Prepared drainage map of Indiana, showing flooded lands, for publication.

Arranged exhibit of division's work at a convention at Turkey Run State Park.

Prepared numerous maps, graphs, and computations for other divisions of this department.

REPORT OF THE DIVISION OF GEOLOGY

W. N. LOGAN, State Geologist.
PAUL F. SIMPSON, Supervisor of Natural Gas.
VERNE PATTY, Curator of Museum.
FLORENCE GRADY, Clerk and Stenographer.

Members of the division who acted in an official, technical, or advisory capacity during the past year were W. N. Logan, economic geology; E. R. Cumings, stratigraphic and paleontologic geology; C. A. Malott, physiographic geology; S. S. Visher, geography; J. E. Switzer, geography; R. E. Esarey, economic geology; C. A. Lamey, economic geology; and Howard Legge, preparator.

Members of the field parties during the field season included, in addition to the above members, Lewis Childs, George Whitlatch, James Organ, George Freed, Johnson Bierry, and Philip Fix.

The gas inspection force includes Paul F. Simpson, supervisor; John Ersinger, Sullivan; J. P. Horton, Montpelier; Herschell Ringo, Muncie; C. E. Noble, Princeton; O. H. Hughes, Sharpsville; Howard Legge, Bloomington; Marion Brown, Loogootee; Herman Chanley, Laconia.

The members of the gas inspection force, with the exception of the supervisor, receive compensation for services rendered from fees. Only the three last mentioned members of the office force draw compensation from division funds.

Geological Field Investigations

During the summer geological investigations in the field were undertaken by members of the division. The investigations of petroleum conditions in several counties and the study of ground water conditions were under the direction of the division head and his corps of assistants.

Field work on the Indiana building stone area was continued by R. E. Esarey. His work consisted of the preparation of thin sections, the photographing of mills and quarries, the drawing of geological sections and other lines of work necessary for the preparation of a report.

Field and office work on the preparation of a report on the Borden in Indiana was continued by P. B. Stockdale.

An investigation of Silurian formations in northern Indiana and in nearby states was continued by E. R. Cumings, who was assisted in the field by Lewis Childs and Edgar C. Cumings.

Work on a survey of subterranean drainage in the region of Lost River was continued by C. A. Malott, who was assisted by R. R. Schrock and Lewis Childs.

SPECIAL GEOLOGICAL INVESTIGATIONS

A large number of problems of a geological nature which were submitted to the division during the year required for their solution an appeal to field and laboratory methods. Most of these requests were for the investigation of some of the economic resources of the state.

A request was made for the examination of an area of coal land in Owen County near the town of Patricksburg. A map of the area was completed showing the drainage and all coal outcrops. Locations were made for drilling tests and at the completion of the drilling a map was constructed to show the distribution of two beds of coal within the area. This investigation required several visits to the area and involved considerable work in the laboratory.

An appeal was made to the division for assistance in the solution of a quarry problem by one of the largest producers of mineral wool in Indiana. The investigation of the problem required a number of visits to the quarry, the services of a competent driller (obtained by the division), and the careful study of the cores obtained from the drilled area. The investigations were spread over several months and at their conclusion a chart and report embodying the results of the investigations were furnished the company. One of the former assistants of the division who assisted in the investigations is now permanently employed by the company.

In the drilling of a deep well near Plymouth, in Marshall County, natural gas was encountered. The well was drilled by an oil company that was not particularly interested in natural gas, but citizens of Plymouth were interested in the possibilities of obtaining commercial supplies of natural gas for industrial purposes. Assistance was requested of the division. Since the bedrock formations of the area are concealed by glacial drift, which attains a thickness of more than 200 feet, it is impossible to study structural conditions of the area by surface examination. It was suggested by the division that three wells, or two in addition to the one which had been completed, be drilled to the upper surface of the Devonian limestone. By the use of the records of these wells, obtained through the study of drillings and of the elevations of the mouths of the wells, the structural conditions will be determined and recommendations made for future drilling. The locations of the test wells have been made and the second well has been completed.

The location of a deposit of plastic dark-burning clay was made for a ceramic company engaged in the manufacture of tile in Indiana. Samples of the clay were first tested in the division's laboratory and later samples were supplied to the company for testing on a larger scale.

A request by citizens of Clay County for the examination of an area of land near Clay City to determine the presence of structural conditions favorable to the accumulation of oil received the attention of the division. A field examination was made, the records of outcrops of coal beds, of mine snafts, and of available deep wells were studied, and a report was made in which the most favorable places for drilling

were indicated. At the request of a citizen of Vanderburgh County a series of rocks and minerals were determined to prevent valuable economic products being covered in a proposed reservoir site.

An examination of an area of land in the northern portion of Washington County, near the Mt. Carmel fault, was made with a view to determining structural conditions favorable to the accumulation of petroleum or natural gas.

A Maryland roofing manufacturing concern submitted a sample of red colored brick with a request for a similar product from Indiana. The manufacturers of red-burning brick in Indiana were asked to submit samples.

A request was made for an examination of a shale deposit near Oak Park, in Putnam County. The shale was thought to have slip qualities. Samples of the clay were subjected to laboratory tests and a report supplied. A deposit of coal near Mineral City, in Greene County, was examined in the field, samples collected and a report furnished. A field examination of an area of building stone land in Shawswick Township, in Lawrence County, was made for stone dealers of Pittsburg. Shales and clays were collected in Brown County for testing in the laboratory to determine ceramic uses. Clays and shales were collected from exposures in Clay County, near Centre Point, for laboratory testing. The examination of an outcrop of limestone in Jackson County, which was desired for road-building purposes, was made and a report on the quality of the stone furnished. A coal deposit near Ardney, in Owen County, was examined to determine its value for stripping purposes. Clays and shales from the Chester formations in Greene County and shales from the Borden formation in Morgan County were collected for laboratory testing. A field examination of an outcrop of oil shale was made. A sample of the shale tested in the laboratory yielded shale oil at the rate of 14 gallons per ton.

An examination of a deposit of calcareous rock which was thought to be Fuller's earth, occurring near Salem, was examined. An area of rocks in Montgomery County supposed to contain gold was examined. Much of the so-called gold proved to be mica. A few flakes of gold were found in connection with rocks from the glacial drift. On request, an area of building stone southeast of Mitchell was examined and a report furnished.

INVESTIGATIONS OF WATER RESOURCES

In recent years the division has received a large number of requests for information concerning possible sources of water supply. These requests have come from individuals and from corporations and towns. In the course of the division's field work in the study of other economic phases of Indiana's geology, information has been collected regarding hydrographic conditions. Particularly has such information been collected in the study of the coals, petroleum, and natural gas.

During the past field season systematic studies of water conditions in a large number of counties were undertaken. Information regarding the depth of wells, the geological conditions of the water-bearing

horizon, the character and abundance of available supplies was obtained in many counties. This information is being organized and placed in a form which will be accessible to those citizens of the state who are confronted with problems of adequate and potable water supply.

Information regarding city water supplies in Indiana, which has already been assembled for a large number of cities of the state, includes facts as to depth to water level, depth to bedrock, kind of water-bearing stratum, volume of water, size of casing, date of drilling, abundance and variation of supply, quality and hardness of water, height of water in wells, location of artesian supplies and springs, if any, use of perforators, number of wells in use, daily consumption, and per capita consumption.

PETROLEUM AND NATURAL GAS INVESTIGATIONS

A further study of geological conditions in Vigo and Sullivan counties was undertaken during the year, and additional information obtained regarding structure conditions in the Siosi field and in the outlying areas. Additional information obtained includes the records of wells recently drilled, the elevation of these wells with reference to sea level, drillings from the wells, and locations of the wells in the field.

A study was undertaken of the oil fields of Spencer County. All of the fields were visited and information obtained regarding the geological conditions. The fields near Gentryville, Patronville, Rock Hill and Troy were visited, as were many of the deep wells which have been drilled in other parts of the county. A map of the county was prepared which exhibited, by structural contours, the principal structural features of the county, and also indicated the locations of the wells which have been drilled. These maps were distributed to operators in the county as requested. These studies will be continued as new developments take place.

Information regarding the gas fields of Decatur County was collected during the course of field work in that county. These fields lie south of Greensburg. They lie on the western slope of the Cincinnati arch not far below the crest. The structure is apparently not a continuous one but consists of a series of small anticlinal structures, which are separated by depressed areas. The natural gas is obtained from the upper portion of the Trenton limestone. Many of the wells which have been producing for a good many years are still producing. Little progress can be made in the determination of structural conditions in a large part of the county because of the absence of outcrops of the bedrock formations.

SPECIAL PETROLEUM INVESTIGATIONS

Many requests for services in connection with petroleum and natural gas development came to the division during the year. All investigations were made with a minimum of expense to the operator and the division.

At the request of an oil company drilling a deep test in Crawford County, an investigation was made which involved laboratory and field work. Samples of drillings from the well were studied in the laboratory. In the field, the elevation of the well above sea level was determined and the geological horizon of the mouth of the well was ascertained. As a result of the studies, the geological formations encountered by the drill were identified and suggestions made as to probable productive horizons and to structural conditions as revealed by this and neighboring wells.

The geological horizon of the mouth of a deep well near Covington was determined, the position of the mouth of the well above sea level determined, a study made of the record and of drillings and the geological formations identified. A similar study was made of a well drilled near Alton, in the southern portion of Crawford County.

An examination of an area of land in Bartholomew County was made to determine the structural conditions. A report on petroleum and natural gas in Indiana was supplied to the author of a book on these resources for the United States.

LABORATORY INVESTIGATIONS

The preparation of thin sections of building stones for study under the microscope was continued. More than 100 sections have been prepared. Sections were made also for use in the study of the mineral wool rock. The clays and shales collected in the study of the ceramic resources of the state were subjected to laboratory tests in the determination of plasticity, shrinkage, bonding power, fusion and other physical properties. Small objects of ceramic art were manufactured from each sample of the clay.

Special geological problems which required laboratory investigations for their solution included a study of drillings from a deep well in Sullivan County to determine geological formations encountered by the drill; a study of drillings from a well at the Dunes Park to determine the geological formation from which water was obtained; identified a collection of fossil plants; furnished information on Silurian limestone of Indiana to a paving products company; supplied information on clay and shale resources near Oakland City; identified a coal horizon near Odon; furnished information on Indiana magnesian limestone to a Michigan chemical company; supplied information on limestone for manufacture of lime near Mitchell; tested a sample of oil shale from Monrovia; examined samples of bog iron ore from near Springville; made laboratory tests and reported on samples of clay and shale from near Hillsdale; reported on oil and gas conditions in eastern Pike County to Chamber of Commerce at Oakland City; supplied information on oil and gas in eastern Indiana to a commercial plant in Hamilton, Ohio; made identification of geological horizons in a deep well in Crawford County through the study of drillings; made an investigation of a supposed meteorite from Patoka; furnished information regarding geological conditions near Ashley and studied drillings from wells for an oil company operating there.

An examination was made of samples of shale or wool rock from

Marion and a report made; examined and reported on iron ores from Ripley County; examined drillings from a deep well in Lagrange County and furnished opinion as to stratigraphy; made a laboratory examination of a sample of gravel and sand from Clark County supposed to be gold bearing; supplied information on Mississippian formations of Indiana to member of Oklahoma geological survey; presented information on Indiana coals to the Coal Conversion Corporation; furnished list of producers of Indiana coal to trade journal; examined sample of solid bitumen from Borden shales; examined sample of soil containing oil from Edinburg; supplied information on gravel production in Marion County.

CO-OPERATIVE INVESTIGATIONS

The division co-operated with a number of divisions and departments of the state government during the year. Visits were made to the Brown County Game Preserve, the Nancy Hanks Memorial, Clifty Falls State Park, Spring Mill State Park, Pokagon State Park, and McCormick's Creek Canyon State Park. These visits were made in the interest of water supply, building materials and other geological problems.

Assistance was also given to the State Highway Department, Department of Mines and Mining, Secretary of State and other departments.

PUBLICATIONS

A number of reports and articles were published by the Division during the year. The "Report of the Division of Geology" for 1928 was published in the annual Year Book. This publication includes reports on field investigations, petroleum investigations, special geological work, laboratory investigations, mineral and rock determinations, office work, state museum, mineral production in Indiana, natural gas supervision, oil and gas operations in Indiana, and summary of drilling operations in 1928.

A report on the "Geological Conditions in the Siosi Field" was published in the division report in the Year Book. This report includes a discussion of the location of the field, the geological conditions in the field, the Pennsylvanian formations, a typical Pennsylvanian section, the Chester formations, a typical Chester section, the older Mississippian formations, the "Big Lime," the Borden formations, the Kinderhook formations, the Devonian formations, the New Albany (Cinnamon) shale, the Corniferous limestone, the Schoharie formation, the Silurian formation, a geological section, the structure map, the cross-sections, conditions beyond the Siosi field, typical well logs, and daily production in barrels.

"Some Structural Features of the Upper Surface of the Trenton Limestone in Indiana" was published in the proceedings of the Indiana Academy of Science. The report shows by means of contour lines the position of the upper surface of the Trenton limestone with reference to sea level. In a small area in the eastern part of Indiana the surface of the Trenton lies more than 100 feet above sea level, while in a small area in the southwestern part of the state it lies at a depth of 4,500 feet below sea level. The northeastern part of the state lies within a synclinal basin, which is separated from a southwestern synclinal basin

by the Cincinnati arch. The arch consists of a southeastern portion and a northwestern portion separated from the former by a sag in the arch. The conditions of the arch and of the synclinal basins are discussed together with the faulting in the southwestern synclinal basin.

Two "Geological Sections Across Indiana" were published. These sections show the geological formations which occur at the surface and which have been encountered in the deep wells of the state, the approximate thickness of each formation, the structural conditions, the location of cities and industries, the economic products from each formation, the mineral production and the rank of the state in each product.

Reports on the geology and economic products of a number of counties were furnished newspapers in those counties. Counties which were supplied with such information were Greene, Warrick, and Spencer. At the request of the Chamber of Commerce of Bedford, a report on the economic resources of Lawrence County was furnished for a publication which they issued.

MINERAL AND ROCK DETERMINATIONS

A large number of rocks and minerals were received at the office and laboratory from citizens of the state with requests for determinations, analyses and reports. Samples were submitted by land owners, collectors, well drillers, and others interested in a commercial or scientific way in the mineral resources of Indiana. Information was supplied concerning the following rocks and minerals:

Well drillings	1,684	Gas	2
Limestones	43	Corals	10
Shales	39	Fossil plants	10
Clays	35	Brachiopods	9
Pyrite	25	Concretions	7
Granite	23	Iron ores	7
Chert	20	Geodes	7
Marcasite	19	Selenite	6
Fossils	17	Igneous rocks	6
Quartzite	16	Schist	5
Water	16	Flint	5
Limonite	16	Lime carbonate concretions	4
Calcite	15	Brick	4
Mica	13	Aluminum silicate	3
Oil	13	Greenstone	3
Sandstone	12	Gneiss	3
Quartz	11	Niccolite	3
Silver and mercury	3	Red ochre	3
Oil shale	3	Albertite	2
Clay ironstone	3	Kaolin	2
Crinoids	3	Marble	1
Pentremites	2	Pegmatite	1
Zinc ore	2	Asbestos	1
Oil sands	2	Copper	1
Sericite	2	Diorite	1
Silt	2	Soils	1
Marl	2	Stylolite	1
Slag	2	Coal	1
Gypsum	2	Meteorite?	1
Silica	2		
		Total	2,157

STATE FAIR EXHIBIT

In co-operation with Indiana University a film was prepared for exhibition at the State Fair. This film carried the story of the operation of coal mines and an appeal to the people of Indiana for a greater consumption of Indiana coal by its industries and its people.

An exhibit of Indiana birds was taken from the state museum to be used as a part of the same exhibit.

MINERAL PRODUCTION IN INDIANA

Although Indiana ranks thirty-seventh in size among the states of the Union, in the value of her mineral production she ranks twelfth. The principal mineral products of the state in order of value are coal, cement, stone and clay products. The following table compiled by a co-operative agreement between the United States Bureau of Mines and the Division of Geology gives the mineral production in Indiana for 1927:

Product		1927	
		Quantity	Value
Cement	barrels	(1)	(1)
Clay products			(2)$17,855,971
Clay, raw	short tons	163,593	206,361
Coal	short tons	17,935,758	36,381,000
Coke	short tons	5,549,762	37,152,981
Iron, pig	long tons	3,447,764	62,097,518
Lime	short tons	116,171	830,527
Mineral paints, zinc and lead	short tons	(1, 3)	(1, 3)
Mineral waters	gallons sold	(4)	(4)
Natural gas	M cubic feet	1,124,000	509,000
Peat	short tons	(4)	(4)
Petroleum	barrels	852,000	1,390,000
Abrasives	short tons	285	37,461
Sand and gravel	short tons	11,870,658	5,552,806
Sand-lime brick	thousands	(1, 2)	(1, 2)
Stone	short tons	5,813,000	22,634,359
Sulphuric acid (5)	short tons	(1, 3)	(1, 3)
Miscellaneous (6)			24,808,283
Total value, eliminating duplications			$107,578,234

(1)Value included under "Miscellaneous."
(2)Figures obtained through cooperation with Bureau of the Census.
(3)Value not included in total value for State.
(4)No canvass.
(5)From zinc smelting.
(6)Includes minerals indicated by "(1)" above.
Statistics gathered by cooperation of Division of Geology with United States Bureau of Mines.

OFFICE WORK

The following have been included in the office work of the division: Answering correspondence, which again showed an increase over the preceding year; preparing maps and reports; collecting information and statistics; giving to callers in the office such information as they desire. A constant effort has been made to insure that all replies to inquiries be made as complete as possible from information available in the office. Many of the inquiries concern development of mineral resources, and an appreciable sum has been saved by advice which prevents the expenditure of money on development that would be unprofitable.

Several charts have been prepared for display in the museum. Part of the geological library has been revised, as well as the stock of salable publications. Copies of the new publications have been mailed to the addresses on our exchange list. Other reports received in exchange are filed in the division library.

The following is a summary of the office work:

Letters received	2,487
Packages received	902
Letters mailed	5,505
Packages mailed	455
Reports distributed	1,540
Handbooks of Indiana Geology	89
Parts of Handbook	32
Geology of the Deep Wells of Indiana	60
Petroleum and Natural Gas in Indiana	10
Geological Conditions of the Oil Fields of S. W. Indiana	32
Kaolin in Indiana	61
Geology of the Silurian Rocks of Northern Indiana	468
Indiana Oolitic Limestone Maps	180
Handmade Indiana Geological Maps	8
Annual geological	600
Oral reports	974

STATE MUSEUM

Progress is noted this year in the fact that the museum, after being closed two years, is again showing a notable collection in cases in the aisles of the basement. The exhibition is attracting much attention and the attendance is rapidly increasing, although it is not as large as when a separate room was available.

Recent work has placed the collection in the best condition it has been in for years. The storage facilities remain very bad and it is hoped that the next legislature will pass a bill creating a fund for a new museum building.

Among the large collections acquired during the year is the Hay collection from Bass Lake, Indiana, one of the most noteworthy in several years. Several specimens have been added to the Russel Ratliff collection.

During the coming year efforts will be made to secure some of the best collections in the state so that a new building can house a collection that will be as large and as complete as any of the state museums.

DONATIONS

French watch, brought to the United States in 1852 by Nicholas Kleber. Donated by Miss Laura Kleber, Corydon, Indiana.

Unique hen's egg. Donated by Frank Arnold, Stilesville, Indiana.

Added to the Russel Ratliff collection: 20 fossils; 28 arrow heads; 32 spear heads; 3 fish spears; large celt (chipped); one celt; 29 pieces arrow and spear heads; 1 book; 1 piece calcite; 1 piece iron; specimen pyrite; chalcopyrite (copper ore); galena (lead ore); sulphur; rock salt; malachite (copper ore); obsidian; lead and silver ore; pyrite and gold; feldspar.

Thirty arrow heads; 23 broken arrow heads; 1 broken drill; 3 pebbles; 2 specimens crystal quartz; 8 quartz specimens; 5 fossil shells; 8 unclassified rocks; 20 pieces bone needles; 2 halves of tusks. The foregoing collection was donated by C. H. Lovett, 715 W. 32nd Street, Indianapolis.

Organ and stool purchased in the 70's by William T. Eaton. Donated by his daughter, Mrs. Mary Eaton Payne, Indianapolis.

Cane (horn), presented to A. P. Hendrickson by General R. S. Foster, October 21, 1891. Donated by Mrs. A. P. Hendrickson.

Two letters dated 1858. Donated by Herman Rossiter, Indianapolis.

During the year the following valuable collection was purchased from J. B. Welborn: 1 Great Blue Heron; 1 Blacksnake; 1 Coot, 1 Robin; 1 Virginia Rail; 1 Ground Hog; 1 Owl; 1 Heron.

Harper's Ferry flint lock musket purchased by the museum. Carried at Cerro Gordo and Harper's Ferry.

Five guns (2 cap and ball) used by guards at the prison at Jeffersonville, Indiana. Presented by Warden Miles of the State Prison, Pendleton.

Side saddle which belonged to Miss Mattie V. (Ross) Smith. Presented to her on her 18th birthday, December 29, 1879. Donated by her heirs Messrs. Guy, Herbert and Clay Smith and Mrs. W. T. Flynn, Des Ark, Arkansas.

A collection secured from the attic of the school building at Westfield, Indiana, through the kindness of the school officials: Piece of very old cloth; double gourd (Indian); quaker hat; shoes from South America; also specimen pottery; comb; 2 pieces basketry; dagger; metal; fibre stripper; pan; wooden spoon; 3 ornaments; 5 photographs; Mexican sandals; 10 shells; 11 fish scales; candle mold; reap hook; rattlesnake rattles; 6 animal skulls; pearls from head of perch; 2 nuts; 19 birds' nests.

Testament of 1836; cane of cedar from Perryville, Kentucky, battlefield; Madonna wood from California; pillbags of Dr. R. Bosworth, the first used in Jay and Randolph counties; necrosed bones of two patients of the doctor; 14 geological specimens collected by the doctor. Presented by Dr. Bosworth's daughter, Mrs. Flora Bosworth Ellwood, Winchester, Indiana.

Bead necklace, made by an old squaw of a reservation near Kingman, Arizona, about 1910, donated by Jane York Moore, Indianapolis.

Five pieces flint, donated by Austin Powell, Greenfield, Indiana.

Flag once used by G. A. R. at New Palestine, presented by Lipman Joseph, New Palestine, Indiana.

Pieces of obsidian from Obsidian Cliff, Yellowstone National Park; 2 arrow points, one unfinished point and 1 piece, all of obsidian from southern Idaho. Donated by Sheriff Sam Cole, Warren County.

Deposit of silica, obsidian, rhyolite and fossilized wood from Yellowstone National Park. Calcium carbonate from Mammoth Hot Springs, the same park. Donated by Theodore Kingsbury, New York City.

Freak hen's egg, donated by Mr. and Mrs. Will Evans, Noblesville, Indiana.

Woods representing different battlefields of the Civil War; Kenesaw Mountain; Chicamauga, Missionary Ridge, Lookout Mountain, Murfreesboro, Stone River, Atlanta-to-the-Sea. Presented by E. S. Wamsley, Indianapolis.

Bird's nest taken from the mouth of a cave. Presented by Paul F. Simpson, Indianapolis.

Cave onyx from Marengo cave. Donated by Fred Ehlers, Indianapolis.

Eight arrow heads, 8 eagle claws, 16 alligator teeth, 1 alligator claw, all from Florida, loaned by George M. Wagner, Jr., Orlando, Florida.

Ballot of Rutherford B. Hayes for president, Wm. A. Wheeler, vice-president and electors, donated by Temple R. Holleroft, Aurora, New York.

Monkey-face barn owl, donated by Venna Leonard, Lebanon, Indiana.

Pair roller skates, among first used. Used by the donor, B. F. Stoner, age 73, Lebanon, Indiana, when he was a young man.

Collection of Frank Hay, of Bass Lake, Indiana, donated as a memorial to her father by Miss Oran Hay, Bass Lake; 6 mastadon bones from Laporte County; leg iron, used by the Spanish on prisoners in the Philippine Islands; 1 bow and four poisoned arrows from the Philippines; flint lock barrel, Wisconsin; 2 orange wood canes, Florida; shark's jaw; bone of swan; fin of whale; geode; diamond back terrapin; Conder turtle; dry land turtle; Florida gopher; fin of whale; birch bark and canoe; 4 pieces wood not named; beaver skull; cutting of beaver and chips from Wisconsin; cutting of beaver; 97 geological specimens; 9 pieces sponge coral; collection of several hundred Florida shells; sea beans; four sea dollars; 24 pieces coral; 7 star fish; three shell egg cases; three sea cucumbers; five specimens sponge growth; ten sponge baskets; 1 aerial bomb; rush Indian mat.

NATURAL GAS SUPERVISION

The duties of the State Gas Supervisor and deputies consist of the following: To inspect gas wells and lines to make sure that natural gas is not being allowed to escape into the open air in violation of the state conservation law; to investigate reports of leaking gas, and if violations are found, to order the lines or wells repaired; to supervise the plugging of abandoned wells; to collect all available information of geological nature, especially that bearing on gas and oil possibilities in Indiana, and make it available to the citizens of Indiana.

Inspection trips have been made to some of the gas fields of the state. A number of abandoned or nearly useless wells were also visited, and recommendations made for plugging or repairing. In most cases the owners willingly met the requirements of the law. Two trips have been made to Jay County during the past year, where an effort was made to clean up the matter of old wells. The wells which are still producing in the nearly exhausted fields are damaged by those which have been abandoned, and which permit water to enter the oil-bearing sand.

Attention is called to the fact that one new deputy has been appointed at Laconia to serve the central-southern part of the state. During the fiscal year, the state supervisor and deputies have plugged 221 wells.

A card file assists in following the progress of wells as they are drilled. The information, which is thus kept fairly recent, is distributed monthly in the Oil and Gas News. This mimeographed bulletin has been published regularly since December, 1921. Its popularity has increased among drillers and operators until its mailing list now includes more than 275 addresses.

A few operators are careless about observing the regulation which requires a log within 30 days after the completion of an oil, gas or test well. A periodic check of our records of drilling operations reveals the violators of this regulation, and letters requesting the logs are sent to them. Three series of letters sent during the year have been the means of obtaining many logs. Approximately 600 logs have been placed in our files since the publication of "The Geology of the Deep Wells of Indiana" in the spring of 1926, which included all of the logs available at that time. Thus a total of over 2,000 well records are available to interested citizens of the state.

OIL AND GAS OPERATIONS IN INDIANA

The detailed records which have been kept for the deep wells that have been drilled in the state show that 181 wells have been completed during the past fiscal year. Of these, 90 were non-productive, 33 produced gas, and 58 were oil producers. In addition, 34 wells remained uncompleted on October 1, 1929.

Drilling has not increased in the old Trenton field, since the main portions of the territory have been thoroughly tested. Wells recently completed have had an initial production of 10 to 40 barrels daily, but have quickly settled to much less. Even with the comparatively low

cost of drilling, the activities are showing a decline. Many more wells are being abandoned than are being drilled, consequently the production for northeastern Indiana has shown a further decrease.

Production in southwestern Indiana has shown an increase, due to an increase in the number of producing wells. Scattered wildcat wells have discovered only one field, in Spencer County near Troy. Early in the summer of this year, numerous tests and extensive leasing predicted a boom for Spencer and Perry counties. The majority of the tests were failures. The small field in the southeastern corner of the county, near Troy, was tapped by wells on the Carlton and Ray farms. Surrounding tests soon indicated that the field was small. However, one well was recently drilled deeper and struck good production in the McCloskey sand, thus reviving interest somewhat. The Siosi pool in Sullivan and Vigo counties and the Mt. Olympus pool in Gibson and Pike counties have shown the greatest activity.

Along the Mt. Carmel fault line in Monroe and Lawrence counties, the Petroleum Exploration Company has leased thousands of acres, and is expecting to thoroughly test the structures coincident to the fault. Their first test is uncompleted. Small quantities of gas and showings of oil have been the net results of former tests in this area. Two wells were drilled in Morgan County near Mooresville, but did not find even a good showing.

The recent development in the Muskegon field in Michigan has caused many leases to be taken in northern Indiana. Two or three scattered tests are now drilling. A little oil was found at Lagrange and some gas at Plymouth. The thick mantle of glacial drift which covers that part of the state makes the geological knowledge of the region obscure, except as revealed in well logs. Many tests will have to be made before it can be said that no structures exist there.

A few new gas wells have been drilled in the Rush and Decatur county fields, all being good producers. The production in the older gas fields has not increased materially, but, with the exception of the old fields of Delaware and neighboring counties, show no prospect of an immediate decline.

The greatest discoveries during the year were the large gas wells near Francisco in Gibson County. One of these gauged an initial open flow production of 11,718,000 cubic feet per day. Other large wells have proved the existence of reservoirs which contain enough gas to supply all of the larger towns in the southwestern corner of the state. Vincennes, Washington, Princeton and neighboring towns are already using natural gas. A ten-inch main has recently been started which will connect Evansville with the producing fields.

The following statistics have been released by the Petroleum Economics Division of the Bureau of Mines, United States Department of Commerce:

In northeastern Indiana during 1927, 960 wells, averaging 0.3 barrel per day, produced 126,000 barrels of oil valued at $1.51 per barrel, or $190,000. In 1928, 900 wells had the same average daily production, but produced only 89,000 barrels, having a value of $110,000 at

$1.24 per barrel. This decrease was more than counteracted by the wells of southwestern Indiana, where, in 1927, 1,100 wells averaged 1.9 barrels per day; their 726,000 barrels, at $1.65, had a value of $1,200,000 at the wells. In 1928, 1,140 wells were averaging 2.3 barrels per day, thus making a total of 963,000 barrels, worth $1,470,000 at $1.53 per barrel.

The following is a summary of the drilling operations in Indiana from October 1, 1928, to September 30, 1929, inclusive:

County	Township	Section	Farm	Kind of Well
Adams	Jefferson	14	Otto Baker, No. 2	Oil
Adams	Jefferson	14	Otto Baker, No. 3	Oil
Adams	Blue Creek	34	Bollenbacher Heirs	Uncompleted
Adams	Jefferson	3	Sam Egley, No. 1	Oil
Adams	Jefferson	3	Sam Egley, No. 2	Oil
Adams	Jefferson	3	Sam Egley, No. 3	Uncompleted
Adams	Wabash	34	Clark Stanley, No. 3	Oil
Adams	Wabash	34	Clark Stanley, No. 4	Oil
Adams	Jefferson	6	John Teeter	Uncompleted
Adams	Wabash		S. Teeter	Dry
Adams	Blue Creek		S. C. Tinkham	Gas
Clay	Posey	34	W. J. Butt	Uncompleted
Crawford	Boone	28	D. S. Gaither	Abandoned
Crawford	Johnson	30	D. W. Jones	Dry
Daviess	Harrison	T. 1, R. 6	Findlay	Gas
Daviess	Veale	21	Frank Gaither, No. 7	Dry
Daviess	Veale	22	Tilman Gaither, No. 2	Dry
Daviess	Veale	21	Alonzo Veale, No. 3	Oil
Decatur	Washington	14	Charles Barnes, No. 1	Gas
Decatur	Washington	14	Charles Barnes, No. 2	Gas
Delaware	Liberty	36	Harley DeMoss, No. 1	Dry
Dubois	Cass	16	Wm. Meissner	Dry
Fountain	Troy	28	W. B. Coffing	Abandoned
Gibson	Columbia	22	George Allen, No. 1	Gas
Gibson	Columbia	22	George Allen, No. 2	Uncompleted
Gibson	Columbia	22	George Allen, No. 3	Uncompleted
Gibson	Columbia	34	Thos. Bailey, No. 1	Dry
Gibson	Columbia	2	S. M. Cantrell	Dry
Gibson	Columbia	15	Manford Corn, No. 2	Dry
Gibson	Washington	18	Laura Dillon, No. 2	Gas
Gibson			Duncan Heirs	Dry
Gibson	Barton	8	Mary E. Duncan	Gas
Gibson	Washington	29	E. S. Ewing	Oil
Gibson	Barton	5	S. M. & W. S. Farries, No. 1	Oil
Gibson	Barton	5	S. M. & W. S. Farries, No. 2	Gas
Gibson	Barton	5	S. M. & W. S. Farries, No. 3	Dry
Gibson	Barton		Tom Fleener	Uncompleted
Gibson	Columbia	25	Gudgell	Uncompleted
Gibson	Columbia	22	F. G. Holton	Dry
Gibson	Washington		Wesley Ice	Gas
Gibson	Washington	Loc. 127	R. F. Lindy	Dry
Gibson	Washington	1	Rudolph Nixon	Dry
Gibson	Columbia	22	Ralph Onyett, No. 1	Gas
Gibson	Columbia	22	Ralph Onyett, No. 2	Gas
Gibson	Washington	7	J. W. Phillips, No. 1	Dry
Gibson	Washington	7	J. W. Phillips, No. 2	Dry
Gibson	Washington	7	J. W. Phillips, No. 3	Dry
Gibson	Center	5	J. Schlump	Dry
Gibson	Washington	1	Ira Seifers, No. 1	Oil
Gibson	Barton	17	Hugo Shumacher	Dry
Gibson	Washington	18	C. T. Sloan, No. 1	Oil
Gibson	Washington	18	C. T. Sloan, No. 2	Gas
Gibson	Washington	6	Frank Thompson, No. 2	Oil
Gibson	Washington	6	Frank Thompson, No. 3	Oil
Gibson	Center	32	Wm. Volkman, No. 1	Gas
Gibson	Center	32	Wm. Volkman, No. 2	Gas
Gibson	Center	32	Wm. Volkman, No. 3	Uncompleted
Gibson	Washington	18	Paul White, No. 1	Gas
Gibson	Center	21	F. Wilderman, No. 3	Dry
Gibson	Barton	5	John Williams, No. 1	Oil
Gibson	Barton	5	John Williams, No. 2	Dry
Gibson	Barton	5	John Williams, No. 3	Oil
Gibson	Barton	5	John Williams, No. 4	Uncompleted
Gibson	Columbia	15	V. Wirth, No. 1	Dry
Gibson	Union	4	J. A. Woods, No. 1	Dry
Greene	Stockton	3	B. A. Rose (Ad Wright)	Dry

County	Township	Section	Farm	Kind of Well
Hancock			(Fountaintown Nat. Gas Co.)	Gas
Hancock			(Fountaintown Nat. Gas Co.)	Gas
Hancock			W. S. Ham	Dry
Harrison	Boone	15	Jonathan Zimmerman	Dry
Jay	Bear Creek	21	C. E. Brinkerhoff, No. 8	Oil
Jay	Richland	24	Oscar Currant	Oil
Johnson	Franklin		McQuiston	Abandoned
Knox	Johnson	Surv. 11	John Emmison, No. 1	Oil
Lagrange	Clay		Ivo Chrystler, No. 2	Abandoned
Lagrange	Clay		Clair Shoup	Uncompleted
Marion	Lawrence		H. F. Fye	Dry
Marshall			Frank Lamson, No. 2	Uncompleted
Martin	Center		Harrison Gibson	Dry
Martin	Baker	30	John Larkin	Abandoned
Monroe			R. Howell, No. 1	Uncompleted
Monroe	Clear Creek	35	John Fox	Abandoned
Morgan	Brown		Newton Godsey	Abandoned
Morgan	Brown		Bill Moon	Uncompleted
Perry			George Beaver	Dry
Perry	Clark	25	Frank J. Delaise	Uncompleted
Perry	Troy	18	Devillez	Dry
Perry	Tobin	18	Adam Glenn	Abandoned
Perry	Troy		Sarah Hammack	Abandoned
Perry	Troy	14	J. W. Jarboe	Dry
Perry	Anderson	31	Frank Lucke	Uncompleted
Perry	Troy		L. E. Peckinpaugh	Abandoned
Perry	Troy	22	Jos. Schneider	Abandoned
Pike			John Arnold	Dry
Pike	Logan	23	Amos Atkinson	Dry
Pike	Clay	Loc. 21	J. R. Brenton, No. 1	Dry
Pike	Washington	19	P. Crow	Dry
Pike	Clay	Loc. 12	J. N. Davidson	Gas
Pike	Jefferson		Frank DeMotte	Uncompleted
Pike	Patoka	19	Jas. Fettinger	Gas
Pike	Clay	Loc. 9	John Ford	Uncompleted
Pike	Logan	26	Fannie Fowler	Oil
Pike	Washington	29	Aaron George, No. 1	Gas
Pike	Washington	29	Aaron George, No. 2	Dry
Pike	Washington	29	Aaron George, No. 3	Gas
Pike	Washington	29	Aaron George, No. 4	Gas
Pike	Washington	29	Lew George, No. 1	Gas
Pike	Washington	29	Lew George, No. 2	Gas
Pike	Washington	29	Lew George, No. 3	Gas
Pike	Clay	31	James Hoagland	Dry
Pike	Patoka	18	Tom Hurt, No. 1	Oil
Pike	Patoka	18	Tom Hurt, No. 2	Uncompleted
Pike	Clay	32	R. A. Hyneman	Oil
Pike	Clay	Loc. 12	Della Kime, No. 1	Oil
Pike	Clay	Loc. 12	Della Kime, No. 2	Oil
Pike	Clay	Loc. 12	Della Kime, No. 3	Oil
Pike	Clay	Loc. 12	Della Kime, No. 4	Oil
Pike	Clay	31	Henry Lindy	Oil
Pike	Clay	31	Neal Lindy, No. 1	Gas
Pike	Lockhart	33	Wilhelmina Martin	Dry
Pike	Clay	22	Chas. McAtee, No. 2	Oil
Pike	Clay	Loc. 16	John McAtee, No. 1	Gas
Pike	Clay	Loc. 16	John McAtee, No. 2	Uncompleted
Pike	Patoka	24	John McRillip	Gas
Pike	Logan	19	Wm. Miley	Dry
Pike	Madison	26	Rufus Morgan	Abandoned
Pike	Washington	30	Verner Preston	Oil
Pike	Patoka	21	Mary E. Price	Dry
Pike	Madison		W. H. Shawhan	Uncompleted
Pike	Logan	23	George Stewart, No. 3	Oil
Pike	Patoka		Williams, No. 3	Oil
Pike	Washington	4	David Wuertz	Dry
Posey	Harmony	28	(Geo. F. Robertson)	Uncompleted
Posey	Marrs		Dr. Welborn	Abandoned
Pulaski	Salem	17	Bennett Taylor	Dry
Putnam			S. F. Kennedy	Uncompleted
Shelby			(Fountaintown Nat. Gas Co.)	Dry
Spencer	Huff	17	Wm. Arnold	Abandoned
Spencer	Ohio	34	Henry Bretz heirs, No. 1	Abandoned
Spencer	Ohio	34	Henry Bretz heirs, No. 2	Dry
Spencer	Ohio	3	Raymond Bretz	Dry
Spencer	Ohio	3	Wm. Bretz	Dry
Spencer	Ohio	3	Brown Trust Co	Dry
Spencer	Ohio		Fred Butler	Dry
Spencer	Huff	11	Lee Carlton, No. 1	Oil
Spencer	Huff	11	Lee Carlton, No. 2	Oil

County	Township	Section	Farm	Kind of Well
Spencer	Huff	11	Lee Carlton, No. 3	Abandoned
Spencer	Ohio	35	George Cissna, No. 1	Oil
Spencer	Ohio	35	George Cissna, No. 2	Oil
Spencer	Luce	5	Cord Dooley	Dry
Spencer	Huff	11	F. W. Grass	Abandoned
Spencer	Huff	11	G. A. Grass	Dry
Spencer	Ohio	2	Chas. Hoffman	Dry
Spencer	Huff	18	A. C. Huff, No. 1	Dry
Spencer	Huff	18	A. C. Huff, No. 2	Dry
Spencer	Jackson		Huppert	Uncompleted
Spencer	Grass	16	John C. Kinney	Dry
Spencer	Grass	6	Truman Lemmon	Uncompleted
Spencer	Clay	4	Mary E. Ludwig	Dry
Spencer	Ohio	33	Orville Martin	Dry
Spencer	Ohio		Catherine Powell	Dry
Spencer	Huff	11	Arthur Ray, No. 1	Oil
Spencer	Huff	11	Arthur Ray, No. 2	Oil
Spencer	Huff	11	Arthur Ray, No. 3	Oil
Spencer	Huff	11	Arthut Ray, No. 4	Oil
Spencer	Huff	11	Arthur Ray, No. 5	Oil
Spencer	Luce	28	J. Ban Richardson, No. 2	Abandoned
Spencer			Edwin Schriefer	Dry
Spencer	Ohio	3	Leo Strassell, No. 1	Oil
Spencer	Ohio	3	Leo Strassell, No. 2	Oil
Spencer	Ohio		Terrell Weatherholt	Dry
Starke	California	10	Wm. B. Lewis	Dry
Steuben	Steuben		Peter Snowberger	Oil
Sullivan	Gill	26	Brock	Gas
Sullivan	Fairbanks	15	I. B. Buchamp	Dry
Sullivan	Gill	4	G. W. Buff, No. 1	Oil
Sullivan	Gill	4	G. W. Buff, No. 2	Uncompleted
Sullivan	Turman	7	A. Cushman	Abandoned
Sullivan	Fairbanks	15	Madison Drake	Abandoned
Sullivan	Turman	30	Lige Duffer, No. 1	Gas
Sullivan	Turman	2	J. Harris	Gas
Sullivan	Hamilton	31	Arthur Hunt	Dry
Sullivan	Gill	4	J. R. Johnson	Dry
Sullivan	Turman	30	Mary Mann	Gas
Sullivan	Gill	4	W. E. Maple	Dry
Sullivan	Fairbanks	5	Tutt Mayfield, No. 2	Oil
Sullivan	Turman	33	Alex Raley, No. 4	Oil
Sullivan	Turman	33	Alex Raley, No. 5	Uncompleted
Sullivan	Fairbanks	6	Chas. W. Scott, No. 2	Oil
Sullivan	Fairbanks	6	Chas. W. Scott, No. 3	Oil
Sullivan	Fairbanks	6	Chas. W. Scott, No. 4	Oil
Sullivan	Gill	26	Morris Unger	Abandoned
Sullivan	Gill	26	Morris Unger, No. 2	Gas
Sullivan	Turman	31	J. W. Watson	Abandoned
Sullivan	Turman	5	Elmore Williams, No. 3	Oil
Sullivan	Fairbanks	5	Iley Williams, No. 4	Oil
Vanderburgh	Armstrong	3	Geo. S. Kroft	Dry
Vanderburgh	Armstrong	32	John Wills	Abandoned
Vigo	Prairie Creek	31	Miles	Uncompleted
Vigo	Prairie Creek	32	W. C. Piety	Uncompleted
Vigo	Prairie Creek	32	R. Prevo	Uncompleted
Vigo	Prairie Creek	31	Wm. Riggs, Ls. 1—No. 7	Oil
Vigo	Prairie Creek	31	Wm. Riggs, Ls. 1—No. 8	Uncompleted
Vigo	Prairie Creek	31	Wm. Riggs, Ls. 38-40—No. 16	Oil
Vigo	Prairie Creek	31	Wm. Riggs, Ls. 38-40—No. 17	Oil
Vigo	Prairie Creek	32	F. E. Shattuck, No. 3	Oil
Vigo	Prairie Creek	32	F. E. Shattuck, No. 4	Uncompleted
Vigo	Prairie Creek	32	Lennie Thomas, No. 1	Oil
Vigo	Prairie Creek	32	Lennie Thomas, No. 2	Oil
Vigo	Prairie Creek	32	Lennie Thomas, No. 3	Uncompleted
Vigo	Prairie Creek	32	Thomas & Williams, No. 1	Oil
Vigo	Prairie Creek	32	F. I. Williams, No. 6	Oil
Warrick	Boone	7	M. W. Hocker	Uncompleted
Warrick	Skelton	5	John Scales	Abandoned
Warrick	Pigeon	35	Wm. Walters	Abandoned

THE MINERAL FUEL RESOURCES OF INDIANA

BY W. N. LOGAN

The primary importance of Indiana's agricultural industries is well known. But parallel in importance with its food-producing resources stands its mineral resources. Food production in these modern days depends upon mineral fuels for the power to conduct many agricultural operations and upon metals for the machinery necessary to the carrying on of many of its activities.

In earlier times in the history of our country man power largely filled the place of fuel power and of machine power in the production of food. In those days the energy of man was concentrated more largely upon the task of obtaining adequate supplies of food, and less energy was expended in the endeavor to bring to man those articles of civilization which contribute more largely to his intellectual well being.

Under the conditions of modern society, when such a large part of the people is engaged in occupations other than food-producing ones, it becomes increasingly necessary to substitute machine power for man power in agriculture in order that a larger amount of food may be produced by a smaller number of producers, and in order that that large number of people in other occupations may obtain sustenance. Thus, it may be seen that in the matter of food production alone mineral fuels have come to occupy an essential and important position.

The industrial and commercial rank of a state is determined largely by quality and abundance of its mineral resources. Any state that is compelled to depend upon other sources than its own for raw materials and mineral fuels is at a great disadvantage industrially. Mineral fuels are generally recognized as constituting a fundamental basis of any industrial civilization. Indiana is indeed fortunate in the possession of a variety of important mineral fuels.

NATURAL GAS

Natural gas, the most perfect fuel, has been found in Indiana in large quantities. Production on a large scale began in Indiana in 1886. The value of the production reached its highest point in 1900, when it had a value of more than seven million dollars. From that period the production declined until recent years when there has been a slight increase in production.

The largest amount of gas produced in Indiana came from the Trenton formation in the eastern part of the state. Many of the wells drilled in this area were high pressure wells and produced large quantities of gas. Some natural gas is still being produced from the Trenton, but the amount is small. Another gas-producing area is located in Harrison County in the southern part of the state. The gas in this county is obtained from the New Albany shale, which is an oil-bearing shale. A part of the gas produced is being used locally, but a part of it is piped to Louisville for consumption.

Natural gas has been produced in southwestern Indiana in connection with the production of petroleum. Some of the gas so produced

has been piped and used in cities and towns, but much of it has been used in the oil production for boiler fuel and pumping. Recently some of the natural gas has been used to force the oil out of reluctant sands. The discovery of natural gas in some of the deeper sands in the southwestern portion of the state may lead to an increased production of gas from that region.

Oakland City, Princeton, Vincennes, and Washington are cities in the southwestern part of Indiana which are being supplied with natural gas. Information regarding the stratigraphic and structural conditions in the developed area was supplied by the Division of Geology and members of the division assisted in the field work.

PETROLEUM

The production of petroleum in Indiana has extended over a period of more than forty years. The highest production was reached in 1904 when more than eleven million barrels were produced. Since that high peak production has decreased until in recent years it has been around one million barrels. It was larger last year than the year before notwithstanding over-production and the low prices of crude oil.

By pipe line measurement Indiana has produced more than 113 million barrels of petroleum, and at least 13 million additional barrels have been produced and used for fuel and in other ways. The total production has been at least 125 million barrels, which had a value exceeding $300,000,000.

Petroleum has been produced in commercial quantities in twenty-two counties of Indiana. In the eastern portion of the state production is obtained from the Trenton limestone of Ordovician age. The discovery of oil in this portion of the state was made during the search for supplies of natural gas. For many years the entire production was obtained from the Trenton field in Indiana.

Small quantities of petroleum have been obtained from Devonian and Trenton sources in the northern and northwestern portions of Indiana.

In the southwestern portion of Indiana petroleum has been obtained from rocks of Pennsylvanian, Mississippian and Devonian age. The largest production has been obtained from Vigo, Sullivan, Pike, Gibson, and Daviess counties. More than twenty oil-bearing horizons have been found in this section of the state. The production of this portion of the state in recent years has exceeded the production in the eastern Trenton field.

The production of oil in Indiana has not been from "gushers." Wells which produce 50 to 60 barrels per day during initial production have been the exception. The wells have been small producers, but a compensating factor has been the long period of production of the large number of wells. Some groups of wells have continued production for more than twenty years and some individual wells for forty years.

OIL SHALES

When the petroleum and the other more readily available mineral fuels of Indiana are exhausted it will be possible to obtain large quan-

tities of oil from our oil shales. There are many important beds of oil shales in Indiana. The most extensive and the most accessible bed is the New Albany shale of Devonian age. This bed exceeds 100 feet in thickness. It is exposed in many counties in the southeastern portion of the state. It is also present in the northern portion but is largely concealed by glacial drift, except for certain small areas along the Wabash River and its tributaries.

The Devonian shales of Indiana contain from 10 to 18 gallons of oil to the ton of shale. The oil is present in the form of solid gum or kerogen and may be released by digestion or distillation. The Indiana shales are more readily mined and prepared for extraction than the richer shales of the West. The cost of mining, preparation and extraction will be much less for the Indiana shales. The Indiana shales carry possible by-products such as potash and ammonia.

In addition to the Devonian shales the coal measures of Indiana contain shales which carry as high as 25 gallons of oil to the ton. Some of these beds of shale could be mined with the beds of coal which often underlie them. Not infrequently these beds of shale contain lenses of bone coal which have a high oil content.

In the more accessible portions of the oil shale area of Indiana there are fifty billion tons of shale with an oil content of at least ten billion barrels. Experimental work which we have carried on in the laboratory in co-operation with the United States Bureau of Mines has demonstrated that oil may be obtained from Indiana shales in continuous process kilns by destructive distillation in which gas fuel from the shale can be utilized. By refining the crude shale oil, motor fuel, fuel oil, lubricating oil, tar, wax, coke, gas, and ammonium sulphate may be obtained.

COAL

Coal is the most important of the mineral fuels of Indiana. It was first discovered in the state as early as 1763 and mined before 1830. The first shaft mine was opened in 1850, and production reached one million tons in 1873. The highest production was attained in 1919 when our production was more than thirty million tons. The total amount of coal which has been produced in the state exceeds 600 million tons. The total amount of coal in Indiana is in excess of forty billion tons.

The bituminous coals of Indiana contain a high percentage of volatile matter and are well adapted to processes of low temperature carbonization. A large number of useful derivatives may be obtained from the volatile matter contained in Indiana coals. The coke or residue of the distillation may be used as fuel. The larger use of coke in industrial and domestic heating plants would largely eliminate the smoke nuisance in our towns and cities, reduce laundry and paint bills, and improve sanitary conditions.

The gas obtained from the distillation can be used for heat production in domestic and industrial plants. From the tar or liquid portion of the coal distillate a large number of useful compounds may be obtained. One of these is crude naphtha from which benzine may be obtained for use as a solvent and as motor fuel. Another derivative

is carbolic oil, from which carbolic acid and naphthalene may be obtained to serve a large number of purposes. Anthracene oil, pitch, picric acid, and coal tar dyes are other products which may be obtained from the volatile matter in the coals.

THE INDIANA COAL FIELDS

GEOGRAPHIC RELATIONS

The Indiana coal field forms part of the larger eastern interior field, which covers parts of Indiana, Illinois, and Kentucky. The Indiana field covers portions of the western and southwestern parts of the state; it is bounded on the south by the Ohio River and on the west by the Wabash River and the northeastern Illinois boundary line.

The coal-bearing area includes approximately 70,000 square miles or about one-fifth of the total area of the state. Coal occurs in 26 of the 92 counties; 16 counties—Parke, Vermillion, Vigo, Clay, Sullivan, Greene, Knox, Daviess, Martin, Gibson, Pike, Dubois, Posey, Vanderburgh, Warrick, and Spencer—lie wholly within the area of coal-bearing rocks; 10 counties—Warren, Fountain, Montgomery, Putnam, Owen, Monroe, Lawrence, Orange, Crawford, and Perry—are partly within that area.

GENERAL FEATURES

The topography of the Indiana coal field is varied. Moderately deep valley trenching followed deposition and elevation of the Pennsylvanian rocks, producing a rugged topography with moderate relief; few of the higher points exceed 400 feet in altitude. During the glacial epoch erosion and deposition further modified the topography of some parts of the field. The northern part of the field lies within the Tipton till plain, which has been partly dissected by the Wabash River and its tributaries, but the relief features of that region are not as pronounced as are those of the southeastern part of the field which lies in the largely unglaciated Crawford upland. Most of this part of the field has strong relief in comparison with adjacent areas. In the southwest part of the field is the Wabash lowland, which lies largely within an area modified by glaciation and trenched to moderate depths by streams, many of them tributaries of the Wabash.

The coal beds are interstratified with beds of shale, sandstone, fire clay, and limestone. The greater part of the shales are gray, and the proportion of sand to clay in them varies considerably. Some of the shales are highly bituminous and split into sheet-like layers. The sandstones usually are soft and incoherent, although in places they form hard, durable beds. The limestone beds are generally thin, rarely exceeding 10 feet in thickness, and are impure. The fire clays ordinarily underlie beds of coal and, used with the more aluminous shales, have proved of value in ceramics.

The coal beds and their associated rocks dip southwest at the rate of about 20 to 35 feet to the mile, except in the extreme north, where the dip is approximately west, and in the extreme south where the dip is northwest and north. The beds outcrop from east to west in

order of their age; the oldest extend farthest east and pass under younger beds toward the west.

There are more than 20 beds of coal in the state; 15 have been mined locally and 9 over large areas. The principal beds, named in the ascending order of stratigraphical position and age, are: Coal I, Lower Block, Upper Block, Minshall, Coal II, Coal III, Coal IV, Coal V, Coal VI, Coal VII, Coal VIII, Coal IX, Parker, Friendsville, and Aldrich.

CLASSES OF COAL

All the coals belong to the bituminous class. Three kinds are recognized—block, cannel, and common bituminous. The block coal is divided into blocklike masses by vertical joints spaced 2 to 4 feet apart and slits readily along bedding planes or laminations, which are marked by layers of mineral charcoal (fusain) interbedded with bright coal (vitrain). Many of the charcoal layers show impressions of plant structure. The blocks of coal do not break readily across the laminae and in weathering split rather than crumble.

The cannel coal is made up largely of spores and other small parts of plants, has a dull luster, and yields oil on distillation. Its surface looks slightly resinous and its physical composition is more homogeneous than that of the other coals. It is only slightly laminated and is jointed somewhat like the block coal but breaks with the conchoidal fracture. Only a small quantity of this class of coal is produced in Indiana.

The greater part of the coal of Indiana is of the common bituminous type. It is generally bright on unweathered surfaces, breaks into somewhat cubical masses of variable size, and is not so strongly laminated as the block coal. The proportion of mineral charcoal is lower and the proportion of bright coal higher than in the block coal.

GEOLOGIC CONDITIONS

The coals of Indiana belong largely to the Pennsylvanian period of geologic time. The rocks of the Pennsylvanian series rest upon the eroded surface of the Mississippian rocks. With the exception of a thin bed of coal that occurs in the lowermost group of the Chester division of the Mississippian, all of the coals of Indiana are found in the rocks of Pennsylvanian age. The coal beds are interstratified with the rocks of the latter series.

GEOLOGIC FORMATIONS

The Pennsylvanian series of Indiana includes the Pottsville, the Allegheny, and the post-Allegheny divisions. The rocks of the Pottsville division, which include the Mansfield and the Brazil groups, rest unconformably upon the rocks of the Mississippian series. The Mansfield group consists largely of a basal conglomerate or sandstone, but also contains minor beds of shale and fire clay, and beds of coal.

POTTSVILLE DIVISION

Mansfield group. The principal bed is known as Coal I, although at least two other beds in the Mansfield group have been mined. Coal I

was deposited in basins of relatively small area, and as a result thins from a central point of maximum thickness toward the margin of each basin. The maximum thickness of the bed is about 4 feet, and the average is probably not more than 3 feet. In some localities it forms a solid bed; in others it is split by a clay parting. The underlying formations may be clay, shale, bone coal, or cannel coal. The overlying formation may be either sandstone or shale. As a rule Coal I is firm and hard, of semiblock character, and not smutty.

Brazil group. The Brazil group contains four mineable beds of coal—the Lower Block, Upper Block, Minshall, and Coal II. The Lower Block is typically developed in the northern part of Clay County and has been mined extensively in the Brazil district, where it has an average thickness of 3 feet. The upper part of the bed consists of 6 to 10 inches of bituminous coal, through which the joints of the block coal below do not extend with any degree of regularity. Below the thickest part of the bed there is in many places a layer or two of soft coal or bone coal separated from the block coal by clay.

The Upper Block is typically developed in Clay and Parke counties. Its average thickness is about 3 feet, but as much as 5 feet has been noted. The Upper Block was deposited in basins one to many square miles in extent. Between these basins the coal is generally continuous but is thin. The joints of the Upper Block are more open at the top than at the bottom, a condition that is reversed in the Lower Block. The Upper Block is characterized by the presence of a layer of hard, brittle coal, about 3 inches thick, a little below the middle of the bed. Clay generally underlies the coal, and shale or sandstone overlies it; it is separated from the Lower Block by about 30 feet of clay, shales, and sandstones.

The Minshall coal is typically developed in Parke County. It occurs in basins. Its average thickness in a basin is about 4 feet and the maximum thickness about 6 feet. As a rule the Minshall has fire clay underlying it and shale above it. The shale contains a thin fossiliferous limestone, which in places becomes a moderately thick, cherty bed and rests on the coal. As a rule 20 to 30 feet of clay, shale, and limestone separate the Minshall coal from Coal II. The coal is firm and bright, semiblock, and not smutty.

The thickness of Coal II varies greatly and a workable thickness is rarer than in other coals of the Brazil group. In the workable areas the coal is 2 to 3½ feet thick. In many places the bed contains clay partings and in some places has been removed by erosion that preceded deposition of the rocks of the Allegheny division.

ALLEGHENY DIVISION

Staunton group. The Allegheny division is divided into three groups—the Staunton, Petersburg, and Shelburn. The first is composed mainly of sandstones and shales. The formations contain Coal III, Coal IIIa, and Coal IV. Coal III is best developed in the northern part of the Indiana coal field, where over larger areas it has an average thickness of 6 feet and in some places reaches a maximum of 11

feet. Pyrite and clay partings are common in the coal. An interval of 75 to 80 feet separates it from Coal II. Coal IIIa lies about 20 feet above Coal III, from which it is separated by sandstone or shale. Nodular limestones are often associated with Coal IIIa. It is not an important bed and is mineable only locally.

Coal IV is typically developed in Greene County, where it has an average thickness of 5 feet and a maximum of 7 feet. In many places it is split into two beds by a parting and even where solid has a smooth parting near the middle. The roof is usually sandstone or shale, and the floor is sandstone or sandy clay. The rock interval between Coal IIIa and Coal IV is about 60 feet. Coal IVa is an unimportant bed lying about 20 feet above Coal IV; it is workable locally under small areas.

Petersburg group. The Petersburg group, consisting of shales, sandstones, limestones, and clays, contains three important coal beds. By reason of its wide distribution and uniform thickness Coal V may be considered the most important coal bed in Indiana. It has an average thickness of 5 feet; under large areas it is 6 to 8 feet thick and locally is 11 feet thick. As a rule the coal has a roof of black, sheety shale, above which is a bed of limestone. In some places the coal is separated from the limestone by about 30 feet of gray shale, and the quality of the coal differs from that found where the roof is black shale. The coal rests on fire clay or shale.

Coal VI is typically developed in Sullivan County to a fairly uniform thickness of 6 to 8 feet. As a rule the lowest foot is an impure coal called "bone." The bed is characterized by two thin shale partings near the middle; these partings are about 5 inches apart and one-half inch thick. The coal usually rests on clay or shale, has a shale roof, and lies about 80 feet above Coal V.

Coal VII normally lies about 45 feet above Coal VI in the northern part of the field, but southward the interval decreases to only a few feet. The bed rests on fire clay, which in some places overlies a bed of limestone; the latter is rarely absent. The coal has a roof of shale or sandstone and its thickness ranges from 3 to 6 feet.

Shelburn group. The Shelburn group, which is composed of shales, limestones, and sandstones, contains two beds of coal—Coal VIII and Coal IX. These beds are not of importance, although the first has been mined locally. The thickness of the group is about 120 feet; the coals are separated by an interval of 50 feet.

POST-ALLEGHENY DIVISION

The post-Allegheny division is composed of two groups, the Merom and the Wabash. The former consists largely of sandstone, which may be replaced wholly or in part by shale. There are also some thin beds of coal. The group is about 150 feet thick. The Wabash group consists of 100 feet or more of sandstones, limestone, and shales containing three beds of coal. The Parker coal near the base of the group has a roof of bituminous shale overlain by limestone. The Friendsville

coal lies about 45 feet above the Parker. It has a shale roof, above which is a bed of limestone. The Aldrich coal lies about 35 feet above the Friendsville. These coals are all thin and are mined only locally. They are present only in the southwestern part of the Indiana field.

The accompanying columnar section shows the stratigraphic relations of the formations and coal beds in Indiana and the approximate intervals between the more productive coal beds.

FIGURE 2—COLUMNAR SECTION OF COAL-BEARING ROCKS IN INDIANA

Series	Division	Group	Bed
Pennsylvanian (1200 to 1300 feet)	Post-Allegheny (280 feet)	Wabash (130 feet)	Shales and sandstones, 50 feet. Aldrich coal. Shales and sandstones, 35 feet. Limestone and shale. Friendsville coal. Sandstones and shales, 45 feet. Limestone and shale. Parker coal.
		Merom (150 feet)	Shales, sandstones, and coals, 150 feet.
	Allegheny (520 feet)	Shelburn (120 feet)	Coal IX. Shales. Limestone (Somerville), 50 feet. Coal VIII. Shales and sandstone, 70 feet.
		Petersburg (250 feet)	Coal VII. Shale, 45 feet. Limestone (Millersburg). Coal VI. Shales and sandstones, 50 feet. Coal Va. Shales and limestone (Alum Cave), 35 feet. Coal V. Sandstones and shales, 100 feet. Coal IVa. Shales and sandstones, 25 feet.
		Staunton (150 feet)	Coal IV. Sandstones and shales, 55 feet. Coal IIIa. Shales and sandstones, 20 feet. Coal III. Shales and sandstones, 75 feet.
	Pottsville (100 to 500 feet)	Brazil (80 feet)	Coal II. Shales and limestone, 20 feet. Minshall coal. Shale, 30 feet. Upper Block coal. Shales and sandstones, 30 feet. Lower Block coal.
		Mansfield (100 to 400 feet)	Sandstones and shales, 100 feet. Coal I. Shales or sandstone.

MINING METHODS, PRODUCTION, AND TRANSPORTATION

MINING METHODS

Coal is mined in Indiana by stripping and by subsurface methods. Near the outcrop of the coal beds, where the overburden does not exceed 60 or 70 feet, much of the coal is mined by removing the overlying clay, shale, and sandstone with steam shovels or drag lines, and with smaller shovels that load the coal directly into mine cars to be

hauled from the pit by small locomotives. Little coal is wasted by this method, but in places land valuable for agriculture is mined.

The larger part of the Indiana coal is mined under ground; the mining systems employed are the ordinary room-and-pillar system and the panel room-and-pillar system. The longwall system has been used a little in a few mines in small areas. In recent years the panel system has been used more extensively.

In the ordinary room-and-pillar system the width of the rooms varies with the conditions of the roof; usually the width is 25 to 30 feet and the length 200 to 300 feet. The rooms are turned on 43 to 53-foot centers and the room necks are 10 to 20 feet wide for 12 feet and then are widened. The room pillars are 9 to 12 feet wide and the crosscuts are about 12 feet wide. Both single and double entry systems are in use.

In the panel room-and-pillar system the length of the panels is 700 to 1,000 feet. A panel entry has 20 to 38 rooms. The rooms are 20 to 33 feet wide; the room necks are 8 to 14 feet wide for 12 feet and then widen. The entries are 7 to 12 feet wide and are turned on 24 to 57-foot centers. The crosscuts are 10 to 18 feet wide. The barrier pillars are about 75 to 80 feet wide. The rooms are 200 to 250 feet long, and the fire pillars at the end of the rooms are 20 feet wide.

Mine openings in Indiana are of four types—open pits, drifts or inclines, tunnels, and shafts. The first three classes of openings are confined to the outcrops of the various coal beds; shafts are used where the overburden is thinner but the roof is good. The deepest shafts do not exceed 450 feet. Shafts are lined with wood or concrete. Hoisting is done by cages that carry mine cars and by cables and drums operated by steam or electricity.

In the larger mines the coal is undercut with electrically operated cutting machines and is shot down with black blasting powder. Loading machines are used in some mines. Underground haulage in the smaller mines is by gravity, man power, and horse power. Gravity and electric power are used in the larger mines.

The roof in the mines is supported by pillars of coal, which are supplemented by gob, timbers, concrete walls and pillars, and steel I-beams. As a rule not much timbering is required, except along the main haulage ways and in and around the shafts.

Most of the mines are dry or contain only a small amount of water. Where floor conditions make it possible the water is drained to the sump near the shaft and is then pumped to the surface. Artificial ventilation is obtained by means of electrically driven fans at the air shafts. The majority of the mines contain little gas and explosions are rare.

The percentage of extraction of coal in Indiana ranges from 25 to 72 per cent; the average extraction is about 50 per cent. A recovery of 85 per cent is possible in some mines. In the better conducted mines the percentage of recovery has increased in recent years.

COAL PRODUCTION

Under the stimulus of heavy demand because of the World War the production of coal in Indiana reached a maximum of 30,000,000 tons,

but since that period it has declined and during the last five years has been as follows:

Year	Tons
1928	16,378,580
1927	16,202,826
1926	22,839,000
1925	21,224,966
1924	21,480,213
1923	26,229,099
1922	19,132,889

Table 1 gives the distribution by counties and the rank by counties of the coal mined in Indiana during 1925:

TABLE 1.—COAL PRODUCTION OF INDIANA BY COUNTIES

	Tons		Tons
Vigo	4,781,606	Pike	2,136,333
Sullivan	4,572,830	Greene	1,274,544
Knox	2,821,785	Gibson	1,003,766
Vermillion	2,326,377	Clay	974,415
Warrick	891,474	Undercut by hand	391,726
Dubois, Spencer and Vanderburgh	237,816	Shot off solid	4,577,590
Owen	83,148	Machine mined	12,925,739
Fountain and Parke	73,452	Mined by stripping	3,269,386
Daviess	38,247	Not specified	60,525
Perry	9,213		

TRANSPORTATION AND DISTRIBUTION

The Indiana coal field is well supplied with steam and electric railways, and the development of the coal industry is little affected by lack of adequate facilities for transportation. The field is crossed from north to south and from east to west—in fact, in almost all directions—by railroads, many of which are important trunk lines. Among the important lines entering and crossing the field are the Baltimore & Ohio; Big Four; Chicago, Indianapolis & Louisville; Chicago, Milwaukee & St. Paul; Chicago & Eastern Illinois; Cincinnati, Indianapolis & Western; Erie; Evansville & Indianapolis; Evansville, Suburban & Newburg; Ferdinand; Illinois Central; Louisville & Nashville; New York Central; Pennsylvania; Southern; Toledo, St. Louis & Western; Terre Haute & Eastern Indiana; Wabash; and others.

More than half of the coal produced in Indiana is consumed within the state. A large part of it is used in manufacturing plants to produce steam and electric power, in large central power plants for the generation of electric power for railway and municipal purposes, as fuel for domestic use, as fuel for railroads, in the manufacture of gas, and for other purposes. Much of the coal shipped to neighboring states is consumed for domestic purposes and for the production of steam on railroads, and in industrial plants.

ANALYSES OF INDIANA COALS

The following analyses represent averages of several samples of coal taken from the more important of the beds of Indiana coals. In nearly all averages at least five analyses were included:*