the Geological Survey and the Indiana University Department of Geology; and operates and maintains a postage meter machine for the Geology Building at Indiana University.

During the past fiscal year the Publications Section sold 7,880 reports and 6,842 maps. The section sent 665 reports and maps on exchange to institutions in the United States and in foreign countries. It also distributed without charge 1,351 reports and 1,060 maps to members of its own organization and to individuals, libraries, and companies in the United States and abroad. The Publications Section sent three general publications announcements to companies, schools, and individuals; served 2,431 office customers; and handled 1,974 letters pertaining to geologic reports and maps.

Publications Released by the Geological Survey During 1966-1967

Bulletins

Rexroad, C. B., 1967, Stratigraphy and conodont paleontology of the Brassfield (Silurian) in the Cincinnati Arch area: Bull. 36, 64 p., 4 pls., 4 figs.

Mineral Economics Series

Carpenter, G. L., 1966, Oil development and production in Indiana during 1965: Mineral Economics Series 12, 17 p., 2 figs., 3 tables.

Special Reports

Schneider, A. F., and Gray, H. H., 1966, Geology of the Upper East Fork Drainage Basin, Indiana: Special Report 3, 55 p., 12 figs., 4 tables.

Miscellaneous Maps

Hutchison, H. C., 1962, rev. 1967, Map of southwestern Indiana showing locations of active coal mines: Misc. Map 7.

Burger, A. M., Keller, S. J., and Wayne, W. J., 1966, Map showing bedrock topography of northern Indiana: Misc. Map 12.

Carr, D. D., and Rooney, L. F., 1967, Map of Bedford-Bloomington dimension limestone belt showing mills, quarries, and outcrop of Salem Limestone: Misc. Map 13.

Webb, W. M., 1967, Locations of clay and shale operations in Indiana: Misc. Map 14.

Petroleum Exploration Maps

Sullivan, D. M., December 31, 1966, Well location map of Shelby County, Indiana, showing total depth of wells: Petroleum Exploration Map 96A.

Keller, S. J., December 31, 1966, Well location map of Rush County, Indiana, showing total depth of wells: Petroleum Exploration Map 97A.

Well location maps showing total depth of wells for the following counties were revised as of December 31, 1966: Warrick County (3A), Sullivan County (4A), Vigo County (5A), Martin County (12A), Greene County (13A), Clay County (14A), Parke County (15A), Vermillion County (16A), Owen County (18A), Dubois County (21A), Jackson County (22A), Knox County (23A), Monroe County (24A), Lawrence County (25A), Daviess County (26A), Orange County (27A), Harrison County (30A), Morgan County (35A), Spencer County (39A), Perry County (40A), White County (42A), Jennings County (46A), Scott County (48A), Clark County (49A), Pike County (51A), Vanderburgh County (52A), Lagrange County (56A), Noble County (57A), Allen County (59A), Whitley County (60A), Kosciusko County (61A), Elkhart County (62A), Marshall County (64A), Fulton County (65A), Cass County (66A), Pulaski County (67A), Starke County (68A), LaPorte County (69A), Porter County (70A), Jasper County (71A), Newton County (72A), Lake County (73A), Miami County (74A),

Wabash County (75A), Switzerland County (84A), Fayette County (90A), Randolph County (92A), Henry County (93A), Hancock County (94A), and Decatur County (95A).

Well location maps for the following counties were revised as of December 31, 1966: Warrick County (3B), Sullivan County (4B), Vigo County (5B), Martin County (12), Green County (13B), Clay County (14B), Dubois County (21B), Knox County (23), Daviess County (26), Harrison County (30), Spency County (39), Perry County (40), Pike County (51), Vanderburgh County (52), Gibson County (53), Posey County (54), Huntington County (76), Adams County (78), Jay County (79), Delaware County (81), and Grant County (82).

Well location maps showing total depth of wells for the following counties were checked without revision as of December 31, 1966: Fountain County (17A), Putnam County (19A), Montgomery County (20A), Crawford County (28A), Washington County (29A), Brown County (31A), Bartholomew County (32A), Hendricks County (33A), Marion County (34A), Johnson County (36A), Tippecanoe County (37A), Warren County (38A), Benton County (41A), Carroll County (43A), Clinton County (44A), Boone County (45A), Jefferson County (47A), Floyd County (50A), Steuben County (55A), DeKalb County (58A), St. Joseph County (63A), Howard County (83A), Ohio County (85A), Dearborn County (86A), Ripley County (87A), Franklin County (88A), Union County (89A), and Wayne County (91A).

Well location maps for the following counties were checked without revision as of December 31, 1966: Wells County (77) and Blackford County (80).

Regional Geologic Maps

Wayne, W. J., Johnson, G. H., and Keller, S. J., 1966, Geologic map of the 1° x 2° Danville Quadrangle, Indiana and Illinois showing bedrock and unconsolidated deposits: Regional Geologic Map 2. Part A (bedrock only) and Part B (unconsolidated deposits only) were also published.