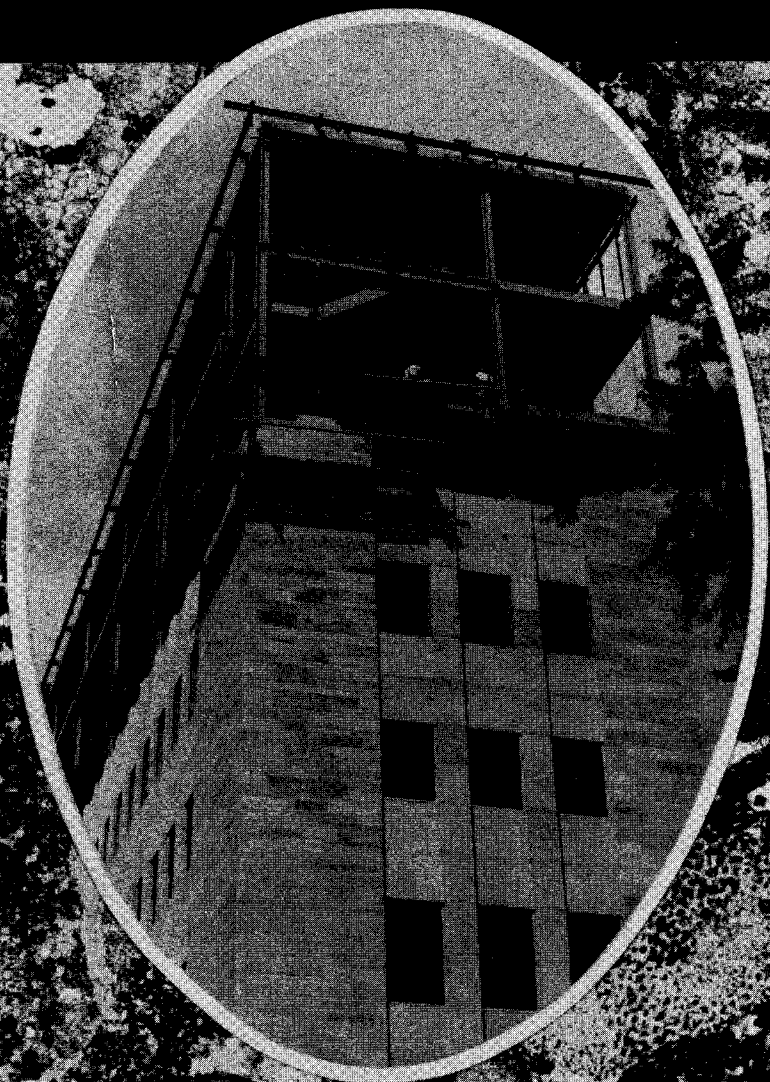


84TH ANNUAL REPORT OF THE STATE GEOLOGIST  
FOR 1959-60



INDIANA DEPARTMENT OF CONSERVATION  
GEOLOGICAL SURVEY

### COVER

A slice of Salem Limestone, so thin that it is virtually transparent, is shown magnified 150 times. Under the microscope this famous building limestone is seen to be largely composed of minute fossils, the remains of animals that lived in a shallow sea that covered most of Indiana more than 240 million years ago.

The inset photograph shows the use of this beautiful stone in construction.

County maps are published at scale  
approximately 1 inch to 1 mile

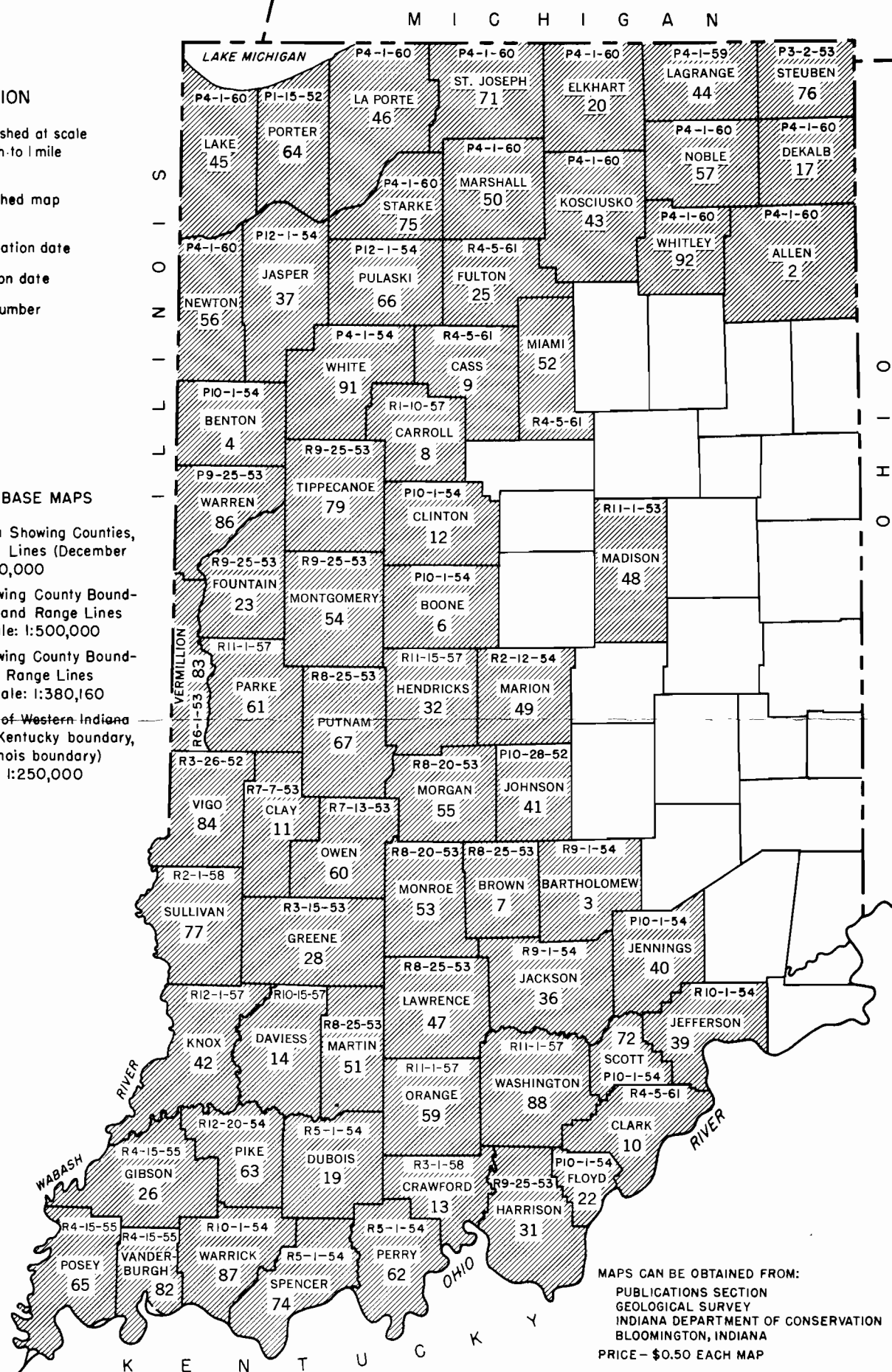
Published map

P00-0-00 Publication date

R 00-0-00 Revision date

00 Map number

- No. 100. Index Map of Indiana Showing Counties, Township and Range Lines (December 1945). Scale: 1:1,000,000
- No. 101. Map of Indiana Showing County Boundaries and Township and Range Lines (January 1952). Scale: 1:500,000
- No. 102. Map of Indiana Showing County Boundaries, Township and Range Lines (November 1951). Scale: 1:380,160
- No. 104. ~~Base Map of Portion of Western Indiana~~ (T. 25 N. to Indiana-Kentucky boundary, R. 1 W. to Indiana-Illinois boundary) (March 1951). Scale: 1:250,000



MAPS CAN BE OBTAINED FROM:  
PUBLICATIONS SECTION  
GEOLOGICAL SURVEY  
INDIANA DEPARTMENT OF CONSERVATION  
BLOOMINGTON, INDIANA  
PRICE - \$0.50 EACH MAP

*Hendrix*

M I C H I G A N

# EXPLANATION

County maps are published at scale approximately 1 inch to 1 mile



Published well location maps

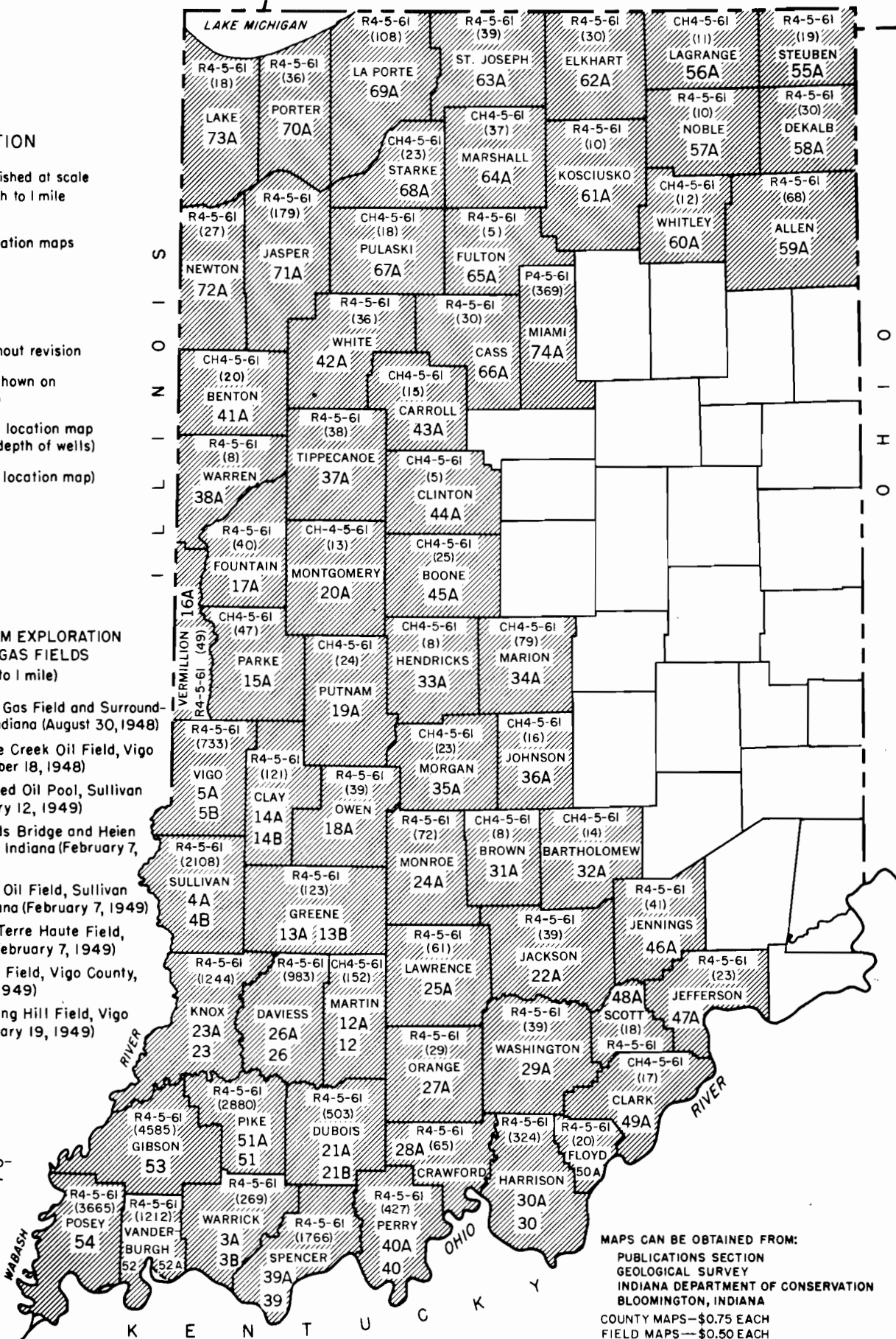
- P00-0-00 Publication date
- R00-0-00 Revision date
- CH00-0-00 Date checked without revision
- (00) Number of wells shown on published map
- 00A Map number (well location map showing total depth of wells)
- 00 or 00B Map number (well location map)

## PUBLISHED PETROLEUM EXPLORATION MAPS OF OIL AND GAS FIELDS (Scale 4 inches to 1 mile)

- No. 1. Structure Map of Alford Gas Field and Surrounding Area, Pike County, Indiana (August 30, 1948)
- No. 2. Structure Map of Prairie Creek Oil Field, Vigo County, Indiana (December 18, 1948)
- No. 6. Structure Map of Wilfred Oil Pool, Sullivan County, Indiana (January 12, 1949)
- No. 7. Structure Map of Dodds Bridge and Heien Fields, Sullivan County, Indiana (February 7, 1949)
- No. 8. Structure Map of Siosi Oil Field, Sullivan and Vigo Counties, Indiana (February 7, 1949)
- No. 9. Structure Map of Old Terre Haute Field, Vigo County, Indiana (February 7, 1949)
- No. 10. Structure Map of Riley Field, Vigo County, Indiana (February 19, 1949)
- No. 11. Structure Map of Spring Hill Field, Vigo County, Indiana (February 19, 1949)

The following Petroleum Exploration maps have been discontinued:

- Nos. 3, 4, 5, 13, 14, 15, 15B, 16, 16B, 17, 17B, 18, 18B, 19, 19B, 20, 20B, 21, 22, 22B, 24, 25, 27, 28, 29, 31, 32, 33, 34, 35, 36, 37, and 38



MAPS CAN BE OBTAINED FROM:  
PUBLICATIONS SECTION  
GEOLOGICAL SURVEY  
INDIANA DEPARTMENT OF CONSERVATION  
BLOOMINGTON, INDIANA  
COUNTY MAPS—\$0.75 EACH  
FIELD MAPS—\$0.50 EACH

## INDEX MAP OF INDIANA SHOWING PUBLISHED COUNTY PETROLEUM EXPLORATION MAPS

April 5, 1961

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**GEOLOGICAL SURVEY  
EIGHTY-FOURTH ANNUAL REPORT OF THE STATE GEOLOGIST**

**PERSONNEL**

Permanent Personnel

Administration

John B. Patton . . . . . Acting State Geologist  
State Geologist (from December 12, 1959)  
Maurice E. Biggs . . . . . Assistant State Geologist (from March 1, 1960)  
Mary Beth Fox . . . . . Mineral Statistician and Secretary  
Martha N. Smith . . . . . Secretary to State Geologist  
Theodore H. Appleton . . . . . Accountant  
Ellen L. Freeman . . . . . Librarian  
Marguerite E. Trisler . . . . . Clerk-Typist

Coal Section

Charles E. Wier . . . . . Geologist and Head  
S. A. Friedman . . . . . Geologist  
Henry H. Gray . . . . . Geologist  
G. K. Guennel . . . . . Paleobotanist  
Harold C. Hutchison . . . . . Geologist  
Larry D. Lawrence . . . . . Geological Assistant  
Richard C. Neavel . . . . . Coal Petrographer  
Janet Sue Helton . . . . . Secretary

Drafting and Photography Section

William H. Moran . . . . . Chief Draftsman and Head  
Robert E. Judah . . . . . Geological Artist-Draftsman  
Micky P. Love . . . . . Geological Draftsman  
John E. Peace . . . . . Senior Geological Draftsman  
George R. Ringer . . . . . Photographer

Educational Services

Reevan Dee Rarick . . . . . Geologist

Geochemistry Section

R. K. Leininger . . . . . Chief Spectrographer and Head  
Maynard E. Collier . . . . . Chemist  
Elmer M. Craig . . . . . Geochemical Assistant  
Louis V. Miller . . . . . Coal Chemist  
Erma J. Wolfe . . . . . Secretary, Geochemistry and Geophysics Sections

Geophysics Section

Maurice E. Biggs . . . . . Geophysicist and Head  
Judson Mead . . . . . Research Advisor

Arthur Wayne Aynes . . . . . Geophysical Assistant  
 Robert F. Blakely . . . . . Geophysicist  
 Jerry D. Fox . . . . . Assistant Driller  
 Charles S. Miller . . . . . Instrument Maker  
 Albert J. Rudman . . . . . Geophysicist  
 Joseph F. Whaley . . . . . Geophysicist  
 John D. Winslow . . . . . Engineering Geologist (to July 14, 1959)  
 Glen L. Workman . . . . . Driller  
 Erma J. Wolfe . . . . . Secretary, Geophysics and Geochemistry Sections

#### Glacial Geology Section

William J. Wayne . . . . . Geologist and Head  
 Wyman Harrison . . . . . Geologist (to August 31, 1959)  
 Allan F. Schneider . . . . . Geologist (from October 1, 1959)

#### Industrial Minerals Section

Duncan J. McGregor . . . . . Geologist and Head  
 Gary R. Gates . . . . . Geologist  
 Seymour S. Greenberg . . . . . Petrographer  
 Jack L. Harrison . . . . . Clay Mineralogist  
 Ned M. Smith . . . . . Geologist  
 Jack A. Sunderman . . . . . Geologist  
 Blanche B. Richards . . . . . Secretary

#### Paleontology Section

Robert H. Shaver . . . . . Paleontologist and Head

#### Petroleum Section

Thomas A. Dawson . . . . . Geologist and Head  
 George A. Abbott . . . . . Draftsman  
 Gerald L. Carpenter . . . . . Geologist  
 James T. Cazee . . . . . Geological Assistant  
 Phillip Cazee . . . . . Geological Assistant  
 Andrew J. Hreha . . . . . Geologist  
 Stanley J. Keller . . . . . Geologist  
 Arthur P. Pinsak . . . . . Geologist  
 Howard Smith . . . . . Geologist  
 Dan M. Sullivan . . . . . Geologist  
 Frank H. Walker . . . . . Geologist  
 M. Ruth Butcher . . . . . Curator of Records and Secretary  
 Vivian McGuire . . . . . Clerk-Typist

#### Publications Section

Gerald S. Woodard . . . . . Editor and Head  
 E. Pauline Brickert . . . . . Secretary

## Seasonal Personnel

### Coal Section

Thomas S. Hirschmann . . . . . Research Assistant (February 16 to May 15, 1960)  
Allan O. Perry . . . . . Research Assistant (September 7, 1959 to January 31, 1960)

### Drafting and Photography Section

Alan H. Zeller . . . . . Laboratory Assistant (May 1 to May 16, 1960)

### Geochemistry Section

Thomas F. Arnold . . . . . Chemist's Assistant (July 1 to September 7, 1959)  
Mina L. Browning . . . . . Laboratory Assistant (September 21, 1959 to January 29, 1960)  
William S. Hutira . . . . . Laboratory Assistant (June 13 to June 30, 1960)  
Robert V. Kixmiller . . . . . Chemist's Assistant (June 13 to June 30, 1960)  
Norma L. Lentz . . . . . Laboratory Assistant (February 15 to June 30, 1960)

### Geophysics Section

Edward E. Berg . . . . . Field Assistant (August 10 to September 8, 1959)  
James C. Crisman . . . . . Shop Assistant (August 24 to September 15, 1959)  
Robert F. Groomer . . . . . Field Assistant (July 1 to August 31, 1959, and June 13 to June 30, 1960)  
John S. Parker . . . . . Field Assistant (August 10 to September 8, 1959)

### Glacial Geology Section

Thomas C. Hutchison . . . . . Laboratory Assistant (September 29, 1959 to June 30, 1960)  
Gerald H. Johnson . . . . . Research Assistant (September 29, 1959 to June 15, 1960)  
Guillermina L. Ladoray . . . . . Typist (July 1 to September 1, 1959)  
Lavonne Joyce Ohl . . . . . Typist (September 21 to October 15, 1959)  
Carolyn Gay Patton . . . . . Typist (October 19, 1959 to January 31, 1960)  
Delonna J. Reed . . . . . Typist (February 1 to June 15, 1960)

### Paleontology Section

William G. Dixon, Jr. . . . . Laboratory Assistant (September 16, 1959 to June 30, 1960)

### Publications Section

Gale M. Helft . . . . . Editorial Assistant (September 21, 1959 to January 22, 1960)  
Sandra K. Jackson . . . . . Manuscript Typist (February 24 to May 27, 1960)  
David M. Kitley . . . . . Editorial Assistant (July 1 to August 14, 1959)  
Paul D. O'Boyle . . . . . Editorial Assistant (February 1 to May 13, 1960)  
Ann Richardson . . . . . Editorial Assistant (June 13 to June 30, 1960)



# FINANCIAL STATEMENT

## FUNCTION OR ACTIVITY

EXPENDITURES 1959-60

### 1. PERSONAL SERVICES

101. Full-time Salaries . . . . .	\$ 312,904.59
101. Part-time - Summer . . . . .	1,175.00
101. Hourly . . . . .	4,891.04
199. Fellowships and Research Assistants . . . . .	9,991.60
TOTAL PERSONAL SERVICES . . . . .	328,962.23

### 2. SERVICES OTHER THAN PERSONAL

201. Postage . . . . .	511.00
202. Telephone and Telegraph . . . . .	2,669.41
204. Freight Express and Drayage . . . . .	394.08
205. Travel (Mileage and Per Diem) . . . . .	11,539.22
206. Dues and Subscriptions . . . . .	133.45
211. Gasoline Credit Cards . . . . .	6,592.49
TOTAL SERVICES OTHER THAN PERSONAL . . . . .	21,839.65

### 3. SERVICES BY CONTRACT

302. Printing and Binding . . . . .	14,959.57
321. Fire Insurance . . . . .	1,867.16
329. Other Insurance, TIAA and Compensation . . . . .	2,560.44
331. Repairs to Buildings . . . . .	0
332. Repairs to Motor Vehicles . . . . .	2,267.06
339. Repairs to Laboratory and Office Equipment . . . . .	1,358.54
399. Contractual Services N.O.C. . . . .	7,707.58
TOTAL SERVICES BY CONTRACT . . . . .	30,720.35

### 4. MATERIALS, SUPPLIES, AND PARTS

401. Office Supplies . . . . .	1,514.47
404. Laboratory and Shop Supplies . . . . .	13,603.18
433. Small Tools and Implements . . . . .	33.55
TOTAL MATERIALS, SUPPLIES, AND PARTS . . . . .	15,151.20

### 5. EQUIPMENT

501. Office Equipment . . . . .	180.00
511. Motor Vehicle Equipment . . . . .	4,190.00
521. Laboratory and Shop Equipment . . . . .	7,341.19
522. Educational Equipment . . . . .	173.41
TOTAL EQUIPMENT . . . . .	11,884.60

TOTAL EXPENDITURES . . . . . \$ 408,558.03

## INTRODUCTION

A geological organization in Indiana has performed an active, useful, and continuous role in the development of the State's mineral resources for nearly 100 years.

The first formal State geologic agency was the Geological Survey of Indiana, created in 1869. In 1879 the name of the agency was changed to the Department of Statistics and Geology of the State of Indiana, and 2 years later, in 1881, it was changed again to the Indiana Department of Geology and Natural History. Following the formation of the Indiana Department of Conservation geologic work in the State was placed under the supervision of the Division of Geology in 1919. In 1951 the name of the division was changed to the Geological Survey.

The creation in 1869 of the Geological Survey of Indiana was a result of the realization by the legislature that Indiana is endowed with a wealth of mineral resources and that it is the responsibility of the State government to see that these resources are used wisely and to the optimum advantage of the State. That this was a wise decision is now well documented by the fact that during the past 4 years our mineral industries produced nearly 1 billion dollars in income and that during 1959 minerals valued at more than 239 million dollars were produced in the State. These totals are impressive, but they represent only a fraction of the indirect income which resulted from utilization of these raw materials in manufactured products. Although our mineral resources include only the more prosaic nonmetallic minerals, and most people do not consider Indiana as a mining State, our production of these resources exceeds in value the mineral production of many States that are regarded as mining regions. The value of one commodity in Indiana, namely, cement, exceeds the value of the entire nation's silver production, however, and the value of our clay and shale products annually exceeds the value of gold produced in the leading gold-producing State. Moreover, a high proportion of our mineral product is used domestically or in nearby regions and is thus related far more closely to the well-being of the State's citizens than is the mineral product of any State that exports most of its produced raw materials.

To produce, process, and utilize many of our commercial minerals require comprehensive geologic information concerning their occurrence, origin, and physical, chemical, and mineralogical composition. The minerals that are being produced today in Indiana were found and proved by geologic research conducted in past years; the minerals which must be produced to meet the future needs of a growing and prosperous State must be found, mapped, and described by geologic research today, tomorrow, and throughout the coming years. As the more readily accessible mineral deposits are exhausted, this work will become more difficult but even more essential.

The role of a State Geological organization is a changing one. An examination of this report will reveal the wide diversity of services and functions that have constituted the activities of the Indiana Geological Survey during the fiscal year that ended June 30, 1960. In addition to such well-recognized geologic endeavors as investigations of the State's mineral resources, responses to inquiries from the general public, and distribution of information in the form of publications and maps, the Geological Survey was requested to supply specialized information in such diverse fields as industrial development, city and county planning, and defense research. To furnish basic geologic information is no longer sufficient. The Geological Survey, if its efforts are to be of maximum use to the public, industry, other agencies, and long-range planning groups, must be



David Dale Owen, M.D., of New Harmony, appointed Geologist of the State of Indiana by a legislative act approved February 6, 1837, was the first man to study Indiana's geology in a systematic way. The act commissioned Owen to make "... a complete and minute geological survey of the whole State ..." and "... to analyze and ascertain the qualities and properties of Mineral substances ..." Owen completed the first reconnaissance of the State during the years 1837-38.

In 1859 Dr. Owen was recommissioned by the General Assembly to undertake a second geological survey. Before the project was completed, Owen died suddenly in 1860, and the survey was finished by his younger brother, Richard, who had been Principal Assistant with the survey. A report on the 1859-60 survey was published by the State in 1862.

able to integrate diverse types of scientific information and relate its findings to the complex economic and social structure resulting from rapid growth and changes within the Hoosier State.

Until now the Geological Survey has been able to meet the challenge of providing the geologic information necessary to assist mineral producers in providing the raw materials demanded in an expanding economy. Two factors may diminish the effectiveness of our program. The first involves operating expenses. During the past 4 years the Geological Survey has been operating on a fixed budget despite increased costs of personnel and supplies. As a result, some functions have had to be curtailed. Most important of these curtailments has been a reduction in the amount of fieldwork we have been able to undertake. A partial program of fieldwork over a period of 2 years may not have affected the Survey's overall program seriously, as a backlog of field data was ready for the finishing stages required for publication. Unless adequate funds are available for a renewed program of fieldwork, however, future exploitation of the State's mineral wealth may lag behind demand, and thus mineral consumers might have to turn to out-of-State suppliers.

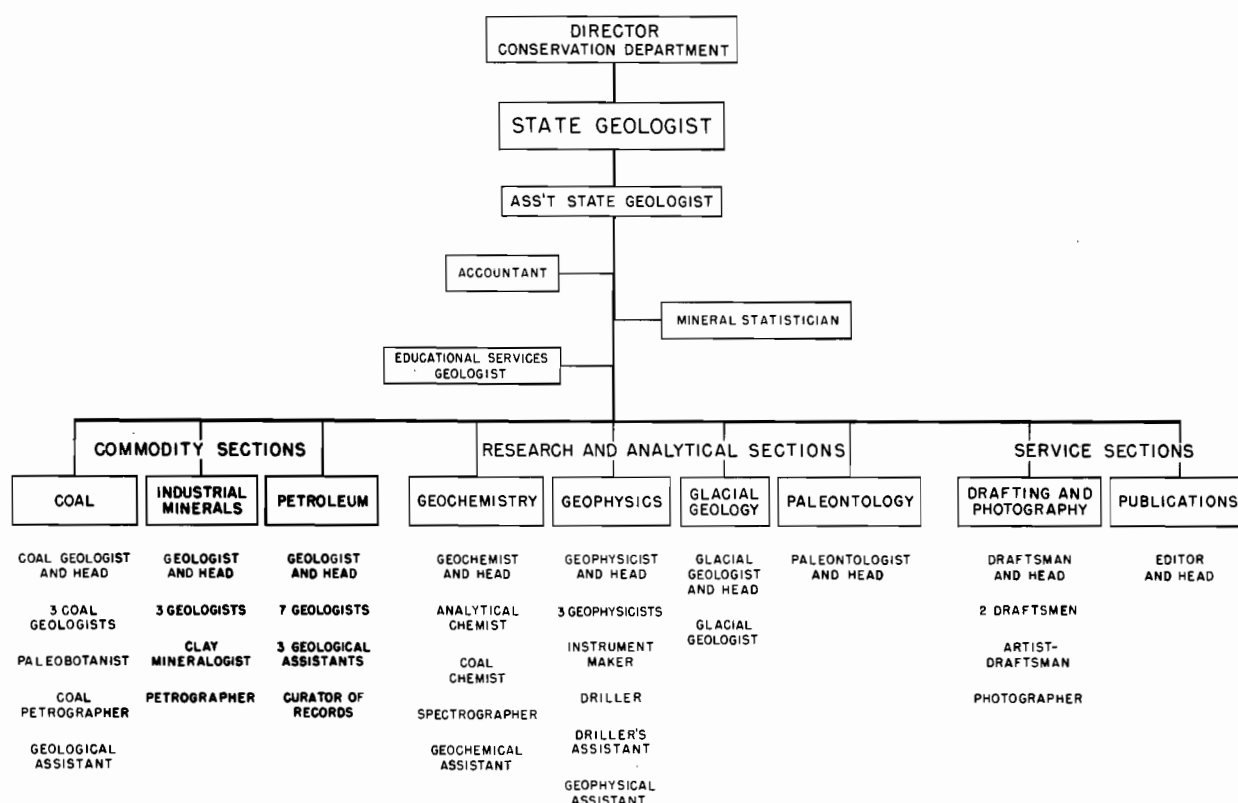
Scattered and inadequate housing constitutes a second serious deterrent to operational efficiency of the Geological Survey. Not only is space so restricted that most of the Survey's sections cannot add additional furniture or equipment, but also valuable records must now be stored in garages. The sections of the Survey are housed in six buildings, including quonset huts and parts of classroom buildings, separated by as much as half a mile on the Indiana University campus. Adequate and unified housing would add greatly to the efficiency of the Geological Survey and would enable it to undertake research programs which have been long delayed owing to lack of space.

### ORGANIZATION AND ADMINISTRATION

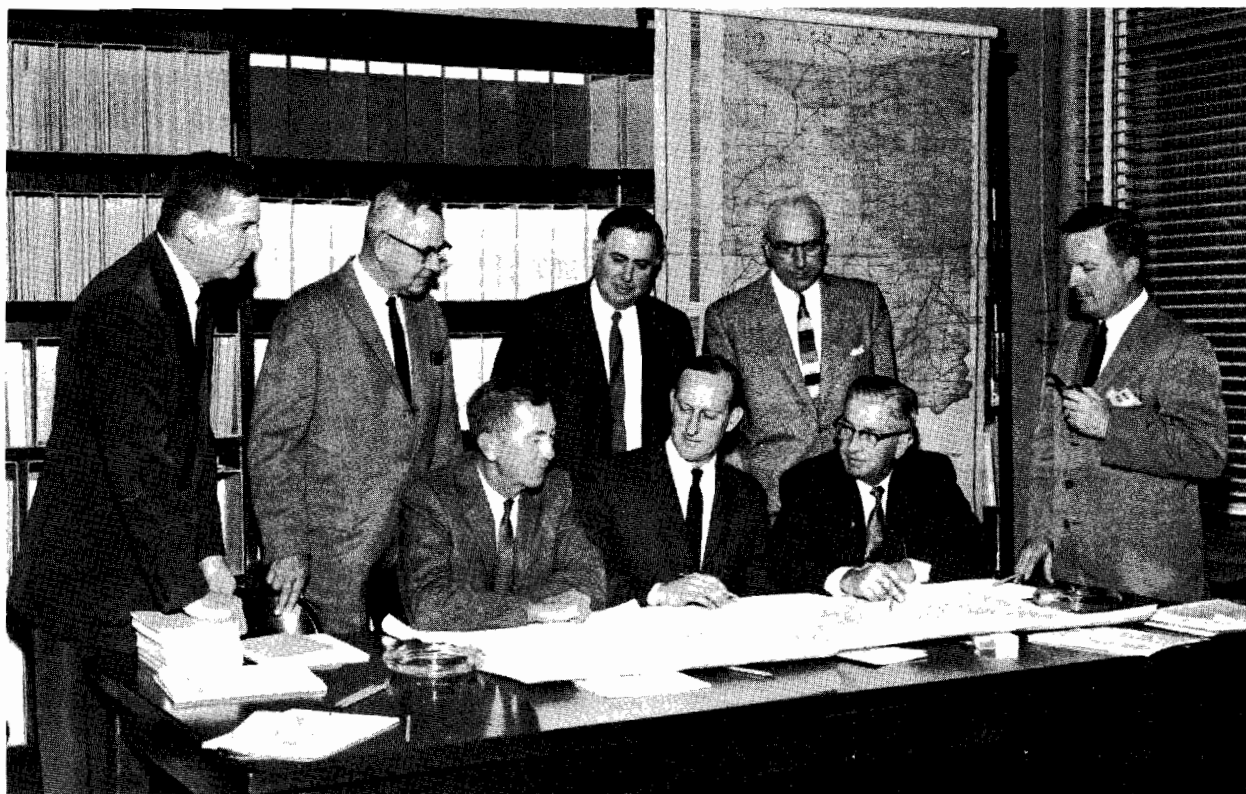
The Geological Survey is headed by the State Geologist, who is responsible to the Director of the Indiana Department of Conservation. The organizational framework consists of three commodity sections (Coal, Industrial Minerals, and Petroleum), four research and analytical sections (Geochemistry, Geophysics, Glacial Geology, and Paleontology), and two service sections (Drafting and Publications). The sections differ widely in size, ranging from the Petroleum Section with 13 full-time employees and some seasonal personnel to the Paleontology Section, which consists of the paleontologist and a few summer field employees and part-time laboratory assistants. 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 Conservation, 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 Conservation, 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 Conservation.

## Organization of the Geological Survey.



An Advisory Committee to the State Geologist, composed of representatives from industries closely related to the State's mineral economy, counsels the State Geologist regarding Survey policy and program. During the fiscal year 1959-60, the Advisory Committee met October 9, 1959, and May 19, 1960. Mr. E. J. Reading, Sun Oil Co., served as chairman of the committee until October 9 when he was succeeded by Mr. W. A. Unsworth, The France Stone Co. The other members were Eugene C. Clemens, Cannelton Sewer Pipe Co.; Robert Ingalls, Sr., Ingalls Stone Co., Inc.; Norman E. Kelb, Aryshire Collieries Corp.; Hugh B. Lee, Jr., Peabody Coal Co.; J. D. Turner, Oil Producer; H. H. Vaughn, The Pennsylvania Railroad Co.; and D. E. Willingham, Louisville Cement Co., Inc. During the year Mr. Richard H. Swallow served as alternate for Mr. Kelb.



The State Geologist is counselled by an advisory committee composed of representatives of the industries that produce Indiana's minerals. The committee advises on such matters as research needed to facilitate development of our mineral resources and the total program and responsibilities of the Geological Survey to the people and the State of Indiana.

Present at this October 1960 meeting were (seated) W. A. Unsworth, France Stone Co., Chairman; H. B. Lee, Jr., Peabody Coal Co.; F. W. Irving, Irving Bros. Gravel Co.; (standing) M. E. Biggs, Assistant State Geologist; E. C. Clemens, Cannelton Sewer Pipe Co.; D. E. Willingham, Louisville Cement Co.; Robert Ingalls, Sr., Ingalls Stone Co.; and J. B. Patton, State Geologist. (Not present when the picture was taken were H. H. Vaughn, Pennsylvania Railroad; J. D. Turner, Oil Producer; N. E. Kelb, Ayrshire Collieries Corp.; and E. L. Reading, Sun Oil Co.)



# STATISTICAL SUMMARY OF ACTIVITIES FOR FISCAL 1959-60

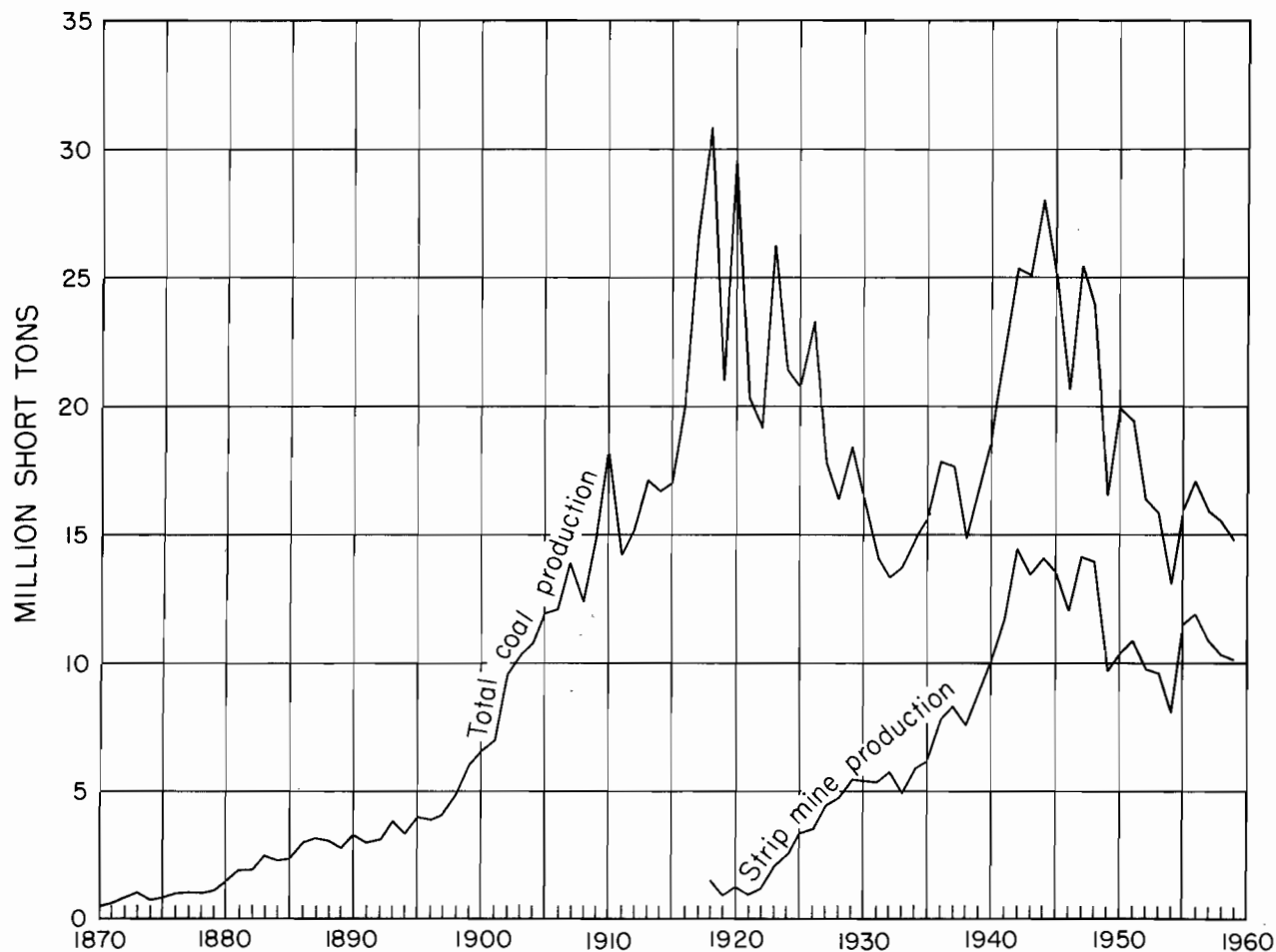
Many of the activities of the Geological Survey can be most readily summarized by the statistical listing that follows.

Projects in progress . . . . .	52
Projects completed . . . . .	49
Conferences . . . . .	1,145
Public lectures . . . . .	52
Special field trips . . . . .	43
News releases submitted . . . . .	33
Outgoing letters . . . . .	3,298
Incoming letters . . . . .	6,073
Statistics questionnaires processes . . . . .	420
Number of field projects . . . . .	20
Man-days of fieldwork . . . . .	1,478
Area mapped (square miles) . . . . .	430
Number of stratigraphic sections measured . . . . .	133
Thickness of sections measured (feet) . . . . .	5,690
Collections (rocks, minerals, fossils) . . . . .	592
Identifications (rocks, minerals, fossils) . . . . .	572
Total number of Survey vehicles . . . . .	24
Total miles traveled in Survey vehicles . . . . .	135,287
Coal spore slides made . . . . .	525
Coal thin sections made . . . . .	150
Coal polished blocks made . . . . .	280
Coke buttons polished . . . . .	69
Coal spores identified . . . . .	2,400
Coal samples analyzed . . . . .	93
Coal determinations . . . . .	718
Rock and mineral sets sent . . . . .	140
Samples analyzed chemically . . . . .	555
Chemical analyses (determinations) . . . . .	1,943
Samples analyzed spectrographically . . . . .	81
Spectrographic determinations (qualitative) . . . . .	766
Spectrographic determinations (quantitative) . . . . .	229
Geophysical measurements . . . . .	1,542
Samples tested - physical constants . . . . .	247
Samples tested - radioactivity . . . . .	46
Feet of holes drilled . . . . .	11,391
Feet of core obtained . . . . .	1,842
X-ray analyses determinations	
Powder camera . . . . .	67
Defractometer . . . . .	1,504
Differential thermal analysis determinations . . . . .	5
Special treatment - clay samples . . . . .	501
Sedimentation test - clay samples . . . . .	39

Temperature gradient furnace bricks made . . . . .	5
Thin sections examined . . . . .	5
Heavy mineral separations . . . . .	405
Well cutting sets catalogued and filed . . . . .	312
Cores (wells) catalogued and filed . . . . .	11
Strip logs made (wells) . . . . .	121
Feet represented on strip logs . . . . .	160,627
Oil wells field-checked . . . . .	876
Camera copies made . . . . .	378
Photomicrographs made . . . . .	159
Prints made	
Black and white . . . . .	713
Color . . . . .	6
Film positive transparencies made . . . . .	75
Projection slides made	
Black and white . . . . .	146
Color . . . . .	111
Memorandum reports . . . . .	15
Reports completed for official publication (now in editorial progress)	
Bulletins . . . . .	4
Maps . . . . .	1
Published reports	
Circulars . . . . .	1
Directories . . . . .	2
Mineral Economics Series . . . . .	1
Reports of Progress . . . . .	5
Published maps	
Coal Investigation Maps . . . . .	2
County Base Maps . . . . .	13
Petroleum Exploration Maps	
New . . . . .	17
Revised . . . . .	47
Checked without revision . . . . .	15
Preliminary Coal Maps . . . . .	1
Published reports sold . . . . .	6,060
Published maps sold . . . . .	3,408
Announcements of publications sent . . . . .	10,600
Reports completed and sent for outside publication	
Abstracts . . . . .	7
Complete reports . . . . .	27
Outside publications . . . . .	21

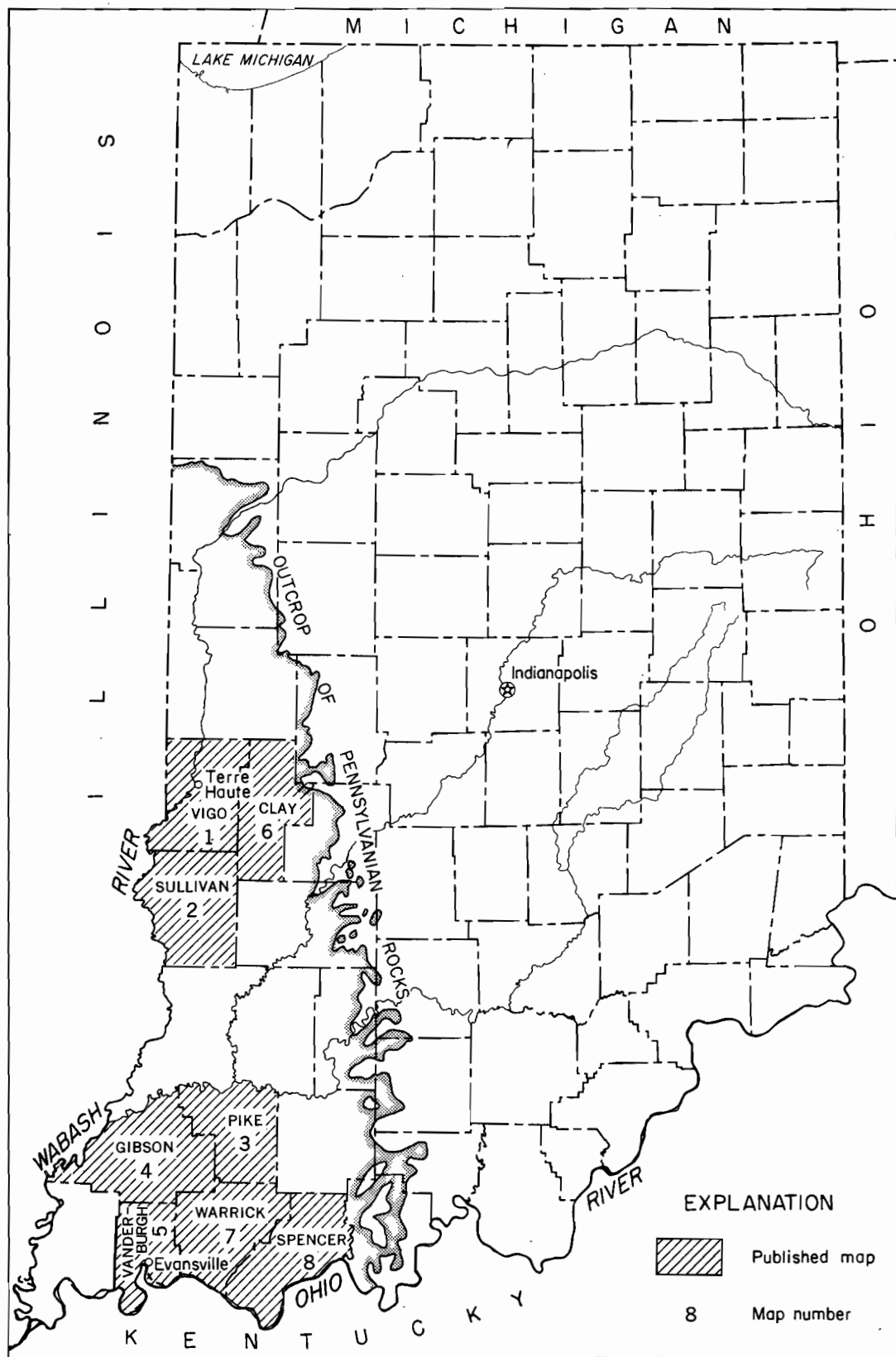
## COAL SECTION

One hundred years ago Richard Owen was just completing the second geological field program for the State of Indiana and, for the first time, published a county by county summary of coal resources in the State. Coal, even then, was our most important mineral commodity. Approximately 75,000 tons of coal was produced in Indiana during 1860. Since that time coal production rose to a high of more than 30 million tons during World War I; decreased to less than 13½ million tons during the depression of 1932; increased again to nearly 28 million tons during World War II; decreased to 13 million in 1954; and is now leveling off at 14,770,242 tons for 1959.



Graph Showing Annual Production of Coal in Indiana, 1870-1959. Compiled from Annual Reports of the U. S. Bureau of Mines, Minerals Yearbooks.

During the production, preparation, and consumption of this coal, many data have accumulated concerning the geographic and geologic occurrence of coal and the physical and chemical characteristics of this valuable commodity. The Coal Section of the Geological Survey uses whatever is available of this backlog of accumulated information, together with current research, to help locate coals with desirable physical and chemical characteristics and to aid in developing methods to mine, prepare, and utilize these coals more efficiently.



### **Resources Studies**

The main purpose of the Survey's resources studies is to show areas where each commercial coal is present and where it has been mined and to determine the general physical and chemical properties of each coal. The results of this work are published either in the Preliminary Coal Map series (by county) or in the Coal Investigations Map series (by quadrangle). Each county map is published at the scale of 1 inch to 2 miles. These maps show boundary lines and mined-out areas of each commercial coal; in addition, other factual and interpretive data are given in tables, cross sections, and a stratigraphic column. The maps for eight counties have been published. A map of Fountain and Warren Counties (combined) was completed during the year, and a map of Dubois County is 85 percent complete.

The quadrangle maps show essentially the same information as county maps, but in greater detail, and they contain a text. They are published at the scale of 1:24,000, or 1 inch to 2,000 feet. Eight of these quadrangles have been published in cooperation with the U. S. Geological Survey. Two of these, the Coal City and Switz City Quadrangles, were published during the past year, and maps of the Terre Haute-Dennison Quadrangles are now in the hands of the printers. Fourteen other quadrangles have been mapped, and information about these quadrangles will be published as four separate bulletins by the Indiana Geological Survey. Maps of the Brazil East and the Brazil West Quadrangles have been submitted for final drafting. The maps of these two quadrangles include information on the rather intensively mined Block coal area. Work on the Mansfield and Catlin Quadrangles is expected to be completed during 1960. The report on these two quadrangles will emphasize the lowermost coal-bearing rocks and the effects of glaciation on these rocks. A third report, which also will be completed during the coming year, is a study that includes the Rosedale, New Goshen, Sandford, Mecca, Clinton, and St. Bernice Quadrangles. This report will deal with most of the important commercial coals in the important mining area of northern Vigo County, southern Vermillion County, and southern Parke County. A fourth report is a study that includes the Lewis, Pimento, Hutton, and Fairbanks Quadrangles and is concerned with the upper half of the coal-bearing rocks in southern Vigo County and northwestern Sullivan County.

### **Stratigraphic Mapping of the Mansfield Formation**

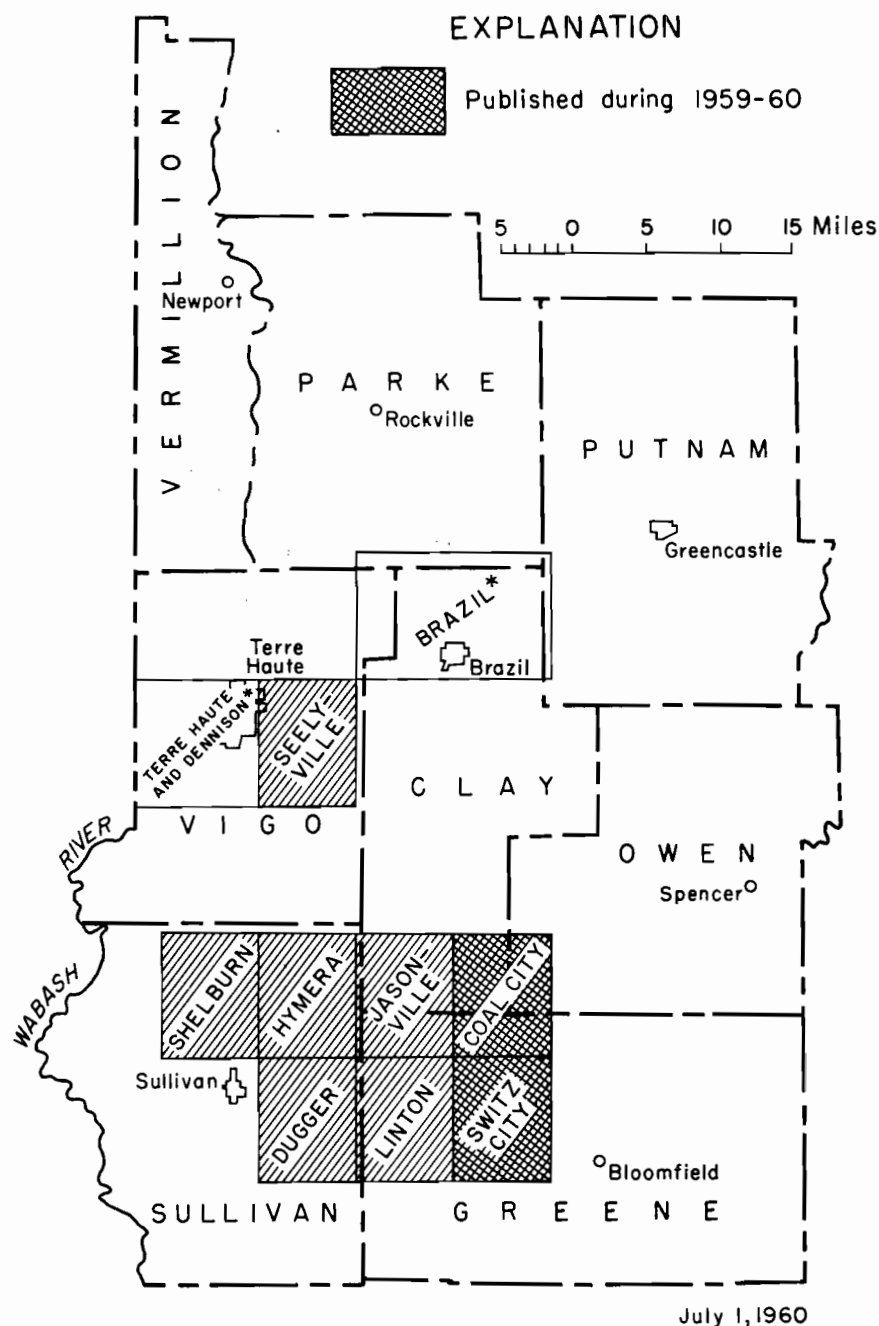
The purpose of this project is to enable us to delimit the various rock types in the 100 to 350 feet of sandstone, shale, clay, coal, and limestone that have been called the Mansfield Formation. The Mansfield Formation crops out from Warren County southward to Perry and Spencer Counties and covers approximately 1,000 square miles. This vast area cannot be mapped in detail, but some detailed mapping is included in the project. For instance, the previously mentioned Mansfield Quadrangle contains the type area of this formation. The report on the Huron and Hillham Quadrangles in Martin, Dubois, and Orange Counties that was completed this year includes detailed mapping of the Mansfield Formation as well as those formations in the underlying Mississippian rocks.

### **Stratigraphy of Pennsylvanian Rocks**

The identification and correlation of beds of coal, limestone, sandstone, shale, and clay are closely allied to coal resources studies, but stratigraphic research not directly applied to resources studies is done by members of the Coal Section. Work is now in progress to correct miscorrelations and misnaming of the middle and upper parts of the Pennsylvanian rocks and to

revise the nomenclature. All names of Pennsylvanian rocks are being reviewed, and their history and usage are being summarized. This summary will be included in a lexicon of geologic names in Indiana.

During the past year members of the Coal Section worked on the compilation of geologic boundaries for the new State geologic map. Six contacts of Pennsylvanian rocks have been completed for the Indianapolis 1 x 2 degree Quadrangle. This quadrangle is the first of eight quadrangles that will be completed for the new State geologic map.



Index Map Showing Name and Location of Published Coal Quadrangle Maps.



### Paleobotanical Studies

Work is continuing in palynology, the microscopic study of spores and pollen grains. This study enables the paleobotanist to identify coal seams on the basis of their spore content. This identification is a great aid to the geologist who is doing resources studies.

Two special projects were completed, and the results were submitted for publication. One, a paper on statistics of spores, utilizes electronic computing equipment to evaluate more precisely the probability of correlation between coals. The other is a special study of unusual sporelike material, *Torispora securis*.



Research does not end with the location and mapping of minable coals. Here a seam of coal in one of the State's strip mines is sampled for further study in the laboratory.

### Coal Petrographic Studies

In order to utilize the coals to the greatest advantage, the variability of the coals both within and between seams must be characterized. It has long been recognized that coal consists of discrete entities which can be megascopically and microscopically differentiated and which react

differently during preparation and utilization of the coal. The characterization of Indiana coal on the basis of these entities and their relationship to the preparation and utilization processes is the ultimate objective of the petrographic study of Indiana coals.

A report discussing the general petrographic character of Indiana coals was completed during the year. This report lists the petrographic and chemical characteristics of the commercial coals and discusses the usefulness of coal petrography to problems of coal mining, preparation, and utilization.

Work is continuing on the relationship of reflectance and other petrographic characteristics to the chemical properties of coal constituents. Closely allied to this work is a study of the petrographic constituents of black shales.

#### **Other Projects**

Additional work in paleobotany, petrography, and stratigraphy has been done on the Indiana paper coal. An article on this paper coal was published in the *Journal of Sedimentary Petrology* during the past year. Talks were given on the correlation of coal beds by petrographic and palynological techniques, the river systems of Pennsylvanian age, the coal geology of Gibson, Posey, and Vanderburgh Counties, and the stratigraphy of the Merom Sandstone.

#### **Reports Published July 1, 1959 to June 30, 1960**

Canright, J. E., 1959, Fossil plants of Indiana: Indiana Geol. Survey Rept. Progress 14, 45 p., 5 pls., 3 figs.

\*Friedman, S. A., 1959, Interbasin river systems superimposed on the major Pennsylvanian coal basins (abs.): *Geol. Soc. America Bull.*, v. 70, p. 1606.

Friedman, S. A., 1960, Underground rivers of stone: *Outdoor Indiana*, v. 3, no. 9, p. 11-13.

Kottowski, F. E., 1959, Geology and coal deposits of the Coal City Quadrangle, Greene, Clay and Owen Counties, Indiana: U. S. Geol. Survey Coal Inv. Map C28.

Kottowski, F. E., 1960, Geology and coal deposits of the Switz City Quadrangle, Greene County, Indiana: U. S. Geol. Survey Coal Inv. Map C41.

\*Neavel, R. C., and Miller, L. V., 1960, Properties of cutinite: *Fuel*, v. 39, p. 217-222, 1 fig.

\*Neavel, R. C., and Guennel, G. K., 1960, Paper coal: composition and deposition: *Jour. Sed. Petrology*, v. 30, p. 241-248, 1 pl., 3 figs.

Deul, M., Neavel, R. C., and Winslow, M. R., 1959, Correlation of coal beds by chemical, physical, petrographic, and palynological techniques (abs.): *Geol. Soc. America Bull.*, v. 70, p. 1588.

Wier, C. E., 1959, Coal stratigraphy and resources 1949-57: *Soc. Econ. Geologists*, v. 54, p. 629-665, 1 fig.

\*Completed during current fiscal year.

**Reports Completed for Publication July 1, 1959, to June 30, 1960 (Not Published)**

Friedman, S. A., Coal geology of Gibson, Posey, and Vanderburgh Counties (abs.): submitted to the Indiana Academy of Science 9-16-59.

Gray, H. H., Cyclic sedimentation of Pottsville rocks near Dundee, Ohio: submitted to the Geological Society of America 6-28-60.

Gray, H. H., Jenkins, R. D., and Weidman, R. M., Geology of the Huron area, southern Indiana: Indiana Geol. Survey Bull. , 8-31-59.

Gray, H. H., and Guennel, G. K., Elementary statistics applied to palynological identification of coal beds: submitted to Micropaleontology 5-19-60.

Guennel, G. K., and Neavel, R. C., *Torispora securis* Balme: Spore or sporangial wall cell?: submitted to Micropaleontology 6-14-60.

Guennel, G. K., Reevaluation of Russian paper coal (abs.): submitted to the Geological Society of America 6-13-60 for oral presentation in November 1960.

Hutchison, H. C., Distribution, structure, and mined areas of coals in Fountain, Warren, and part of Vermillion Counties, Indiana: Indiana Geol. Survey Prelim. Coal Map 9.

Neavel, R. C., Petrographic and chemical composition of Indiana coals: Indiana Geol. Survey Bull. , 12-8-59.

Neavel, R. C., Reflectivity, chemical properties, and classification of coal constituents (abs.): submitted to the Geological Society of America 6-20-60 for oral presentation in November 1960.

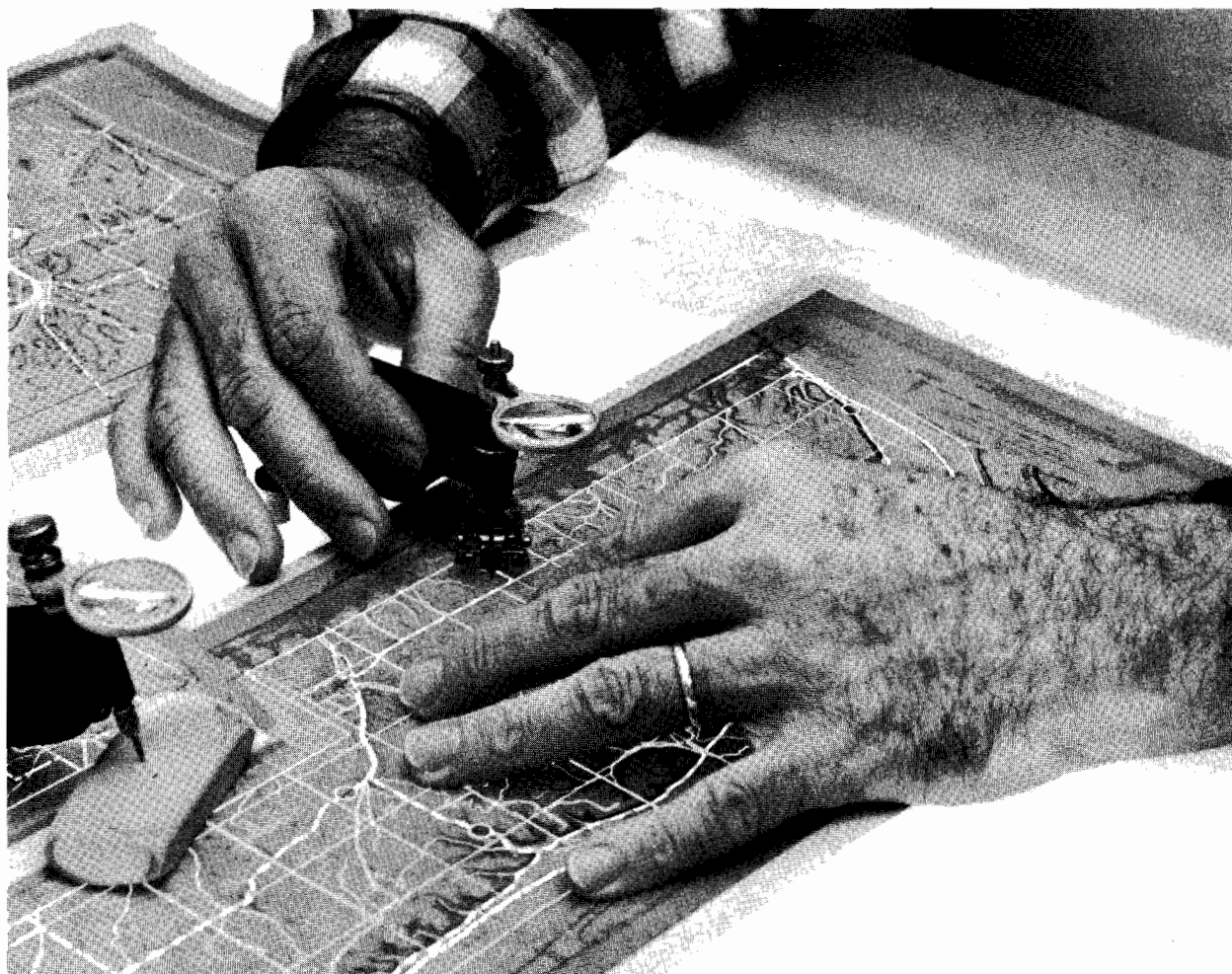
Wier, C. E., Stratigraphic relations of the Merom Sandstone near Merom, Indiana: submitted to the Indiana Academy of Science 11-17-59.

**DRAFTING AND PHOTOGRAPHY SECTION**

The Drafting Section and Photography were merged in October 1959. The section is responsible for furnishing drafted and photographic copies to all other sections of the Survey for use in publications, talks, and routine work.

Drafting work consists primarily of the final preparation of maps and other line drawings. Most of the work is prepared with pen and ink, but negative scribing, brush, airbrush, charcoal, and pencil also are used. A black and white printer is maintained and operated in the section. Base and petroleum exploration maps are printed for the Publications Section, and general printing and map mounting services are provided for all sections.

Illustrations for the following reports were completed during the year: Bulletin 16, Geology and Coal Deposits of the Brazil Quadrangles, Indiana; Bulletin 17, Petrography of Indiana Sandstones Collected for High-Silica Evaluation; Bulletin 18, Minerals of Indiana; Report of Progress 16, The Mt. Carmel Fault and Related Structural Features in South-Central Indiana; Report of Progress 17, Gravels of Indiana; Report of Progress 18, A Seismic Reflection Survey of the Surface of the Basement Complex in Indiana; Report of Progress 19, Engineering Geology of Dam Site and Spillway Areas for the Monroe Reservoir, Southern Indiana; Circular 7, Fossils: Prehistoric Animals in Hoosier Rocks; Director 7, Directory of Producers and Consumers of Clay and Shale in Indiana; and Mineral Economics Series , Chemical Analyses, Geological Survey, Indiana Department of Conservation, 1948-58.



Maps depicting Indiana's geology must be drafted with great care to locate accurately rocks that may someday be the sources of a valuable mineral deposit.

Also completed were illustrations for five Outdoor Indiana articles, five articles for outside publications, a special report, a publications list, an annual report, 10 talks, and an exhibit. Other major projects completed during the year include the compilation and drafting of Base Maps for 13 northern Indiana counties; the completion of Miscellaneous Map No. 6, Map of Indiana

Showing Crude Oil, Natural Gas, and Refined Petroleum Products Pipelines; the drafting of Petroleum Exploration Maps of 17 northern Indiana counties; and the revision of other county maps of that series.

Other drafting jobs started were Bulletin 20, Geology of the Huron Area, South-Central Indiana (5 percent complete); Report of Progress 20, Preliminary Engineering Geology Report of Dam Sites on the East Fork of the Muscatatuck River, Scott, Jennings, and Jefferson Counties, Indiana (6 percent complete); Preliminary Coal Map 9, Distribution, Structure, and Mined Areas of Coals in Fountain, Warren, and part of Vermillion Counties, Indiana (10 percent complete); and a topographic base map of Monroe County (91 percent complete).

Photography work consisted of the preparation of lantern slides, both black and white and color; photomicrographs; black and white and color prints; film positive transparencies; outdoor photographs; tinted negatives; portraits; group photographs; identification cards; guide copy for negative scribing; and dry mounting.

Photographic work processed during the year consisted of 378 camera copies, 159 photomicrographs, 713 black and white prints, 6 color prints, 75 film positive transparencies, 146 black and white slides, and 111 color slides.

### EDUCATIONAL SERVICES

From its beginning in 1869 the Indiana Geological Survey has recognized the importance of informing the public about the geology and mineral resources of the State. During the first year of its existence the Survey began the preparation and distribution of geologic information for citizens of the State. The First Annual Report of the Geological Survey for the year 1869 was published by the State of Indiana early in 1870.

From 1869 until 1919, when the Geological Survey became a division of the newly created Indiana Department of Conservation, almost all geologic research done in the State was included in the annual reports on Indiana geology published by the State of Indiana. Although many scientific papers were included in these publications, an effort was made by most authors to present the results of their research in a form that would be meaningful and could be enjoyed by the interested citizen having no background in geology.

The Indiana Yearbook, first published in 1920, contained the annual reports of all departments of the state government. Although, for a number of years, short articles on the geology and mineral resources of Indiana continued to be included in the report of the Division of Geology, Indiana Department of Conservation, results of geologic research by Survey personnel were published individually by study or project. Until the early 1950's material published by the Indiana Geological Survey was primarily of a professional nature.

In 1952 the Geological Survey added a new member to its publication series. The circular, designed to include miscellaneous nontechnical reports, was issued primarily to provide authoritative geologic information for lay readers, public schools, and youth groups.

In 1958 a new trend began in the presentation of information for the amateur or beginning student interested in the numerous facets of the science of geology. Circular No. 5, "Let's Look at Some Rocks," not only incorporated many ideas learned during the preparation of earlier circulars for presenting scientific data to children and lay readers but also was the first Survey publication to be illustrated profusely with sketches and line drawings to clarify information within the text. Circular No. 5 was also the first publication to have an illustrated cover in color.

The Office of Educational Services was established by the State Geologist in 1958 to coordinate the Geological Survey's efforts in fulfilling its obligations to provide geologic information to the public. This office also is striving to develop a continuing educational program and to assist in preparing materials for public schools, youth groups, and lay readers. By means of news releases to Indiana's newspapers and reviews sent to appropriate magazines, the Office of Educational Services assists in the distribution of these educational materials to interested people.

Improved roads and methods of transportation during the past 100 years have permitted members of the Geological Survey to travel over the State of Indiana with a minimum of time and effort to assist its citizens. During the last year the Office of Educational Services conducted the following field trips: field trip in the vicinity of The Shades and Turkey Run State Park for the park naturalists of these two state parks; field trip to McCormick's Creek State Park for members of Indiana Section of the American Camping Association; 1-day field trips for visiting high school students to the coal and petroleum producing areas of Vigo and Sullivan Counties, the building-stone quarries and mills near Bedford in Lawrence County, and the quartz-pebble quarry and mill and gypsum-processing mill in Martin County; field trip to Stevens Creek and bioherm east of Bloomington for the Biology Teachers group of the Indiana State Teachers Association; field trip through a shale pit and a tile plant in Morgan County; orientation and collection hikes for four groups of students attending the Indianapolis School Camp at Camp Riley, Bradford Woods, near Martinsville; rock and fossil-collecting trips near Merom for members of the Hoosier Recreation Workshop; field trip for the Salem High School Science Club through a building-stone quarry and finishing mills near Bloomington, the coal-mining area near Brazil, and a clay pit north of Brazil.

Talks and lectures presented on Indiana geology and mineral resources included: (1) lectures to four groups attending the Indianapolis School Camp (Camp Riley, Bradford Woods-Martinsville area); (2) prefield-trip talk "Geology and Mineral Resources of the Bradford Woods Area" (Indiana University Conservation-Education Workshop, Bradford Woods-Martinsville area); (3) "Introducing Geology in a Summer Camp Program" (Indiana Section of the American Camping Association, McCormick's Creek State Park); (4) "Mapping Fundamentals" and a film on maps and their uses (science students, Westlane Junior High School, Indianapolis); (5) "Volcanos" and a film on the same subject (elementary class at University school, Bloomington); (6) "Introduction to Rock, Mineral, and Fossil Collecting," (presented to four groups of students attending the Indianapolis School Camp, Camp Riley, Bradford Woods-Martinsville area); (7) "Indiana's Rocks and Minerals" and showing of the Geological Survey film "The State Beneath Us" (Y.M.C.A. Rock and Mineral Club, Peru); (8) "Introducing Rock and Fossil Collecting in a Recreation Program" (Hoosier Recreation Workshop, Merom Institute, Merom).





A geologist shows samples of the State's rocks and minerals to members of a school camp as part of the Geological Survey's public education program.

During the last year the Office of Educational Services visited the Pike Township Schools in Marion County; Meridian School, Kokomo; Bon-Air School, Kokomo; and Westlane Junior High School, Indianapolis. These visits were made at the request of science teachers wishing to include more geology in their curriculums. The schools were provided with basic sets of rocks from which to build a student collection, and the teachers were alerted to geologic materials available through the Geological Survey that might be helpful to them.

For the summer of 1960 the Geological Survey offered a 12-week research assistantship in geology for an outstanding graduating high-school senior boy. Announcements and application forms were mailed to the science teachers of 740 Indiana high schools. Twelve applications and five requests for additional information were received. From the finalists the selections committee chose Mr. Robert Kixmiller, Petersburg High School, Pike County, as the 1960 winner of the award.

During the past year the Office of Educational Services issued 33 news releases concerning the activities of the Geological Survey. Reports of the major news items of the Survey were submitted to the editor of the State Geologist's Journal, which is published semi-annually.

For the Fifth Annual Indiana University High School Science Institute a guidebook was prepared, and a field trip covering the geology and mineral industries of the Bloomington area was conducted by Professor Carl W. Beck, of the University Department of Geology, and R. Dee Rarick, of the Geological Survey.

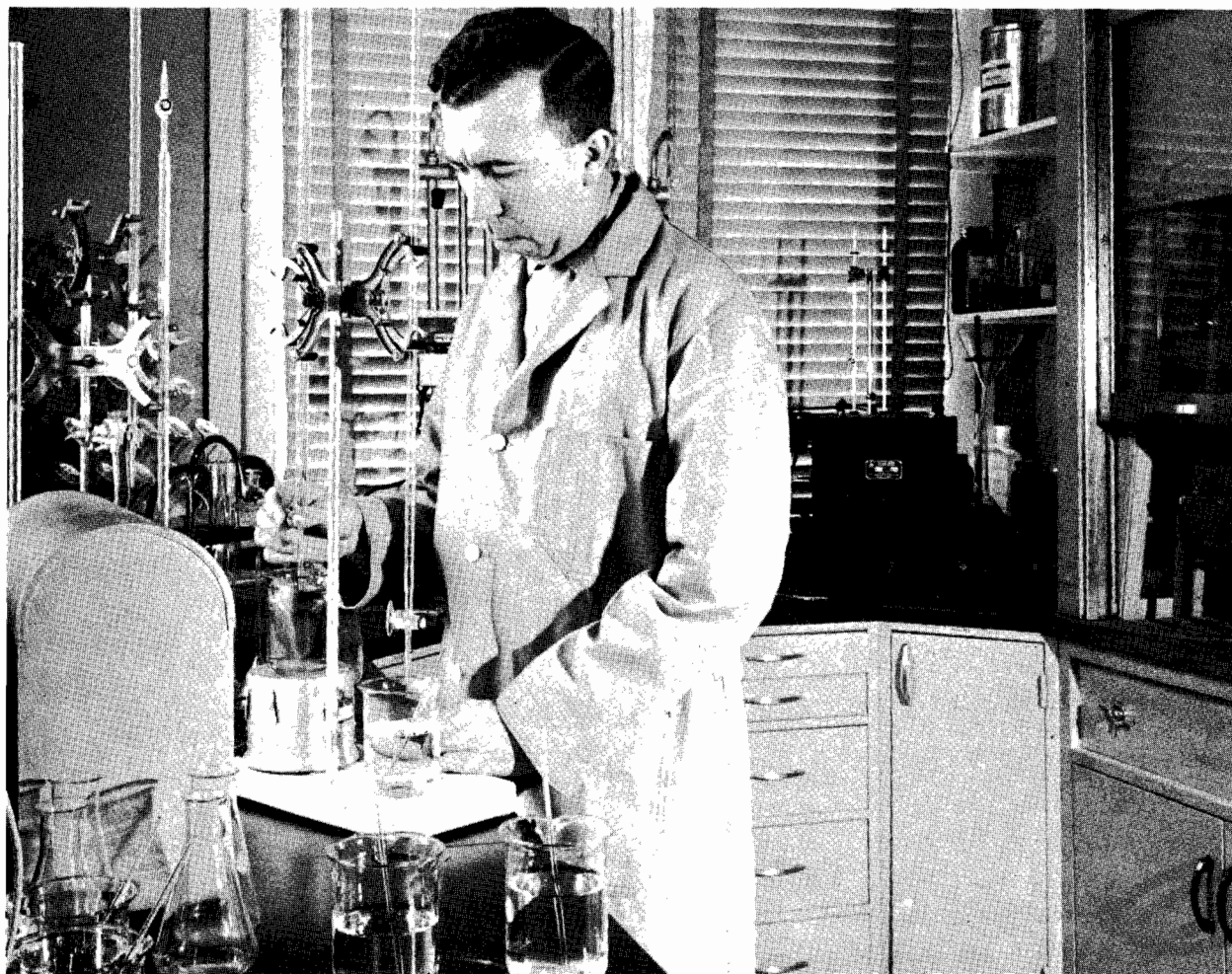
Articles published in Outdoor Indiana included: "Indiana's Earth Detectives," by R. Dee Rarick, and a Memorial to Dr. Charles F. Deiss (published in the August 1959 issue of Outdoor Indiana); Strata Data, geology briefs: "Trilobites, Rulers of the Ancient Seas" (October issue); Strata Data, geology briefs: "Rock 'Traps' Produce Oil" (November issue); "Deepest Oil Test Well Drilled," by R. Dee Rarick (December issue); "Swamp Forest," by R. Dee Rarick (January 1960 issue); "Underground Rivers of Stone," by S. A. Friedman, and an announcement of the appointment of Dr. J. B. Patton as State Geologist (March issue); Strata Data, geology briefs: "Crinoids," by R. Dee Rarick (April issue); Strata Data, geology briefs: "Indiana During the Great Ice Age" (May issue); Fossil Ossa, geology briefs: "Indiana's Ancient Elephants," by R. Dee Rarick (June issue). Articles appearing in other publications included: "The 'Ups and Downs' of Indiana's Oil Industry," by R. Dee Rarick (published in the October 1959 issue of the Indiana Business and Industry Magazine); "Indiana's Deepest Oil Test Well," by R. Dee Rarick (published in the October 1959 issue of the State Geologist's Journal); "Indiana's Buried Treasure," by Richard S. Simons (published in the December 6, 1959, issue of the Indianapolis Star Magazine); "Geological Survey Helps State Find, Use Natural Wealth," by R. Dee Rarick (published in the March 1960 issue of the Indiana Business Review).

The office of Educational Services also participated in the 6th Annual Workshop on Interpretative Programs, Bradford Woods-Martinsville area.

## GEOCHEMISTRY SECTION

The utilization of natural materials depends on either or both their chemical and their physical properties. From a geologist's point of view, the chemical properties and some physical properties of most natural materials are expressions of type of rock or, more fundamentally, the type of minerals present. The development of the sciences of chemistry and mineralogy began with the recognition of different properties of different minerals and groups of minerals in rocks. Natural materials with certain combinations of properties became known as species of the mineral kingdom. Early alchemists learned about the compositions of these species and founded descriptive inorganic chemistry. By 1860 the chemical compositions of the relatively few common mineral species were well known. Crystallographers and mineralogists at that time were able to identify many of the mineral species and to calculate the composition of rocks on the basis of the proportions of different minerals. In the following hundred years many refinements were made in the studies of composition and properties of natural materials. The most important advances came

after the birth of X-ray crystallography in 1912; since that year the atomic structures of many of the common minerals have been determined. On the basis of the chemical composition and the atomic structure of the minerals involved, the chemical and physical properties of newly discovered deposits of our natural resources have been more easily predicted after preliminary investigation of the rocks in the deposit.



Chemical analyses are made of rock samples collected in the field to determine constituents and possible uses.

Chemical and physical specifications are now commonly applied for the acceptance or rejection of natural materials from various sources. To provide for the study of the chemical composition of Indiana's natural resources, a spectrographic laboratory was established in 1948 as part of the Industrial Minerals Section of the Geological Survey. A chemical analysis laboratory was established in 1949 for the joint benefit of the Geological Survey and the Department of Geology of Indiana University. By the time a laboratory for coal analysis was established in 1954, the chemical studies of the Survey were combined into the Geochemistry Section. Studies of physical properties of materials are carried on in several sections of the Survey, principally in the Industrial Minerals and Geophysics Section.

During the fiscal year 1959-60 the Geochemistry Section provided analytical services to the commodity sections of the Survey. In conjunction with commodity studies and work on stratigraphic problems, several cores were sampled; the samples were processed through preparation, analysis, and storage.

Routine preparation and analysis of coal, limestone, dolomite, clay, shale, and brine samples and the tabulation of the analytical data, along with geographic and geologic information about the samples, constituted most of the work of the section. Statistical data pertaining to this work are included in the statistical summary of this annual report.

In cooperation with the High School Science Institute at Indiana University, a computer program was written for the calculation of the mineralogy of limestone and dolomite samples from chemical analytical data. The results have proved useful in the study of the stratigraphic formations in the State.

A joint project with the Petroleum Section for the analysis of oilfield brines was continued; at the close of the fiscal year 88 analyses had been completed. The project is to continue until samples have been collected from rocks over as wide an area in Indiana as possible.

A project concerning the analysis of the waste products of the coal industry was set up during the year. Initiation of a sampling program had to be delayed until prior projects could be completed. Before studies on the possibilities for utilization of waste products can begin, a knowledge of the composition of the waste products must be gained.

Two projects on the chemistry of weathering of glacial till were continued through the year, but little new work was done on the projects.

Five samples of silicate rock from a deep core were analyzed in the chemical laboratory. Completion of the analyses by the addition of spectrographic determination of trace elements will be accomplished during 1960-61. Two standard samples for use in chemical and spectrochemical analysis were analyzed in cooperation with the Canadian Association for Applied Spectroscopy. Analysis of samples from a core through Pennsylvanian rocks was begun for a study of correlation of chemical composition and environment of deposition. This work is being done to furnish information to the Coal Section.

The compilation of analytical data for 1948-58 was extended to include data obtained in 1959. The manuscript to accompany these data was completed in the fiscal year 1958-59. Compilation of previously published analyses of Indiana rocks and minerals was begun; completion of this work is anticipated in 1961-62.

During the year considerable time was spent in making plans for the occupation by the Survey of remodeled quarters on the Indiana University campus. Although the plans were abandoned, the knowledge gained during planning will be of great aid in future planning for adequate quarters for the Survey.

As in the past, the backlog of samples for which analysis will be required increased despite the progress of analytical work. An unfilled position in the spectrographic laboratory and insufficient manpower in the chemical analysis laboratory have seriously curtailed the output of data.

#### **Publications**

Filby, Royston H., and Leininger, R. K., Spectrographic determination of the major constituents of Granite G-1 and Diabase W-1, in Stevens, R. E., and others, Second Report on a cooperative investigation of the composition of two silicate rocks. U. S. Geological Survey Bulletin 1113.

Neavel, R. C., and Miller, L. V., Properties of cutinite: Fuel, v. 39, no. 3, p. 217-222.

### **GEOPHYSICS SECTION**

Although a Geophysics Section was not added to the Geological Survey until 1951, as far back as 1879 workers in Indiana geology foresaw the need for measurement of physical properties of the rocks and minerals which form our State. In that year physical tests were run on samples of the Salem Limestone to compare its bending strength with the strength of other prominent building stones. The Salem Limestone was found to be far stronger than the other stones, and architects were urged to use this superior stone in building specifications. Similar tests were run in 1897, but were expanded to include measurements of specific gravity, coefficient of absorption, and crushing strength.

Although some electrical measurements were made in the field to explore for water, no significant geological fieldwork was done until 1933, when at the request of R. R. Shrock and C. A. Malott, Dr. Justin Zinn, of the University of Wisconsin, made a magnetic survey in the vicinity of disturbed Ordovician rocks near Kentland. After this brief survey, geophysical work in the State was almost entirely handled by commercial companies until the organization of the Geophysics Section. This section now utilizes standard geophysical methods, including seismic, gravity, magnetic, and electrical measurements, to obtain information about buried or inaccessible features for coal reserve, glacial geology, and engineering geology studies.

#### **Seismic Reflection Measurements**

The Geological Survey is engaged in a long-term project to study the basement complex or framework of ancient crystalline rocks which underlie Indiana. These rocks range in depth from about 3,000 feet in east-central Indiana to nearly 15,000 feet in the southwest corner of the State. An understanding of these rocks is important as their structural pattern controls the position of later sedimentary rocks which contain the oil, gas, and other mineral resources of the State.

A seismic reflection party measured depths to the basement complex in Posey, Vanderburgh, Warrick, Gibson, and Pike Counties, and the results of this survey were published in Report of Progress 18. During the past year the party completed a seismic profile across southern Indiana from Pike County to Dearborn County and started traverses from Lawrence County to Vigo County and from Pike County to Vigo County. Short traverses also were made across Whitley County and across the Mt. Carmel Fault in Lawrence County. This second phase of seismic reflection surveys in southern Indiana is approximately 60 percent complete.

### **Seismic Refraction Measurements**

Since 1950 seismic refraction measurements have been made in Indiana to determine the thickness of drift, till, flood-plain, and other unconsolidated deposits in order to aid glacial, water-supply, and engineering studies. During the past year a seismic refraction field party engaged in surveys of three areas in western Indiana. These included parts of Owen, Clay, and Putnam Counties; Greene County, and Dubois County. Although carried out in widely separated areas, this work was done in each area to map the depth to the buried bedrock surface and to determine the depth to a limestone marker bed. Results of this work will enable geologists of the Coal Section to prepare more precise estimates of the State's coal reserves by indicating the volume of coal removed by erosion.

### **Engineering Geology**

The Survey's engineering geologist, John D. Winslow, resigned on July 14, 1959, but projects started during the preceding year were completed by Dr. Winslow and other Survey geologists. This work included a case history of the engineering geology of reservoir sites of Salt Creek in Monroe County and laboratory studies of the engineering properties of some Indiana soils with particular reference to the determination and usefulness of Atterberg limits.

### **Magnetic and Gravity Surveys**

Total intensity aeromagnetic maps of Indiana counties have been published on a cooperative basis by the Indiana Geological Survey and the U. S. Geological Survey. These maps show variations in the earth's magnetic field and have been useful to geologists in the analysis of geologic structures. They also show approximately 20 sharp anomalies that are of particular interest to geophysicists. The Geophysics Section has a program of mapping areas showing the anomalies by surface gravity and magnetic surveys. Three anomalies were mapped during the past year. They include a linear feature which crosses Fayette, Wayne, and Randolph Counties and intense circular anomalies in Pulaski and Hamilton Counties. Closely spaced gravity and magnetic stations were established across anomalies along 20 traverses across the elongate feature and 10 traverses across each circular anomaly. Data from these surveys are now being supplemented by seismic reflection profiles. Results of these surveys should provide information about the depth and mineralogy of rocks having magnetic susceptibilities and densities different from surrounding rock. This project is approximately 80 percent complete.

### **Altitudes of Wells and Seismic Shot Points**

Altitudes of seismic and magnetic and gravity stations are measured routinely in order that resulting computations may be referred to sea-level datum. This is a continuing program which supplements other geophysical projects.

### **Physical Properties of Indiana Rocks**

Measurement of the seismic velocities, resistivity, conductivity, coefficient of absorption, crushing strength, density, magnetism, and radio-activity of Indiana's sedimentary rocks was continued during the year. Samples were obtained from materials sent in by the public, from the Survey's core drilling program, and from collecting programs of other sections of the Geological Survey. Information from these measurements have been useful in the selection of suitable building stone for particular structural requirements and as an aid in the interpretation of field geological surveys. This project was started in 1953 and is a continuing one. A report covering results obtained to date is in preparation.



### New Requirements

Because of a lack of funds for supplies and personnel during the past 2 years, the Geophysics Section has had to curtail summer field operations to one seismic reflection party. Extensive seismic refraction work in Allen County and other northeastern Indiana counties has been delayed because of the restricted program.



Rock samples are tested to reveal their physical properties. Here a geophysicist determines the radioactivity of an Indiana shale.

Up to this time, the Geophysics Section has borrowed instruments from the Indiana University Department of Geology for gravity and magnetic surveys. As the Department's summer field program at the field station in Montana has increased, the availability of these instruments has become less during the most favorable times of the year for such surveys. In order that the Geological Survey may study anomalies shown on the aeromagnetic maps, it is important that a gravity meter and magnetometer be obtained. These instruments would also be available for reconnaissance surveys throughout the State and for study of individual structures, possible ore deposits, and hidden geologic features.

The Survey's program of handling well data, mineral statistics information, and computations for petrology, geochemistry, and geophysics has increased to the point that full-time use can be made of a digital computer device. Although such equipment is available on the campus of Indiana University, the cost of full and continued use of this facility is prohibitive. Low-cost computing equipment is now available and could be used to great advantage by the Geophysics Section for data reduction.

## GLACIAL GEOLOGY SECTION

Virtually all the gravel, sand, and clay resources of Indiana have resulted directly from glaciation. Glacial clays have been used for ceramic materials, and some of the sediments that fill lake basins left by the last glacier, such as peat and marl, are locally important as mineral resources.

Almost all large construction projects in Indiana, such as highways, bridges, and reservoirs, are concerned with glacial deposits. One of the State's most valuable natural resources is ground water, which is abundant in the buried gravels and sands left by torrents of melt water that flowed from the ice sheet.

In their early county reports, geologists of the Indiana Geological Survey provided many of the details about these glacial deposits that were amplified by geologists of the U. S. Geological Survey, especially by T. C. Chamberlain (1883, 3d Ann. Rept., U. S. Geological Survey) and by Frank Leverett and F. B. Taylor (1915, U. S. Geological Survey Monograph 53) in their report on the Pleistocene of Indiana and Michigan. This monographic paper was a milestone in the study of Indiana's glacial deposits and still stands as an outstanding reference on the subject.

Between 1915 and 1948 the study of the glacial deposits of Indiana lagged considerably. Malott (1922, Handbook of Indiana Geology, Indiana Department of Conservation Publication 21, pt. 2) modified Leverett's map somewhat and described some of the details of physiography in the glaciated parts of Indiana. One important report that was written during this period was W. D. Thornbury's study of the glacial geology of south-central Indiana, published by the Indiana Department of Conservation in 1937.

Research on the glacial deposits of Indiana has been carried on continuously by the Indiana Geological Survey since 1948 when the State Geologist, the late Charles F. Deiss, set up a program of mapping. Since 1952 a full-time research program has been in progress, and studies of the glacial geology of the State have included detailed areal geologic reports and maps, papers on the thickness, character, and stratigraphy of the deposits, and petrologic and paleontologic reports. The primary task of the Glacial Geology Section of the Indiana Geological Survey is to learn as much as possible about the glacial drift of Indiana. Our personnel accumulate, file, and interpret data on the distribution of the different kinds of materials in glacial drift, on the thickness and internal variability of the drift, and on as many as possible of its other physical properties. This information is then assembled and prepared for publication.



Most of Indiana's sand and gravel was deposited by glaciers of the Ice Age. A geologist is sampling and mapping a glacial deposit preliminary to further study in the laboratory.

Four basic types of projects are undertaken by the Glacial Geology Section; these are: areal mapping, stratigraphic research, service projects, and public information projects.

#### **Areal Mapping**

Both detailed and reconnaissance areal geologic maps are prepared by the Glacial Geology Section. Detailed mapping, by using U. S. Geological Survey topographic maps as a field base and stereoscopic study of aerial photographs as one of the principal research tools, will result in accurate maps published on a scale of 1 inch equals 1 mile or more. Reconnaissance maps are prepared for publication on a smaller scale, generally about 1 inch equals 4 miles or less. During the 1959-60 fiscal year, the section has had in progress three mapping projects and one reconnaissance mapping project.

A study of the geology of Marion County was undertaken by Wyman Harrison in 1956. His report was submitted for review for publication as a bulletin in June 1959 and has since undergone considerable revision.

Fieldwork on the geology of Johnson County, also begun in 1956, will result in a report accompanied by a colored geologic map, scale 1:48,000, as will the Marion County report. This project has been delayed several times but is now about 17 percent complete.

Work on the geology of the Catlin and Mansfield Quadrangles is a cooperative project between the Coal and Glacial Geology Sections. Harold C. Hutchison mapped the rocks of Mississippian and Pennsylvanian age and the coal resources, and William J. Wayne mapped the sediments of Pleistocene age. Mapping of these Pleistocene sediments was started in 1956 and is now about 99 percent complete. The completed maps probably will be published in color on a scale of 1:48,000.

The Glacial Geology Section is correcting and compiling the Pleistocene geology of the Indianapolis 1 x 2 degree A.M.S. Quadrangle, scale 1:250,000, the first sheet of a series intended to be used as a revision of the geologic map of Indiana. Allan F. Schneider began compilation of data for this map in November 1959. The Glacial Geology part of the project is now about 30 percent complete.

#### **Stratigraphic Research**

Areal geologic studies, as well as most of the fields of "applied geology," depend heavily on an accurate and detailed knowledge of the character and sequence of the rocks involved. Pleistocene geologic studies are no exception, and much of the time of geologists in the Glacial Geology Section is used in furthering basic knowledge on stratigraphy, sedimentation, and paleontology of the Pleistocene sediments in Indiana.

The petrology and petrography of some tills in central Indiana became topics of investigation by Wyman Harrison while he studied the sediments of Marion County. Results of work on the petrographic similarity of Wisconsin tills in Marion County were published in September 1959 as the Geological Survey's Report of Progress 15. Another part of this study, entitled "Original Bedrock Composition of Wisconsin Till in Central Indiana," was approved for publication in an outside journal.

The paleontology of fossiliferous Pleistocene sediments has been a continuing project carried on by William J. Wayne since December 1952. Snails and clams are among the few groups of organisms whose remains are well represented as fossils in the Pleistocene sediments of Indiana. Inasmuch as these land and fresh-water mollusks are sensitive to changes in local vegetation and climate, studies of them provide data on the ecologic conditions surrounding their existence and burial in glacial sediments. A compilation of the stratigraphic occurrence of 15 fossil-rich samples and the ecologic significance of the faunas, entitled "Stratigraphic Distribution of Pleistocene Land Snails in Indiana," was published in November 1959 in the first number of *Sterkiana*, a new journal devoted to papers on land and fresh-water mollusks.

During August 1959 William J. Wayne worked on the excavation of an incomplete mastodon skeleton on the Darrow farm near Oliver Lake in LaGrange County. The specimen and the geology of the site were reported in a paper presented before the Indiana Academy of Science in November 1959.

Glacial deposits of Pleistocene age have in the past been afforded a stratigraphic treatment somewhat dissimilar from other sedimentary rocks. "Pleistocene Formations in Indiana," by William J. Wayne, is a report that attempts to unify Pleistocene stratigraphic treatment and nomenclature with that currently in use for the rest of the geologic column. The study was begun in October 1958; a review of it was presented before the National Academy of Sciences in November 1959 (abstract published in *Science*, v. 130, p. 1425). The paper is now 99 percent complete and will be submitted for consideration by the Indiana Geological Survey as a Report of Progress.

"Stratigraphy of the Ohio River Formation," by William J. Wayne, was submitted for publication in 1957, but the manuscript required extensive revision and expansion to ready it for publication. This revision was completed in March 1960, and the report was sent to the editor. It will be published as a Bulletin. A paper on the Ohio River Formation was presented at the March meeting in Lexington, Ky., of the Southeastern Section of the Geological Society of America. The abstract of this paper will appear in the Geological Society of America Bulletin for December 1960.

#### **Service Projects**

Personnel of the Glacial Geology Section provide assistance to other organizations in Indiana in interpreting unconsolidated sediments. Most projects of this type are in the field of engineering geology, in particular, the geology of reservoir sites and dam sites, and geologic problems related to ground-water supply. Most of these projects result in open-file reports, but some are completed by conferences and no written report is submitted. Reports were written for the following service projects during this fiscal year: geology of the Helmsburg (Brown County) Elementary School well field, Allan F. Schneider, October 1959, and a geologic report of a proposed reservoir area for the Brownsburg (Hendricks County) Conservation Club, by Wayne and Schneider, April 1960.

#### **Educational Projects**

Glacial geologists frequently are asked to work with groups of nongeologists in order to help as many persons as possible obtain a better appreciation and understanding of earth science and of their State. Talks are given before amateur geological societies, school science classes, garden clubs, service clubs, and scout groups on aspects of Indiana geology. From time to time popular or nontechnical accounts of geologic phenomena are written for use by persons interested in, but untrained in, geology. The following more formal projects of this nature were undertaken during the fiscal year: article on ground-water pollution, coauthored by Charles Bechert of the Division of Water Resources and William J. Wayne; this article is to be published in *Outdoor Indiana*. William J. Wayne taught the geology part of Purdue University's summer camp course in Conservation Education, directed by H. H. Michaud, from June 15 to 18, 1960.



## INDUSTRIAL MINERALS SECTION

Indiana's industrial minerals include clay and shale, dimension limestone and sandstone, crushed limestone and dolomite, cement, sand and gravel, quartz-pebble conglomerate, gypsum, whetstone, marl, peat, pyrite, and lightweight aggregate.

These minerals are so vital to industry that without them no steel could be made, drilling for oil would be difficult, good roads could not be built, poor buildings would be erected, and little power would be generated. The relationship between the geology of the industrial minerals and conservation is difficult to explain because many people look upon the word conservation as meaning the preservation of what we now have. Conservation, however, does have meaning when its definition is broadened to include "wise use of a mineral resource." Thus our industrial minerals, although classified as exhaustible, nonmaintainable, and nonresuable, must be looked upon as being essential to our existence and must be used with a minimum of waste. The job of the Industrial Minerals Section is to map, sample, and classify our mineral commodities and to seek new uses for these minerals. To the extent that as a State we are interested in the "wise use" of our mineral commodities, we will follow practices of good conservation.



A planer works along a shale face removing material to be used in the manufacture of numerous ceramic products.

### **Clay and Shale**

The Clay Mineralogy Laboratory continued projects to determine the manner in which the mineralogy of natural clays and shales correlates with such physical properties as elasticity, hardness, fusion point, strength, shrinkage, and color. A report on the clays and shales of Indiana by H. H. Murray and Jack L. Harrison is nearly completed. A research program on the refractory clays of Indiana indicates that some of these clays are suitable for the manufacture of refractory clay products, that is, products that will withstand high temperatures.



One of Indiana's most famous mineral resources is building stone. This photograph shows limestone being quarried near Bedford in Lawrence County.

A study is also being made of economic utilization of the Borden Group of rocks in Indiana. Preliminary results from this work indicate that extensive deposits of clay and shale remain to be developed.

### **Dimension Stone**

The Industrial Minerals Section has a continuing program of sampling new exposures of the Salem Limestone (the Indiana limestone of trade) from which most of the dimension limestone is quarried. The report "The Petrography of the Salem Limestone" is nearly complete. This comprehensive work describes the geology, location, distribution, thickness, and petrology of this stone.



### **Crushed Stone**

The work of measuring and sampling new quarry faces and the extension or deepening of old quarries continued during the year. This study is done to provide producers and users of crushed stone full information concerning the location, distribution, petrography, and estimated thickness of overburden of quarriable rock throughout the State.

A project to investigate the petrography of northern Indiana limestones is now in progress, and a report on high-calcium limestone and dolomite in the State has been submitted for publication by the Survey. These studies are mainly concerned with obtaining information to ensure optimum use of the State's limestone and dolomite resources.

### **Sand and Gravel**

A report that reviews types of gravel deposits, the importance of sedimentary processes in gravel deposition, and the size distribution and composition of Indiana gravel was published by the Survey during the year.

### **High-Silica Sand**

A report entitled "Petrography of Indiana Sandstones Collected for High-Silica Evaluation," now ready for printing, will be published as a Bulletin. This work discusses high-silica sand deposits in Indiana and indicates that some cleaning of the raw material may be necessary before it can be used in manufacturing glass and refractory brick.

### **Geologic Mapping**

The section continued as active program of mapping important mineral-producing areas of the State. The maps are published on a scale of 1:48,000 and will show the distribution of rock units in detail. Five projects are currently in progress:

- (1) "Geology and Mineral Resources of Monroe County," by W. H. Melhorn and Gary R. Gates. The manuscript for this report is 95 percent complete and should be ready to submit for publication in October 1960.
- (2) "Geology and Mineral Resources of Lawrence County," by Ned M. Smith. The project was begun in June 1956 but has had several interruptions. About 40 percent of the fieldwork has been completed. The report will not be ready for submission until late in the next fiscal year.
- (3) "Geology and Mineral Resources of Washington County," by Jack A. Sunderman. All fieldwork, most of the laboratory work, and much of the writing for the report are done. The report should be ready to submit for publication by the middle of the next fiscal year.
- (4) "Geology and Mineral Resources of Putnam County," by Jack A. Sunderman. This project was begun in July 1959 and is about 40 percent complete. A manuscript will be submitted for publication during the next fiscal year.
- (5) The mapping of the Mississippian rocks of the Indianapolis Quadrangle is part of the work being done for a new State geologic map. About 90 percent of the fieldwork is done.

### **Papers and Talks**

Members of the Section wrote and presented the following scientific papers and talks:

- (1) "A Fossil Cave Filling in the St. Louis Limestone in Putnam County, Indiana," by Gary R. Gates, Ned M. Smith, and W. N. Melhorn, was presented by Gary R. Gates at the Indiana Academy of Science annual meeting. An abstract of the paper will be published in the proceedings.
- (2) "The Lowly Nonmetallics," by Duncan J. McGregor, was given before the Indiana Academy of Science. The abstract of this paper will be published in the proceedings.
- (3) "Unusual Mineral Assemblage Associated with Lower Pennsylvanian Conglomerate," by Jack A. Sunderman and Seymour S. Greenberg, was read before the Indiana Academy of Science. An abstract will be published in the proceedings.
- (4) "Petrology of Sandstones from the Big Clifty Formation of Indiana," by Seymour S. Greenberg, was presented before the Indiana Academy of Science. The abstract will be published in the proceedings.
- (5) "Breccia and Pennsylvanian Cave Filling, Putnam County, Indiana," by Ned M. Smith, Jack A. Sunderman, and W. N. Melhorn, has been accepted for publication in the Journal of Sedimentary Petrology.
- (6) "Minerals Associated with Lower Pennsylvanian Conglomerate, Lawrence County, Indiana," by Jack A. Sunderman, will be published in the Journal of Sedimentary Petrology.
- (7) "Lightweight Aggregate in Indiana" was presented before the Indiana Mineral Aggregates Association.
- (8) "Outgrowths of Authigenic Brookite on Leucoxene Grains in Pennsylvanian and Late Mississippian Sandstones in Indiana" has been accepted for publication in the Journal of Sedimentary Petrology.
- (9) "Crystal Chemistry," by Jack L. Harrison, was presented before the Journal Club, Indiana Department of Geology.

### **Service Reports**

Members of the section wrote the following service reports:

- (1) "Bedrock Geology of Flood Control Reservoir F-7 Franch Lick Creek, Orange County" was written for the Indiana Flood Control and Water Resources Commission.
- (2) "Bedrock Geology of the Site of the New Geology Building" was written at the request of Indiana University.
- (3) "Mineral Resources of Delaware County" was written at the request of the Mayor of Muncie, Indiana.

(4) "Mineral Resources of Crawford County" was written for the Crawford County Development Committee last year and was revised for the Conservation Education Committee of the Department of Conservation.

(5) "Clay and Shale Potential of Porter and LaPorte Counties" was written for Natco Corp. of Pittsburgh, Pa.

(6) "A Source of Clay and Shale in the Region Near Logansport, Indiana" was written for the Louisville Cement Co.

#### **Meetings and Conferences Attended**

Members of the section attended the following meetings and conferences: Geological Society of America annual meetings in Pittsburgh, Pa.; American Association of Petroleum Geologists annual meetings in Atlantic City, N. J.; American Ceramic Society sectional meeting in Cannelton, Ind.; Indiana Academy of Science annual meeting in Indianapolis; Michigan Basin Geological Society annual field conference, Madison, Wis.; Geological Society of America field conferences on the glacial geology of northwestern Pennsylvania, the Pennsylvanian of western Pennsylvania, and Monogahela Series, Pennsylvanian System, and Washington and Greene Series, Permian System, of the Appalachian Basin; and the annual clay conference held in Norman, Okla.

#### **Miscellaneous Projects**

Other projects undertaken in the section are: "The Mineralogy of Gardner Mine Ridge," by Seymour S. Greenberg; "Petrology of a Basic Igneous Rock from a Deep Core in Lawrence County, Indiana," by Seymour S. Greenberg and Charles J. Vitaliano; "Mutual need of Geology and the Nonmetallics," by Duncan J. McGregor; and "Geology and the Mineral Aggregates Industry," by Duncan J. McGregor.

The following abstracts were prepared and were sent prior to presentation of papers at forthcoming meetings:

(1) "Deltaite is Crandallite Plus Hydroxylapatite," by Seymour S. Greenberg and Bill Elberty. This paper will be presented before the Geological Society of America meetings to be held in Denver, Colo., in November 1960.

(2) "Clay Mineral Alteration in Some Indiana Soils," by John B. Droste, N. Bhattacharya, and Jack A. Sunderman. This paper will be presented before the annual clay conference to be held at Purdue University in October 1960.

(3) "Dehydration of Halloysite," by Jack L. Harrison and Seymour S. Greenberg. This paper will be read before the annual clay conference at Purdue University in October 1960.

## MINERAL STATISTICS

Since 1945, when the Indiana Geological Survey was reorganized and became the active research and service organization that it is today, we have received many requests for statistical information on mineral production in Indiana. These requests come from other governmental agencies, companies planning new operations or expansion of existing operations, companies involved in court cases, organizations which compile and publish such data on a nationwide basis, and others. As we had no systematic method for securing this type of information, any figures we provided were necessarily estimates based on data assembled from various sources and on our own familiarity with individual companies. In order to give accurate answers to inquiries received and also to enable us to determine the effect of the mineral industries on the State's economy, we entered, in 1954, into a cooperative agreement with the U. S. Bureau of Mines for the collection of mineral statistics. Under the terms of this agreement, we have immediate access to the questionnaires sent out by the Bureau of Mines to all mineral producers in the State (except the mineral fuels) and can tabulate the desired information promptly.

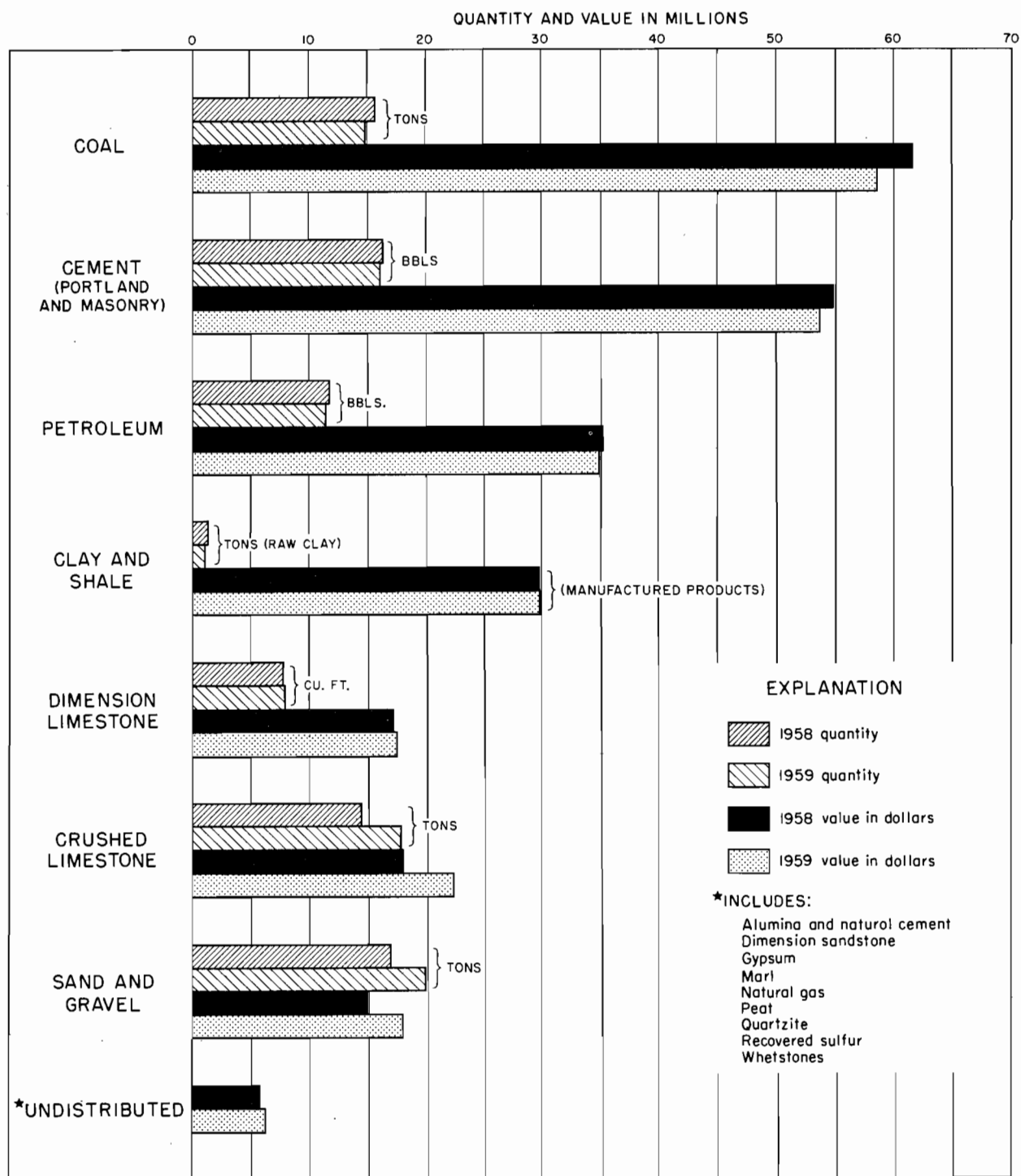
The total value of minerals produced in Indiana has risen, despite fluctuations, from \$165,369,000 in 1954 to \$239,034,690 in 1959. (See table 1.)

Table 1. - Mineral production in Indiana, 1954-59

Year	Value
1954 . . . . .	\$165,369,000
1955 . . . . .	214,998,794
1956 . . . . .	235,705,807
1957 . . . . .	226,530,071
1958 . . . . .	235,310,206
1959 . . . . .	239,034,690

The large increase shown for 1955 does not necessarily reflect a corresponding increase in mineral production; a part must be attributed to the cooperation of a greater number of producers in the State in making their company data available to us as they come to realize the value of a central source for such information, which they may have occasion to need in the future.

The total value of minerals produced in 1959 increased 1.58 percent over 1958. (See table 2.) A comparison of the major individual commodities is shown on the graph. The increased production of building materials, particularly the roadbuilding materials - crushed limestone and sand and gravel, compensated for the decline shown for the fuels (coal, petroleum, and natural gas) and cement. In spite of this decline, coal, cement, and petroleum, in that order, continued to maintain their positions as the three most economically important mineral commodities produced in Indiana.



Comparison of Quantity and Value of Indiana Mineral Resources in 1958 and 1959.

Table 2. — Mineral Production in Indiana in 1958 and 1959

	Quantity 1 (1958)	Value 1 (1958)	Quantity 2 (1959)	Value 2 (1959)	Increase or decrease	
					Quantity (pct.)	Value (pct.)
Coal . . . . .	15,620,680 tons	61,701,686	14,770,242 tons	58,526,848	- 5.44	- 5.15
Cement (portland and masonry) . . . .	16,268,991 bbl	54,984,516	16,102,977 bbl	53,613,607	- 1.02	- 2.49
Petroleum. . . . .	11,811,000 bbl	35,201,943	11,554,000 bbl	34,887,540	- 2.18	- .89
Clay and shale (raw material) . . . . .	1,350,229 tons		1,125,999 tons		-16.61	
(manufactured products)		29,783,135		29,903,280		+ .40
Limestone, crushed . . . . .	14,479,077 tons	17,914,054	17,745,003 tons	22,325,348	+22.56	+24.62
Limestone, dimension. . . . .	7,803,655 cu ft	17,163,521	7,914,454 cu ft	17,468,219	+ 1.42	+ 1.78
Sand and gravel. . . . .	16,905,705 tons	14,838,547	19,804,472 tons	17,822,330	+17.15	+20.11
Sandstone, dimension. . . . .	25,831 tons	636,125	30,244 tons	703,602	+17.09	+10.61
Natural gas. . . . .	631,440,000 cu ft	88,383	483,562,500 cu ft	71,514	-23.42	-19.09
Peat . . . . .	30,265 cu yd	144,974	30,600 cu yd	122,400	+ 1.11	-15.57
Marl . . . . .	63,792 cu yd	77,890	65,011 cu yd	49,222	+ 1.91	-36.81
Whetstones. . . . .	20,000 lb	10,500	10,000 lb	13,000	-50.00	+23.81
Undistributed: Alumina & natural cement, gypsum, quartzite, recovered sulfur. . . . .		4,745,636		5,325,259		+ 12.21
Total (adjusted so values for stone and clay used for cement will not be duplicated). . . . .		235,310,206		239,034,690		+ 1.58

1 Adjusted. 2 Subject to adjustment.

## PALEONTOLOGY SECTION

### Orientation in Purpose and Time

The Paleontology Section was established July 1, 1956, and was charged with: (1) service – collecting and studying fossils as an aid to, and supplementing the work of, field parties and other Survey personnel in the several sections, (2) research – providing basic information on fossils and their enclosing rock strata which is intended as a contribution to the science of paleontology and as a useful stratigraphic tool leading to greater understanding and utilization of Indiana's rock strata, (3) information and education – answering specific inquiries and otherwise informing Indiana's citizens and agents on matters pertaining to fossils, and (4) maintaining the Survey's fossil collections.

The shifting emphasis in Indiana paleontology during the last century is a mirror of the change in the science of geology itself. The place of paleontology in geology has been likened to the ancient walled core of a modern European city. Just as newer important parts of the city sprang up outside the walls, so have special disciplines found increasingly important roles in geology. Thus, paleontology and the walled core, relatively, do not now form such large parts of the wholes, but they remain as integral parts, as both the newer disciplines in geology and the outlying districts of the city rely in part on the central foundations.

Thus we find that fossils and their application were among the first interests of the early State Geologists. The first geological report of Indiana by David Dale Owen in 1838 contained the recommendation: "if means are provided, to make observations on the natural history of Indiana generally; to examine carefully the various species to which the fossils belong, and make a rigorous comparison between them and those found in other parts of America and Europe with a view of correlating our formations and those of other parts of the United States and the Eastern Hemisphere. This is a subject now of the highest interest to scientific men in all parts of the world, as it is to confirm or demolish theories, which materially affect the science of geology, in a practical as well as scientific point of view." D. D. Owen was assisted by the most noted paleobotanist of his time, Leo Lesquereux, whose report for Indiana appeared in the first report of Richard Owen in 1862. This report is a milestone in Indiana's paleontology, as it was the first attempt at correlation of the coal beds of the State by means of their plant fossils. The same Owen report may be classified into 15 items of which no fewer than 7 dealt with organic remains.

Such early emphasis on fossil and modern organisms even found its way into the Indiana General Assembly's empowering act for the fourth Indiana Survey of 1869 (and others): "to collect, properly label and arrange in the Agricultural rooms, specimens of the – organic remains of quadrupeds, birds, reptiles, fishes, crustaceans, mollusca, insects and all other objects of natural history peculiar to the State."

The next few decades saw natural history and paleontology rise above economic geology as the most intensively treated subject in the annual reports. The list of authors includes such names as C. A. White, Leo Lesquereux, S. A. Miller, James Hall, S. S. Gorby, and E. M. Kindle, and it forms a who's who in American paleontology of that time.



The preoccupation with paleontology is easily understood. The new science of geology used paleontology as its correlative and mapping tool more than any other. Furthermore, the State of Indiana provided remarkable hunting grounds, particularly in the area between Richmond, Cincinnati, and Jeffersonville. Among laymen, the more inquisitive local citizens formed natural history societies even in communities of very modest size. Even today many residents of Madison may spend a Sunday afternoon collecting fossils, whereas the average citizen of Indianapolis could not recognize a brachiopod.

And so the Indiana Surveys were caught up in the descriptive phase of American paleontology. Part of their justification was practical, that is, for purposes of mapping, correlating, and classifying the State's rock strata. Part was scientific and educational, and, unfortunately, some justification was merely for the sake of collecting.

After the turn of the century, paleontology lost its preeminent position in State Survey affairs because of increasing attention to other geological matters. The relative decline of paleontology in Indiana was not abrupt, however, and the momentum that had been engendered carried the State's responsible position in this scientific endeavor into the early decades of the twentieth century. These eminent names appeared as authors in State reports: E. M. Kindle, E. R. Cumings, E. B. Branson, J. W. Beede, J. J. Galloway, R. R. Shrock, and Roy L. Moodie. These and earlier authors kept the State officially abreast of the American paleontological wave that succeeded in describing many of the major groups of macrofossils and in putting them to some practical use in correlating and mapping. These men were scientists, some professors, and not all of them actually were employed by the older State Surveys, which in spite of chronic financial troubles nevertheless managed their paleontological interests fairly well.

The newest Survey's efforts in paleontology are slowly gaining momentum. The effort is largely micropaleontological. Thus, the study of spores in the Coal Section contributes simultaneously to the special branch called palynology and to the correlation of coal beds and estimation of reserves of the State's number one natural resource. The study of tiny mollusks from the glacial deposits is a contribution from the Glacial Geology Section. It permits better understanding of these surficial materials that must be produced or dealt with in virtually every farming, drilling, constructional, and raw materials venture in three-fourths of the State. Studies of protozoans and microcrustaceans from the coal-bearing strata and the most important limestone-producing rocks are underway. Conodonts, protozoans, and bryozoans from deep well cuttings and cores are hardly touched, but they offer an important means to the understanding and mapping of the great middle Paleozoic carbonate rock section that lies everywhere in our subsurface.

Educational reports on fossils are prompted by the phenomenal growth during postwar years of the amateur geological societies, of independent interest, and of interest in the public schools. This interest revives at least one aspect of the flourishing natural history societies of earlier decades. An educational report on the tiny fossil protozoan *Endothyra* appears insignificant, but it advertises the famous Indiana building stone and serves to bridge the artificial gulf between fossils and practicality that might have been suggested in that earlier report contrasting the discovery of fossils with that of building stone.

The Survey's efforts should be increased to cover the lost ground. We are handicapped already, as reports to be released during the next several years will be on groups of fossils that were

studied in some surrounding states 10 to 30 years ago. We need full-time paleontologists, and we should join hands with academic efforts in paleontology at Indiana University and other institutions. Part-time employment, underwriting of field expenses, and publication of independent research are ready avenues of progress. At this point we have hardly begun to think officially of the newest emphases in paleontology as a part of geology which include joint efforts by paleontologists and sedimentary petrologists and geochemists. Such efforts will unravel still more of the secrets of rocks that ultimately result in better use and, thus, conservation for the next 100 years.

Perhaps at this point we have also turned a full circle, so that we now may modify that statement of fossils in the first Indiana report to read: "the scientific point of view is the practical view." We also see that the city's ancient walled core, although now small by comparison, is mutually interdependent with the newer districts.

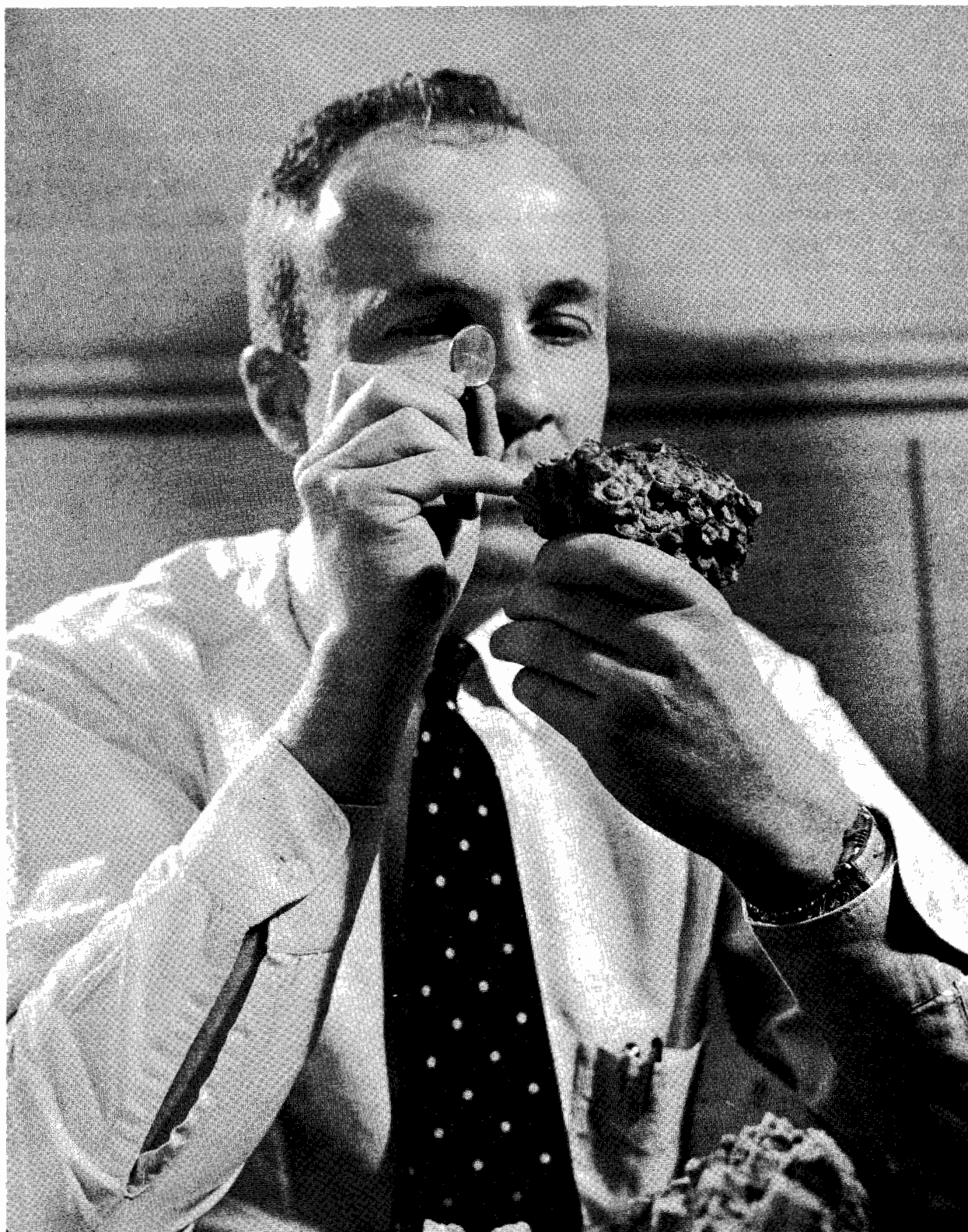
#### **Research Projects**

The research program includes three basic projects. The first of these, Mississippian Ostracoda of Indiana, was begun in July 1956 and is less than half complete. This study is expected to provide an additional basis for correlation of the Mississippian formations, but no new progress was made during the past 2 years because the opportunity to cooperate with the Illinois Geological Survey in the second and third projects was given top priority.

M. L. Thompson, of the Illinois Geological Survey, and Robert H. Shaver began work during August 1957 on the joint projects, Pennsylvanian Fusulinidae and Ostracoda of Indiana. The projects are less than half complete. Thompson and Shaver are studying the faunas taken so far from 121 exposures, mostly of early and early middle Pennsylvanian age. The studies also have been extended to seven cores. They are expected to lead to our adoption of Midcontinent series terminology for the Pennsylvanian System and to better correlation and mapping of formations in Indiana and the Illinois Basin. Three preliminary reports resulting from this project were published or prepared during 1959-60: (1) A paper, "Early Pennsylvanian Fusulinids and Ostracodes of the Illinois Basin," was published during September 1959 in the *Journal of Paleontology*. (2) Another short report, "The Pennsylvanian Ostracode *Bairdia oklahomaensis* in Indiana," was sent to the same journal during July 1959. (3) A memorandum report of March 1960 listing 117 Pennsylvanian sections, together with faunal age determinations, was transmitted to the Coal Section. A more general Survey report (Bulletin) on the early faunas is in preparation. A separate study on the ostracodes of the West Franklin Limestone is being conducted by a graduate student, Steven Cohen.

#### **Service Projects**

Nearly the full efforts of the section were required between November 5, 1959, and February 29, 1960, to complete a study on the "Ordovician-Silurian Contact in Cores from North-Central Indiana." The project was suggested by the State Geologist because this contact has been picked erratically in deep wells, the contact may be troublesome in mapping in northern Indiana for the 1 x 2 degree quadrangles, and basal Silurian and upper Cincinnati subsurface stratigraphy is not well understood. These problems were approached by studying the inorganic and organic constituents of 66 insoluble residues from seven cores in six counties. The study shows that (1) as much as 25 feet of Silurian strata lie below the cherty Brassfield of subsurface stratigraphers,



A fragment of coral from an ancient Indiana sea provides the paleontologist with clues about the rock strata from which it was collected.

(2) the systematic contact can be picked more consistently by noting the first appearance downward of quickly alternating Ordovician lithologies and by placing less emphasis on Silurian chert and glauconite or other presumed typical lithologies in either system of rocks, (3) the striking differences between Ordovician and Silurian conodonts offer a precise criterion for picking the contact, and the distinctive Ordovician fossil detritus, as well as other systemically characteristic organic and inorganic objects in the residues, offers reliable means for picking the contact, and (4) the conodonts and lithologic observations suggest that present subsurface stratigraphic concepts of the Brassfield and related strata are in a very preliminary state, that the Richmond Group of Indiana has its partial equivalent in the Maquoketa Shale of Iowa, and that the uppermost exposed Richmond formation(s) does (do) not have subsurface equivalents. A memorandum report of this project was transmitted on February 29, 1960, and it should be revised for publication as a Report of Progress.

A memorandum report (to the Industrial Minerals Section, October 1959) identified species of middle Devonian corals that were collected from the center, west line, sec. 36, T. 27 N., R. 1 W., Cass County, in an area mapped as Silurian in an older Survey report. Here is evidence, then, that further opens to question the exact age of the "upper Silurian" of northern Indiana.

#### **Nonpaleontological Service Projects**

R. H. Shaver organized the work of a committee that reported (June 1960) on the Survey's publishing program.

This section also was responsible for continuing the organizational work for the Geologic Names Committee that was begun by John B. Patton toward the publication of a lexicon, "Origin and Status of Rock-Unit Names in Indiana," and that led to the release, during 1958-59, of the preliminary "Chart of Indiana Stratigraphic Terms" (not a publication). This work is resulting in more consistent and meaningful usage by Survey and other authors of stratigraphic terms, and it expedites the preparation and publication of manuscripts. A memorandum report (April 1960) lists numerous miscellaneous rulings and opinions on nomenclatural problems and should further expedite the preparation of manuscripts.

The section was responsible for organizational work and some fieldwork for the tenth field conference (May 5-7, 1961) to be sponsored jointly by the Survey and the Indiana University Department of Geology for professional and industrial people, students, and amateurs. The projected conference is on Silurian stratigraphy of northern Indiana. This subject will be presented from the viewpoint of geologic history and its many unsolved problems.

#### **Educational Reports**

Circular 6, "Adventures With Fossils," was released during July 1959. Circular 7, "Fossils: Prehistoric Animals in Hoosier Rocks," by T. G. Perry, was released during March 1960. These reports were designed to meet needs of school children, adults, collectors, and those who are scientifically curious.

#### **Miscellaneous Activities**

Papers and talks were presented to two scientific societies and four educational groups. A manuscript on many unassigned ostracodes was sent to the editor of the "Treatise on Invertebrate Paleontology." Duties as associate editor for the Journal of Paleontology required a small amount of time from the section.

## PETROLEUM SECTION

Indiana has been an oil-producing State for more than 70 years, and it has enjoyed two boom periods of oil production. Indiana became an oil-producing State in the late 1880's with the discovery of oil in east-central Indiana. The first boom period followed shortly thereafter, and between 1890 and 1910 approximately 100 million barrels of oil was produced from the thousands of wells drilled in Adams, Wells, Huntington, Grant, Blackford, Jay, and Delaware Counties. The continuous productive area of these counties in east-central Indiana was known as the Trenton Oil Field. Production was from the Trenton Limestone at a depth of approximately 1,000 feet.

The years from 1910 to 1939 were lean ones for Indiana's oil business. Production averaged only about 1 million barrels per year. It came from stripper wells in the Trenton Field and from a half-dozen shallow fields in southwestern Indiana.

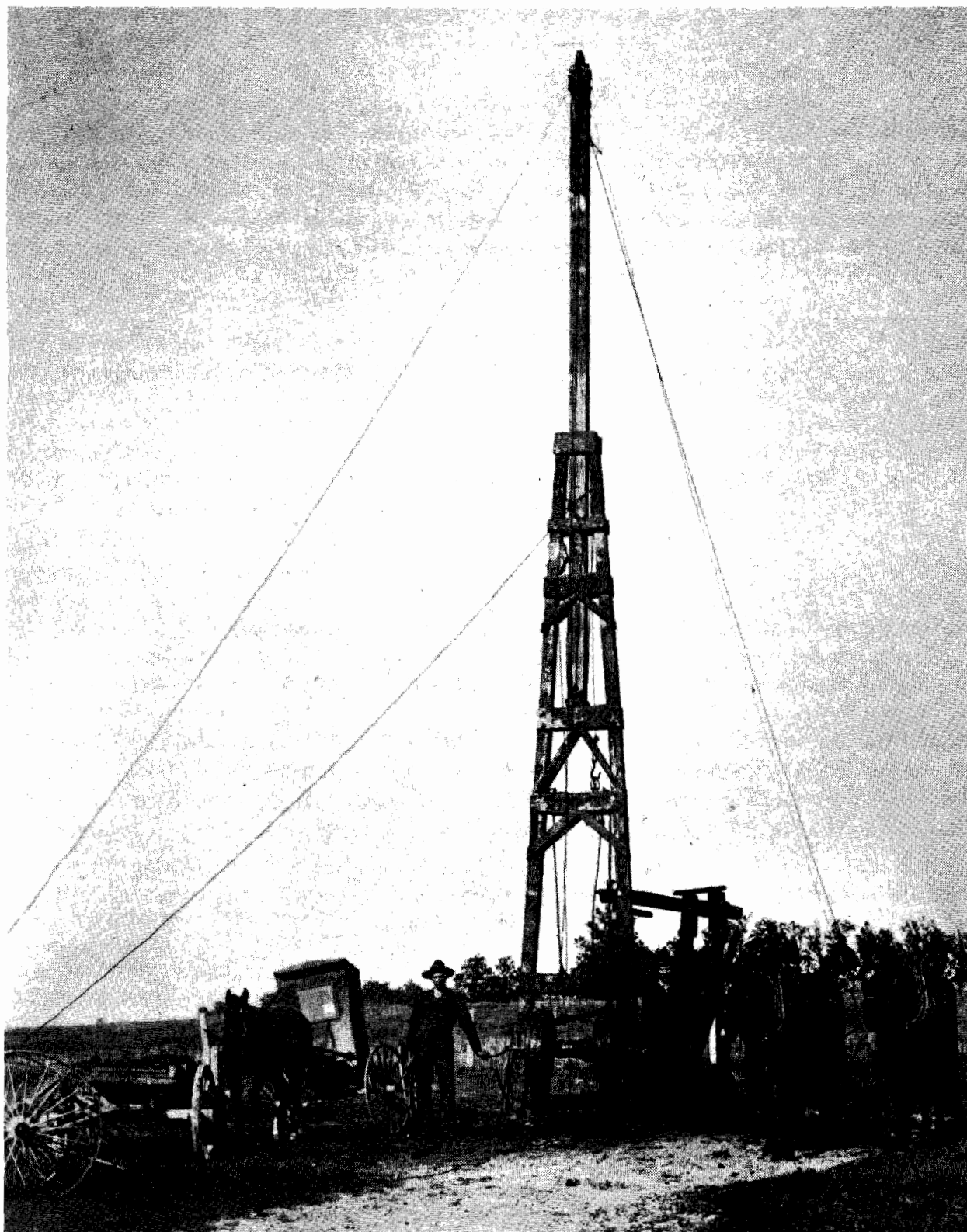
Indiana's second oil boom has occurred in the southwestern part of the State and was sparked by the discovery of high-grade, relatively deep production in western Gibson County in 1939. Oil development and production have continued at an active pace in southwestern Indiana from 1939 to the present. Productive counties include Posey, Gibson, Vanderburgh, Warrick, Spencer, Dubois, Pike, Daviess, Knox, Sullivan, and Vigo. Production, in contrast to the single continuous reservoir of the Trenton Field, is from hundreds of relatively small reservoirs in Devonian, Mississippian, and Pennsylvanian rocks at depths ranging from less than 1,000 feet to more than 3,000 feet. Annual production from 1939 through 1959 has averaged approximately 9 million barrels per year, and the current rate of production is approximately 11½ million barrels per year.

The oil industry was in an adolescent stage at the turn of the century when Indiana was experiencing its first oil boom. Since then there have been great technological advances in the development and production of oil, for example, well spacing, special completion techniques, conservation of reservoir energy, and secondary recovery of oil by reenergizing reservoirs. As a result, a much greater percentage of the oil in the reservoirs of southwestern Indiana will be recovered than was recovered from the Trenton Field.

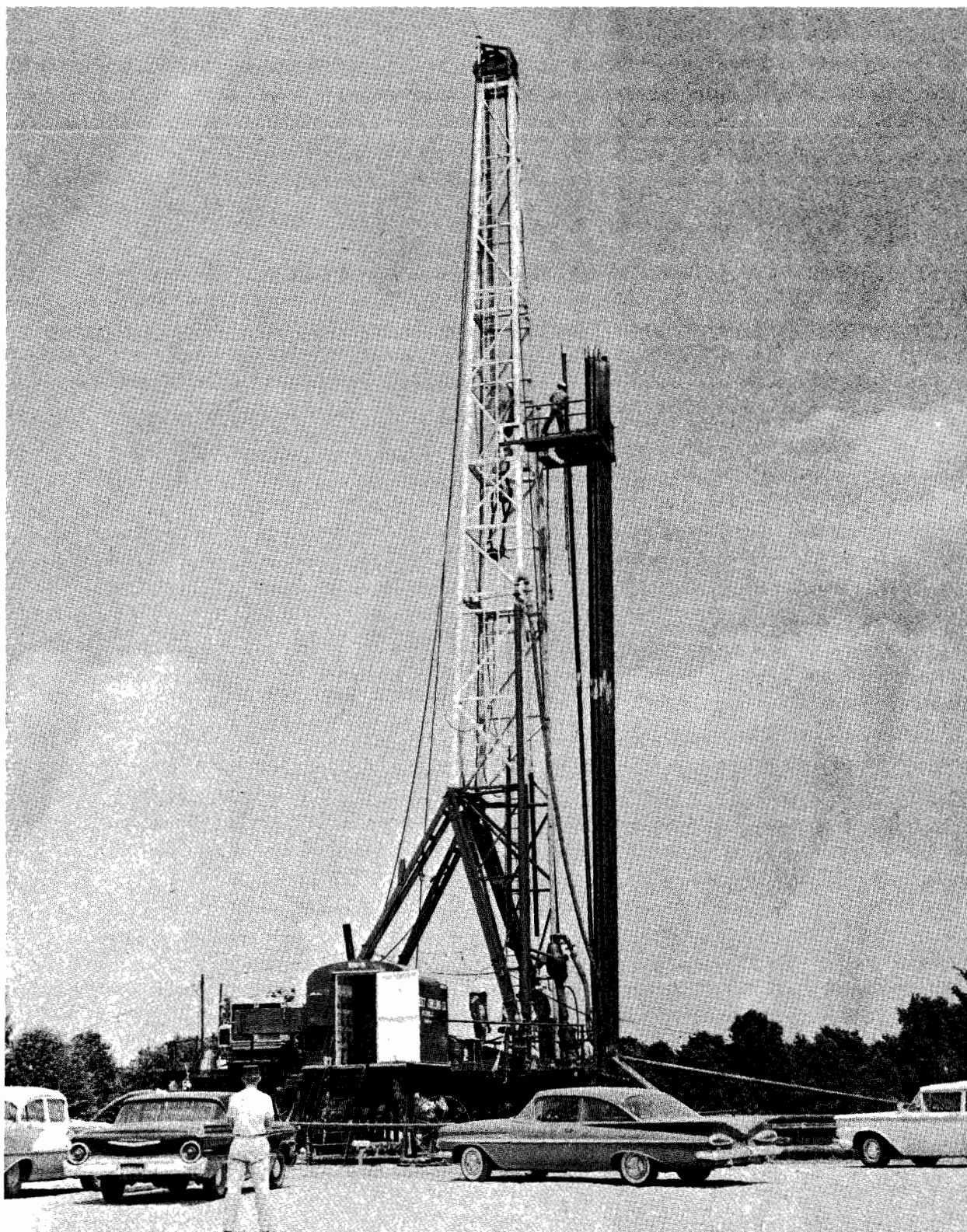
The Petroleum Section functions primarily as a service organization with research responsibility. Of the several service obligations charged to the Petroleum Section, the most basic is that of collecting and maintaining in the most accurate manner possible the various types of geological information derived from wells drilled for oil and gas. This information takes the form of elevation data, location data, scout tickets, drillers' logs, sample studies, electric logs, samples, and cores. Other service obligations consist of furnishing geological information to individuals and industrial organizations by personal conference, telephone, and letter and of compiling annual reports of a statistical nature.

As a research organization the Petroleum Section is concerned with subsurface geology. As a result of the basic service obligation of collecting and accurately maintaining well data, there is housed in the Petroleum Section quarters the most complete and most usable set of data that exists for studying the subsurface geology of Indiana.





Work at an oil well in the early part of the 1900's required horsepower and manpower. This pulling rig was used to clean out an oil well near Phoenix, Wells County, Indiana.



A powerful modern drilling rig recently completed the deepest test well ever drilled in Indiana. The hole, located in eastern Lawrence County, reached a total depth of 6,806 feet.



The service obligations of the Petroleum Section have gradually increased through the years and continues to increase, but the housing and working facilities available for performing service and research obligations have remained unchanged for years. As a consequence, inasmuch as service obligations come first, it has been necessary to reduce research functions to the degree that it has been necessary to assume increased service obligations. This is most unfortunate, as research on the subsurface geology of Indiana is fundamental to an understanding of basic geology in Indiana and to the development of mineral commodities in Indiana.

#### **Committee on Statistics of Exploratory Drilling**

Statistics on exploratory drilling in Indiana for 1959 were prepared for the Committee on Statistics of Exploratory Drilling of the American Association of Petroleum Geologists. Detailed records on exploratory drilling are maintained throughout the year so that the CSED statistics can be compiled quickly at the end of the calendar year. The statistics on exploratory drilling in Indiana are published as part of a statistical summary on exploratory drilling in the United States. Publication is in the June issue of the Bulletin of the American Association of Petroleum Geologists.

#### **American Association of Petroleum Geologists**

The AAPG paper "Developments in Indiana in 1959" was prepared at the close of the calendar year. The principal theme of this paper, which is prepared annually, is oil exploration, that is, newly discovered oil and its significance. Publication is in the June issue of the AAPG Bulletin.

#### **Oil Production Report**

The paper "Oil Development and Production in Indiana During 1959" was compiled at the end of the calendar year. This paper is primarily a statistical report on oil production. Included in it are production figures for each oilfield in Indiana.

In previous years the statistical report on oil production has been prepared for publication by the Petroleum Branch of the American Institute of Mining and Metallurgical Engineers and has been prepared according to a format designated by the organization. For 1959 the report will be published only by the Indiana Geological Survey, and a modified format has been established for it. The 1959 report will be published as Mineral Economic Series No. 6.

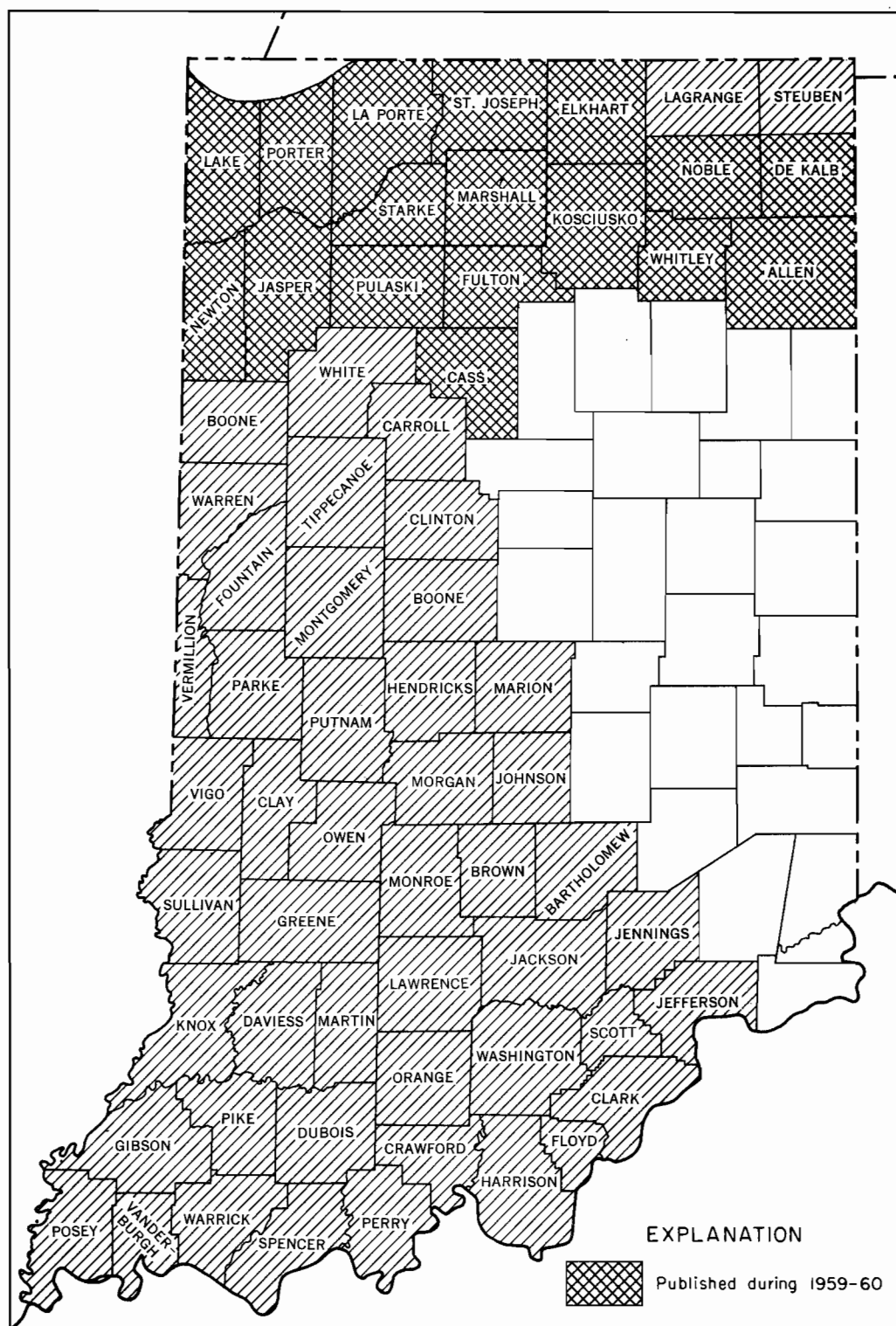
#### **Oil Reserves**

Personnel of the Petroleum Section take part in the annual meetings of an American Petroleum Institute committee for determination of oil reserves in the Illinois Basin. To do this, production curves are plotted for all Indiana oilfields with reserves of as much as 500,000 barrels. At the end of the calendar year, previously prepared curves were brought up to date, and curves for newly discovered fields with reserves of as much as 500,000 barrels were plotted.

#### **Review of Northern Indiana Well Records**

During the 1958-59 fiscal year a program for determining accurate locations and elevations of all wells in 19 northern Indiana counties was completed. During the past year these locations and elevations were incorporated in the individual well-record files. In addition, all drillers' logs and sample studies were plotted and correlated, all electric logs and lithologic strips were correlated, and petroleum exploration maps were compiled. Published under date of April 6, 1960, were new petroleum exploration maps for Allen, De Kalb, Noble, Whitley, Kosciusko, Elkhart,

St. Joseph, Marshall, Fulton, Cass, Pulaski, Porter, Starke, La Porte, Jasper, Newton, and Lake Counties. Revised under date of April 6, 1960, were petroleum exploration maps for Steuben and LaGrange Counties.



Index Map of Indiana Showing Published County Petroleum Exploration Maps.

### **Oil and Gas Well Plugging Guide**

This project was effected at the request of the Supervisor of the Division of Oil and Gas. A report was compiled reviewing practices and basic needs in plugging oil and gas test wells on abandonment. In addition, an index map of Indiana was prepared showing depths at which plugs should be placed for securing fresh water from contamination by brines on abandonment of oil and gas test wells. This map is currently being used as a guide to plugging by the Division of Oil and Gas.

### **Spencer County Oil Development**

Spencer County has become Indiana's most active oil-producing county. Because of the high degree of interest in this county, the Geological Survey was requested to present a paper on recent developments at the annual meeting of the Kentucky Oil and Gas Association. The paper that was presented is titled "Recent Oil Development in Spencer County, Indiana." It will be published by the Kentucky Geological Survey as a part of the proceedings of the Kentucky Oil and Gas Association annual meeting.

### **Underground Natural Gas Storage**

The amount of natural gas that can be transmitted through gas transmission lines can be greatly increased by storing gas underground near distribution areas in the summer months when demand for natural gas is relatively low. Underground storage of natural gas is of national importance, and the Interstate Oil Compact Commission plans to publish a review of underground storage throughout the United States. The report titled "Underground Storage of Natural Gas in Indiana" was prepared during the year and will be published as a part of national report by the Interstate Oil Compact Commission.

### **Renault-Aux Vases-Ste. Genevieve Subsurface Study**

This comprehensive study, which was started in 1955, was nearly completed during the year. Its purpose is to gain an understanding of the interrelationships of the Renault, Aux Vases, and Ste. Genevieve formations. Important oil reservoirs occur in the Renault, Aux Vases, and Ste. Genevieve in southwestern Indiana, and a publication based on the study of them should be of value to the oil industry. Publication is to be by the Geological Survey.

### **Cypress-Paint Creek-Bethel Subsurface Study**

The objective of this study is to show the distribution of the various lithologic units that constitute the Cypress-Paint Creek-Bethel section and to show the geographic and stratigraphic distribution of oil in it. This study was initiated in 1957. Little progress was made on it during the year. It is estimated that the project is 38 percent complete.

### **Collection of Indiana Brines**

The Petroleum Section is cooperating with the Geochemistry Section in a 4 to 5 year program of collecting and analyzing Indiana brines. Analysis of the brine samples is the responsibility of the Geochemistry Section, and collection of the brine samples is the responsibility of the Petroleum Section. Collection of brine samples involves planning so that samples collected will be uniformly distributed, both geographically and stratigraphically. Approximately 90 samples have been collected (and analyzed) to date. The project was started in March 1959 and is scheduled for completion in 1964. It should result in a comprehensive brine report in 1965.

### **Deep Test Well Study**

Indiana's deepest oil and gas test well was drilled in Lawrence County in 1959. This test well was drilled into Precambrian rocks and completed at a depth of 6,806 feet. The objective of a study based on this deep hole is to provide the petroleum industry with a knowledge of the successful drilling methods employed and, in addition, to review the important new data obtained on the lower Ordovician and Cambrian rocks. This study will result in a Report of Progress by the Geological Survey. It is 96 percent complete.

## **PUBLICATIONS SECTION**

From 1869 until 1919 all reports on Indiana geology that were issued during a given year were published in the Annual Report for that year. Between 1919 and 1946 geological reports were issued separately as Indiana Department of Conservation publications.

Like its predecessor organizations, the present Indiana Geological Survey informs the public of the results of its field and laboratory investigations by means of published maps and reports. Geological reports are issued currently as separate numbers in the following series: Bulletin, Circular, Directory, Field Conference Guidebook, Mineral Economics Series, and Report of Progress. Maps are issued currently as numbers in the following series: Atlas of Mineral Resources of Indiana, Petroleum Exploration Map, Base Map, Preliminary Coal Map, and Miscellaneous Map. Maps also have been published cooperatively with the United States Geological Survey as Coal Investigations Maps and Total Intensity Aeromagnetic Maps.

The Publications Section was organized to conduct the publishing program of the Indiana Geological Survey. This section, with the assistance of the Drafting and Photography Section, prepares maps and reports for printing. The Publications Section also informs the public of new reports and maps as they are issued and handles all matters pertaining to the sale and distribution of publications.

During the fiscal year the Publications Section sold 6,060 reports and 3,408 maps. The section sent 705 reports and maps on exchange to institutions in the United States and 789 reports and maps on exchange to institutions in foreign countries. It also distributed without charge 3,801 publications to members of its own organization and to individuals, libraries, and companies in the United States and abroad. The Publications Section sent 14 general publications announcements to companies, schools, and individuals; served 506 office customers; received 3,048 letters; and answered 614 requests for geologic information.

## **PUBLICATIONS RELEASED BY THE GEOLOGICAL SURVEY DURING 1959-60**

### **Circulars**

Perry, T. G., 1959, Fossils: Prehistoric animals in Hoosier rocks: Circ. 7, 83 p., 19 figs.

### **Directories**

Harrison, J. L., 1960, Directory of producers and consumers of clay and shale in Indiana: Directory 7, 38 p., 4 figs.

Dawson, T. A., Sullivan, D. M., and Hreha, A. J., 1960, Catalogue of well samples of the Indiana Geological Survey: Directory 8, 458 p., 4 figs., 4 tables.

#### **Mineral Economics Series**

Dawson, T. A., and Carpenter, G. L., 1959, Oil development and production in Indiana during 1958: Min. Econ. Ser. 5, 12 p., 2 illus., 2 tables.

#### **Reports of Progress**

Canright, J. E., 1959, Fossil plants of Indiana: Rept. Progress 14, 45 p., 5 pls., 3 text figs., 3 tables.

Harrison, W., 1959, Petrographic similarity of Wisconsin tills in Marion County, Indiana: Rept. Progress 15, 39 p., 5 figs., 4 tables.

Melhorn, W. N., and Smith, N. M., 1959, The Mt. Carmel Fault and related structural features in south-central Indiana: Rept. Progress 16, 29 p., 1 pl., 2 tables.

McGregor, D. J., 1960, Gravels of Indiana: Rept. Progress 17, 53 p., 1 pl., 17 figs., 5 tables.

Rudman, A. J., 1960, A seismic reflection survey of the surface of the basement complex in Indiana: Rept. Progress 18, 26 p., 3 pls., 7 figs., 2 tables.

#### **Coal Investigation Maps**

Kottlowski, F. E., 1959, Geology and coal deposits of the Coal City Quadrangle, Greene, Clay, and Owen Counties, Indiana: U.S. Geol. Survey Coal Inv. Map C 28.

Kottlowski, F. E., 1960, Geology and coal deposits of the Switz City Quadrangle, Greene County, Indiana: U.S. Geol. Survey Coal Inv. Map C 41.

#### **County Base Maps**

Peace, J. E., April 1, 1960, Base map of Allen County, Indiana: Base Map 2.

Peace, J. E., April 1, 1960, Base map of De Kalb County, Indiana: Base Map 17.

Peace, J. E., April 1, 1960, Base map of Elkhart County, Indiana: Base Map 20.

Peace, J. E., April 1, 1960, Base map of Fulton County, Indiana: Base Map 25.

Peace, J. E., April 1, 1960, Base map of Kosciusko County, Indiana: Base Map 43.

Peace, J. E., April 1, 1960, Base map of Lake County, Indiana: Base Map 45.

Peace, J. E., April 1, 1960, Base map of La Porte County, Indiana: Base Map 46.

Peace, J. E., April 1, 1960, Base map of Marshall County, Indiana: Base Map 50.

Peace, J. E., April 1, 1960, Base map of Newton County, Indiana: Base Map 56.

Peace, J. E., April 1, 1960, Base map of Noble County, Indiana: Base Map 57.

Peace, J. E., April 1, 1960, Base map of St. Joseph County, Indiana: Base Map 71.

Peace, J. E., April 1, 1960, Base map of Starke County, Indiana: Base Map 75.

Peace, J. E., April 1, 1960, Base map of Whitley County, Indiana: Base Map 92.

#### **Petroleum Exploration Maps**

Keller, Stanley, and Walker, F. H., April 6, 1960, Well location map of Noble County, Indiana, showing total depth of wells: Petroleum Explor. Map 57A.

Keller, Stanley, and Smith, Howard, April 6, 1960, Well location map of De Kalb County, Indiana, showing total depth of wells: Petroleum Explor. Map 58A.

Keller, Stanley, and Sullivan, D. M., April 6, 1960, Well location map of Allen County, Indiana, showing total depth of wells: Petroleum Explor. Map 59A.

Keller, Stanley, and Smith, Howard, April 6, 1960, Well location map of Whitley County, Indiana, showing total depth of wells: Petroleum Explor. Map 60A.

Keller, Stanley, and Sullivan, D. M., April 6, 1960, Well location map of Kosciusko County, Indiana, showing total depth of wells: Petroleum Explor. Map 61A.

Keller, Stanley, and Smith, Howard, April 6, 1960, Well location map of Elkhart County, Indiana, showing total depth of wells: Petroleum Explor. Map 62A.

Keller, Stanley, and Walker, F. H., April 6, 1960, Well location map of St. Joseph County, Indiana, showing total depth of wells: Petroleum Explor. Map 63A.

Keller, Stanley, and Sullivan, D. M., April 6, 1960, Well location map of Marshall County, Indiana, showing total depth of wells: Petroleum Explor. Map 64A.

Keller, Stanley, and Walker, F. H., April 6, 1960, Well location map of Fulton County, Indiana, showing total depth of wells: Petroleum Explor. Map 65A.

Keller, Stanley, and Walker, F. H., April 6, 1960, Well location map of Cass County, Indiana, showing total depth of wells: Petroleum Explor. Map 66A.

Keller, Stanley, and Smith, Howard, April 6, 1960, Well location map of Pulaski County, Indiana, showing total depth of wells: Petroleum Explor. Map 67A.

Keller, Stanley, and Sullivan, D. M., April 6, 1960, Well location map of Starke County, Indiana, showing total depth of wells: Petroleum Explor. Map 68A.

Keller, Stanley, and Walker, F. H., April 6, 1960, Well location map of La Porte County, Indiana, showing total depth of wells: Petroleum Explor. Map 69A.

Keller, Stanley, and Smith, Howard, April 6, 1960, Well location map of Porter County, Indiana, showing total depth of wells: Petroleum Explor. Map 70A.

Keller, Stanley, and Sullivan, D. M., April 6, 1960, Well location map of Jasper County, Indiana, showing total depth of wells: Petroleum Explor. Map 71A.

Keller, Stanley, and Walker, F. H., April 6, 1960, Well location map of Newton County, Indiana, showing total depth of wells: Petroleum Explor. Map 72A.

Keller, Stanley, and Smith, Howard, April 6, 1960, Well location map of Lake County, Indiana, showing total depth of wells: Petroleum Explor. Map 73A.

Well location maps showing total depth of wells for the following counties were revised as of April 6, 1960: Warrick County (3A), Sullivan County (4A), Vigo County (5A), Martin County (12A), Greene County (13A), Clay County (14A), Vermillion County (16A), Fountain County (17A), Putnam County (19A), Dubois County (21A), Jackson County (22A), Knox County (23A), Monroe County (24A), Lawrence County (25A), Daviess County (26A), Orange County (27A), Crawford County (28A), Washington County (29A), Harrison County (30A), Hendricks County (33A), Marion County (34A), Morgan County (35A), Tippecanoe County (37A), Spencer County (39A), Perry County (40A), Boone County (45A), Jennings County (46A), Scott County (48A), Pike County (51A), Vanderburgh County (52A), and Steuben County (55A).

Well location maps for the following counties were revised as of April 6, 1960: Warrick County (3B), Sullivan County (4B), Vigo County (5B), Martin County (12), Greene County (13B), Clay County (14B), Dubois County (21B), Knox County (23), Daviess County (26), Harrison County (30), Spencer County (39), Perry County (40), Pike County (51), Vanderburgh County (52), Gibson County (53), and Posey County (54).

Well location maps showing total depth of wells for the following counties were checked without revision as of April 6, 1960: Parke County (15A), Owen County (18A), Montgomery County (20A), Brown County (31A), Bartholomew County (32A), Johnson County (36A), Warren County (38A), Benton County (41A), White County (42A), Carroll County (43A), Clinton County (44A), Jefferson County (47A), Clark County (49A), Floyd County (50A), and LaGrange County (56A).

#### **Preliminary Coal Maps**

Hutchison, H. C., 1959, Distribution, structure, and mined areas of coals in Spencer County, Indiana: Prelim. Coal Map 8.