

A CENTURY OF GEOLOGY IN INDIANA.

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A wise man once said that the Good Lord made the Geology of Indiana simple so that it could be easily understood by the State Geologists elected by the people. Whether the Almighty had that idea in mind, when the geological formations now constituting the area comprising the State were laid down, is and always will be a matter of conjecture. Suffice it to say, that according to the best knowledge obtainable, those formations were deposited in the order and manner set forth by the writer in another paper presented to this Academy in 1903.*

Prior to 1837 there is but little record of work done toward utilizing the mineral resources or determining the geology of Indiana. It is known that as early as 1804 the location of outcrops of coal was noted and marked on the land survey maps of the State, and in 1811 a small mine had been opened at Fulton, Perry County, from which it is said Robert Fulton obtained a supply of fuel for the first steamboat descending the Ohio River.

In 1817, William McClure, who afterward came to New Harmony with Robert Dale Owen, published a work "Observations on the Geology of the United States of America, etc." in which was a colored geological map of the Eastern United States. This shows Indiana in one color, the entire area of the State being included under what he called the "secondary" or area of stratified rocks. Indiana is not mentioned in the text of this work.

FIRST ACCOUNTS OF WYANDOTTE CAVE.

In 1819, appeared the first published account of any cave in the United States, that of Wyandotte Cave, of Crawford County. It appeared in Wm. McMurtrie's "Sketches of Louisville and its Environs", under the heading, "The Mammoth Cave of Indiana." The cave at that time was owned by one Dr. Benjamin Adams who had preempted the land on which it is situated for the purpose of making saltpetre. McMurtrie says: "At what precise period it was first discovered must be left to tradition and wild conjecture to determine, but it is evident, from circumstances hereafter to be mentioned, that many ages must have elapsed, since that terrible convulsion of the earth, which has, in some places, rent asunder the solid rock for a hundred feet together. Although its existence was generally ascertained in 1798, it is only since the year 1814 that we have any account of it that can be relied on." He states on the next page, however, that Gen. Wm. H. Harrison visited the

*"The Indiana of Nature; Its Evolution," Presidential address by W. S. Blatchley, delivered December 28, 1903.

cave in 1806. "This gentleman informed Dr. Adams that there were at that time, enormous lumps of some saline matter scattered over the floor, individual pieces of which, he was persuaded, would have weighed from one to 200 pounds. The whole of this crystalized body must have been an impure sulphate of magnesia, which is still found there, though in small crystals, and only on the sides and in the interstices of the rock, which is owing to all the larger ones having been removed, several wagon loads of which were taken to Frankfort and other places."

McMurtrie's brief description is of the old cave only, the new portion not having been discovered until 1850. He says that the earth in the old passage "contains about five pounds of the nitrate of lime or magnesia, to the bushel, and is composed of decaying animal and vegetable matter, principally of bats' dung, which may be seen hanging in tufts on every rock." From the wording one does not know whether he meant that the bats or the dung clung to the rocks, but probably the former." "Continuing on the main route for some distance further" says McMurtrie, "the eye is involuntarily attracted by immense pebbles, weighing from one to five hundred tons, which lie precisely in the middle of it. I say pebbles, because, although they are composed of carbonate of lime, they are as completely rounded as any fragment of a primitive rock that can be produced in a water course." Some one must have needed these "rounded pebbles" and removed them from the cave, as I have never seen any signs of them. Continuing, he says: "The first serious impediment that presents itself consists in the ceiling or roof of the gallery descending so low as to touch the floor, leaving a small arched opening, through which, whoever wishes to penetrate further, must crawl and scuffle, not on his hands and knees, for that is impossible from the shallowness of the arch, but, literally speaking, on his belly. This spot has been styled by the guide, and not inaptly, the bat's burial place, the soil on which you creep, to the depth of a foot, being composed entirely of their remains."

After reaching the large room at the end of the old cave which he calls the "Chamber of Fountains," and descending upon the wonders of what is now known as the Pillar of the Constitution, McMurtrie says: "I think that I may safely assert that the cave bears along with it most unequivocal proof of its having originated in an earthquake, which has split the rock, and opened a passage for a superincumbent body of water that has rushed in and filled a part, if not the whole of the cavity."

In Vol. 1, "Transactions and Collections of the American Antiquarian Society," published in 1820, is an Appendix entitled "Account of a Great and very Extraordinary Cave in Indiana, in a letter from the owner to a gentleman in Frankfort, Kentucky." This letter was written by Dr. Adams, February 27, 1818, to John H. Farnham of Frankfort, but was not published till 1820, or one year after McMurtrie's work above cited. In transmitting it, Farnham said: "To the chymist and natural philosopher, the Indiana cave presents a most interesting theatre of experience and speculation;

and I congratulate the public that it is in the possession and ownership of a gentleman of the enlarged and liberal mind of Dr. Adams." The letter of Adams set forth but more briefly the same facts as given in McMurtrie's account. He called the column at the end of the old route the "Pillar", states that it is about one and one fourth miles from the entrance and, as did also McMurtrie, that it is composed of "satin-spar." The main idea of Dr. Adams in this letter seems to have been the advertising of the salts of the cave. He called it his "Epsom Salts Cave," and stated that the "first in importance was the sulphate of magnesia or epsom salts, which abounds throughout this cave in almost its whole extent and which I believe has no parallel in the history of that article. The quality of the salt in the cave is inferior to none and when it takes its proper stand in regular and domestic practice must be of national utility. Every competent judge must pronounce it inexhaustible. The worst earth that has been tried will yield four pounds of salt to the bushel, and the best from 20 to 25 pounds. The next production is the nitrate of lime or saltpetre earth. There are vast quantities of this earth and equal in strength to any that I have ever seen. There are also large quantities of nitrate of allumina or nitrate of argil, etc." Dr. Adams carried on the business of leaching these salts between 1812 and 1820 on an extensive scale, and as late as 1905 remains of his old wooden hoppers and troughs were to be seen in the vicinity of the mouth of Wyandotte.

In 1823 the legislature passed "an act concerning saltpetre caves and for other purposes." The preamble to the act recited that "it has been represented to this General Assembly that great loss has been sustained by the owners of stock, cattle and horses, from the use of substance extracted from saltpetre caves, epsom salt caves and others of different kinds, in consequence of the same having been left unenclosed by the owners or occupiers thereof, for remedy whereof, etc." The act provided that the owner of any such cave who should allow it to remain unenclosed and exposed to the stock of the neighborhood, should be liable to a fine of \$10 for every day it was left so exposed, and also liable in damages for stock injured. This act continued in force many years and was embodied in the Revised Statutes of 1843.

In Flint's "Geography of the Mississippi Valley," published in 1833, there is also a brief account of Wyandotte under the name of "Epsom Salts Cave," but it was evidently compiled from the two articles above quoted.

SURVEY FOR CANAL TO CONNECT WATERS OF LAKE MICHIGAN AND WABASH RIVER.

In April, 1829 Howard Stansbury, a civil engineer in the employ of the United States, was instructed "to ascertain the practicability of uniting by a canal the waters of Lake Michigan with the Wabash River." With a party of assistants he spent two seasons, those of 1829 and 1830, in the field. From his report, dated October 17, 1831, I have taken a few facts of general geological

interest since they show some of the conditions existing in Northern Indiana nearly 90 years ago. He was ordered to examine and compare the two routes described as follows:

1.—“The first, starting from Lake Michigan, would ascend the valley of the St. Joseph River (of the lake) to leave it at a convenient point near to the Kankakee River; then it would cross to this stream to descend its valley down to the mouth of Yellow River thence up the same to a point from which a cross canal could be run to Tippecanoe River. From hence the route descends this stream, and then the Wabash, to the head of steamboat navigation.

2.—“The other would ascend the valley of the St. Joseph River (of the lake) up to one of its head branches; from thence to the fork formed by the St. Joseph of the Maumee and St. Mary’s rivers, then from that point through the valley of Little River, to the Wabash River, as far down as the head of steamboat navigation.”

The first of these routes he designated in his report as the “Southern route,” stated that most of the territory through which it passed was included within the Indian boundary lines, had never been explored and that none of the lands belonging to the Government had been surveyed. He says that along the greater parts of both routes there was a great scarcity of stone, and that all locks, dams, aqueducts, etc., would have to be constructed of wood. The St. Joseph River near South Bend was gauged at a very low stage on July 25, 1829, and found to have a flow of 1,395 cubic feet per second.

The soil of the wet prairies near the Kankakee, “after penetrating the turf with which they are covered, is found to consist of quicksand and soft mud, in most instances of great fluidity and considerable depth. Embankments will be required to pass the canal over them, the earth for which, consisting of a mixture of sand, clay, and pretty coarse gravel, is generally convenient.”

While surveying the line from Yellow River to the Tippecanoe, a distance of nine and two-thirds miles, he learned from the Indians that upon the summit of the water shed between these streams was a large lake which they called Mek-sin-kuk-keek and which it was stated would supply all the water that was needed for that section of the canal. He therefore ran lines from Yellow River to the lake, found that the route was practicable but that the lake lay ten miles to the left of the direct course and would require some deep cuts. He states that “this route was therefore abandoned for the more direct one on which we found that another lake lay immediately in our way which although not as large as the former, was nevertheless fully capable, together with Yellow River, to furnish the needed supply of water. This route is termed the “Devil Lake Route” from the name of the lake on its summit, which was found to contain 7,313,883 square yards.” This so called “Devil Lake” of the Stansbury report is now the well known “Bass Lake,” a noted resort for Chicago and Indianapolis citizens during the sum-

mer months. It is interesting to note also that what is now known as Monon Creek, a tributary of the Tippecanoe and from which the town and railway of the same name derived their names, was, in the Stansbury Report, called the Motimonon River.

The total length of the southern route as surveyed by Stansbury from the mouth of the St. Joseph at Lake Michigan to the mouth of the Tippecanoe where the canal would connect with the Wabash was found to be 157.7 miles; the ascent and descent 127 and 171 feet, respectively; the number of locks required, 37 and the estimate of the total cost, \$1,895,904.

In surveying the proposed "Northern Route" Stansbury found that the most feasible connection between the St. Joseph of Lake Michigan and the St. Joseph of the Maumee was by way of Pigeon River, a large branch of the former. This stream he found had its source in a cluster of lakes, in one of which, Fish Creek, a tributary of the other St. Joseph, also had its rise.

The following paragraph from the Stansbury report regarding the summit level between the two streams, located in what is now Steuben County, is of especial interest in this connection:

"The country around the summit level, abounds in small lakes, from an half to two miles in length, either connected together in chains, or separate and alone, without any apparent inlet or outlet. They consist of the purest spring water, are full of the finest fish, and are of immense depth (in one of them, the bottom, as I have been informed, was sought in vain with a line of 250 yards). The soil of the surrounding country is a mixture of sand, clay and gravel, indicating a bed of clay. Their supply from beneath being constant, they do not appear to be affected by the drought of summer, but where there are outlets, these are considerably swollen by the melting of the snows and ice on their banks, in the spring."

You will note that Stansbury did not sound the lake himself, but was informed that it was more than 750 feet in depth. The truth is that, like the lengths of the caves of Southern Indiana, the depths of the Northern Indiana lakes are greatly exaggerated by the surrounding inhabitants. According to their story many of them are "bottomless," or have deep holes in which it is "impossible to find bottom." Their attempts at sounding were probably made with an ordinary fishing line or the butt end of a cane pole. No one of the local residents who has such beliefs has ever brought up a Chinaman's queue on his fish hook or a new species of fish from the central regions of the earth. The fact is that the deepest water in any lake of the State, and the writer has sounded them all, is 121 feet in Tippecanoe Lake, Kosciusko County.

Stansbury found that the length of the proposed canal by the northern route from Lake Michigan to Fort Wayne, where it was proposed to connect it with the Wabash and Erie canal, would be 177.11 miles, its descent 553 feet, the number of locks required 69 and the estimated cost \$1,860,468. He states that the southern or Kankakee—Tippecanoe River route "is shorter by more than twenty miles. It will require but 36 instead of 69 locks, thereby

occasioning a great saving of time in the transportation of all articles of trade; and, lastly and principally, it enjoys the paramount advantage of commanding an unfailing and ample supply of water on the summit. For these reasons the preference has, without hesitation, been given to the southern route."

He ends his interesting report with the following paragraph: "The prosecution of this extensive survey, by subjecting to minute inspection a very interesting portion of our country, has tended entirely to confirm the view in which the examination has its origin. It has conducted the brigade through a region abounding in every natural advantage, fertile in soil, presenting great facilities of communication, and lying immediately adjunct, on one side, to a stream which will soon be rendered navigable throughout its length, and covered with the bustle of an active trade; and, on the other, to a great arm of our Mediterranean waters, stretching itself into the very heart of a rich and, soon to be, a populous country; and furnishing, for the naval defense of our internal frontier, a safe and convenient harbor, easily fortified, and affording every possible advantage for a naval depot. The means of uniting the two, have now been sufficiently developed to render it certain that that valuable improvement may be effected at a small comparative expenditure of money and labor; and a path has been fully opened for the enterprise of a young, but rapidly advancing State."

THE ERA OF INTERNAL IMPROVEMENTS.

Between 1830 and 1835 there was a great awakening of the public road spirit in the United States. The era of "Internal Improvements" was on, and canals, railways and improved roads were projected, either on paper or in reality in many of the States. The people of Indiana caught the fever, and in 1835 the Legislature authorized the surveys of six important routes, as follows:

1. A route for a railroad or turnpike road from Madison via Indianapolis, Danville and Crawfordsville to Lafayette.
2. A route for a railroad or turnpike road from Crawfordsville via Greencastle, Bloomington, Bedford and Salem, to New Albany.
3. A route for a railroad from Evansville via Princeton to Vincennes.
4. A route for a railroad from Vincennes to Terre Haute.
5. A route for a macadamized turnpike road from New Albany via Greenville, Fredericksburgh, Paoli, Mount Pleasant and Washington to Vincennes.
6. The completion of the surveys and estimates on the Lawrenceburgh and Indianapolis railway.

Noah Noble was then Governor of Indiana, and, at his request, made to the United States Topographical Bureau, for an engineer of ability to take charge of the surveys, Howard Stansbury, the U. S. Assistant Civil Engineer who had made the survey for the Lake Michigan-Wabash River Canal, was

detailed for the service. The reports of Mr. Stansbury and his several assistants, dated December 17, 1835, were published in the House Documentary Journal for 1835 and 1836, and are very full and exceedingly interesting, containing many notes on the local outcrops of stone and surface topography of the regions traversed. For example, the assistant in charge of the Madison-Indianapolis Railway survey describes the country in the vicinity of Flat Rock Creek in the following glowing terms:

"In this rich and fertile country, which abounds with noble specimens of stately white oak, the valleys of water courses are bounded by ranges of sand and gravel hills running in parallelism with the streams, the bottom lands of which in some instances, expand to a width of two or three miles, and possess a soil, exuberant in a high degree, being nowhere infested with rocks or stones, and exhibit proofs of the greatest fecundity in the rankness of their vegetable products, while the beautiful area between them is a uniform plain, having no rise perceptible to the eye, and admirably adapted for the reception of a railway."

Edward Watts, the assistant engineer in charge of Route 2, which proposed either a railroad or a turnpike road from Crawfordsville to New Albany, turned down the railroad end of it in the following brief paragraph:

"By reference to the maps you will discover that a railroad, in order to pass through the points prescribed by law, necessarily passes over undulating country, crossing water courses nearly at right angles, thereby occasioning ascents and descents entirely inadmissible upon a railway, which could only be removed by long, deep cuts and heavy embankments, the cost of which would be so enormous as to render any idea of the construction of the work out of the question."

Though rejected as impracticable by Mr. Watts, the railway between New Albany and Crawfordsville was begun by private capital in 1847, completed to Lafayette in 1854 and afterward to Michigan City, thus connecting Lake Michigan and the Ohio River. It is now a part of the main line of the C. I. & L. (Monon) Railway, extending from Chicago to Louisville, Kentucky.

The first two railways planned and completed within the State were thus north and south lines having their southern terminals on the Ohio River, which was then the main artery of commerce for all the states along its borders. These roads were constructed mainly for the shipment of food supplies and raw and manufactured products from their river terminals to the consumers in the interior of a young and rapidly growing State.

When the New Albany and Crawfordsville railroad was built it was projected along a crooked line which brought it close to important mineral resources of which probably its builders had no knowledge, yet which have been for years its source of greatest revenue. They were the Indiana oolitic limestone and the French Lick Pluto Water. Take from that division of the Monon these two things and it would go into bankruptcy tomorrow.

Careful estimates by Mr. Stansbury were submitted, stating the cost of each of the works above mentioned, the total being \$5,538,031. The legis-

lature of 1836, which convened soon after his report, passed an internal improvement bill appropriating nearly \$16,000,000 for the building of canals, railways and macadam roads. This was to be raised by the sale of State bonds. Work was begun on many of the projects, but the only one completed by the State was the turnpike between New Albany and Paoli, a distance of 41 miles. It was macadamized with limestone taken from quarries along its route, and was completed in 1839 at a cost of \$12,537 per mile. In November, 1839, the Internal Improvement bubble burst; the State was unable to sell more bonds and with certain minor exceptions all public work was suspended.

One result of especial geological interest connected with this internal improvement boom, was the publishing in the House Record of 1836 of the first "Table of Altitudes in Indiana" of which I can find record. It was prepared by Howard D. Stansbury and Jesse L. Williams and gave elevations of 208 different points in the State "with regard to the plain on which the Capital of the State is built; high water of the Ohio at the head of the Falls; the surface of Lake Erie, and tide water in the Hudson."

FIRST GEOLOGICAL SURVEY OF INDIANA.

David Dale Owen, son of Robert Owen, the noted philanthropist and reformer who founded the socialistic colony at New Harmony in 1825, was the first, the most learned and the most eminent of Indiana's State Geologists. He was born at New Lanark, Scotland, June 24, 1807, being only 27 days younger than Louis Agassiz the noted Swiss scientist, who also spent most of his years in America. Young Owen was educated at New Lanark and at the celebrated school of Fellenberg at Hofwyl, Switzerland, and came to New Harmony, Posey County, Indiana, in 1827. He returned to London in 1831 for two years' additional study in chemistry and geology, then returned to this country and was graduated from the Ohio Medical College at Cincinnati in 1836. It is said that he took this course in medicine to increase his knowledge of anatomy and physiology as an aid in the study of paleontology. He spent the following summer as an assistant of Dr. Gerard Troost, the State Geologist of Tennessee, and was then appointed by Governor Noble as Geologist of the State of Indiana. This appointment was made in accordance with an act entitled "An act to provide for a Geological Survey of Indiana, Approved February 6, 1837," which read as follows:

Section 1.—*Be it enacted by the General Assembly of the State of Indiana,* That the Governor be and is hereby authorized and required annually hereafter to appoint and commission a person of talents, integrity and suitable scientific acquirements as Geologist for the State of Indiana, who shall receive in consideration of his faithful performance of his duties, an annual salary not exceeding \$1,500 and necessary expenses not to exceed \$250, to be paid as the salaries of other civil officers of the State.

Sec. 2.—That it shall be the duty of the geologist to be appointed as aforesaid, to make a complete and minute geological survey of the whole

State, commencing with those portions in the vicinity of the contemplated public works (always having reference to the directions hereinafter provided) and thence through the other portions of the State with as much expedition and accuracy as may be consistent with minuteness and dispatch and he shall prepare and lay before the legislature a detailed account of all remarkable discoveries made and the progress of the work, accompanied with proper maps and diagrams including a geological chart of the State.

Sec. 3.—It shall further be the duty of the Geologist of the State, at those seasons not suited to the active prosecution of the geological survey, to analyze and ascertain the qualities and properties of mineral substances or soils left at his office or residence for that purpose by any citizen of the State and taken from any portion of the territory of the State.

Sec. 4.—That the said Geologist appointed by virtue of this act, shall be subject to the orders of the executive of the State and shall hold himself ready on reasonable notice to make geological examinations in the vicinity of the canals, railroads or other works of internal improvements which the legislature has or may hereafter direct to be made, *Provided*, That this act shall expire at the termination of the year 1838 unless the same be re-enacted by the next Legislature of the State.

Sec. 5.—This Act to be in force from and after its passage.

Right here I wish to call attention to certain phrases of this Act which I have emphasized in the reading. This was probably the first sum ever appropriated by a Legislature of Indiana for scientific purposes. That eminent body evidently thought it was buying a gold brick and proposed to pay for it the least sum possible. Here it was proposed to hire a man who had spent years and probably thousands of dollars in preparing himself for the work—"A person of talents, integrity and scientific attainments," who shall travel on foot or on horseback through a wilderness from one end of the State to another and make a "complete and minute" geological survey of the whole State with accompanying charts and geological maps. For this he was to receive the munificent sum of \$1,500 a year and \$250 for all expenses. He had to do all the work himself or else hire assistants and pay them out of his own salary or that \$250. He was to do field work for nine months of the year and for the other three, instead of having his time to prepare his report and make his maps, he was to analyze soils and minerals for every crank and hobo that wanted something of the kind done. Ye Gods and little fishes! I wish the author of that bill were here tonight to take his medicine.

This then was the beginning of that short sighted parsimonious policy which has continued, toward not only the geological department but every other scientific bureau of the State of Indiana, from that day to this. The writer carried on the work of the Geological Department of the State for sixteen years with never to exceed \$4,250 a year for help and all expenses, when Illinois was getting \$25,000, Pennsylvania \$100,000 and other states in proportion. The average politician who is chosen as a "representative" (mark the word) of the dear "peepul" of the State of Indiana knows nothing

about science, cares nothing about science—sees no connection between science and the future development of the State and is afraid to vote an extra dollar even in a worthy cause for fear that he will be snowed under at the next election. The Geologist or other scientist who is dependent solely upon political appropriations to do good work in the State of Indiana has indeed a rocky road to travel.

THE GEOLOGICAL REPORTS OF DAVID DALE OWEN.

Based upon the discoveries which he made during his two years' term of office, Dr. Owen issued two reports, addressed "To the Honorable, the Legislature of Indiana." The first of 38 pages was published at Indianapolis in 1838 and entitled "Report of a Geological Reconnoissance of the State of Indiana made in the year 1837 in conformity to an order of the Legislature." The second of 54 pages, published in 1839, was entitled "Continuation of Report of a Geological Reconnoissance of the State of Indiana made in the year 1838 in conformity to an order of the Legislature." The first of these reports was reprinted verbatim in 1853 and was revised, enlarged to 69 pages and again reprinted in 1859. The second one was reprinted with very few changes in 1859. These reprints on the dates mentioned were probably due to the fact that in 1852 an attempt was made to reinstate a geological survey, while in 1859 it was renewed for a brief period. Although Dr. Owen fully realized the great value of paleontology in determining the relative age and consequent nature and position of the stratified formations, he showed in these two brief works, in which are outlined for the first time the principal rock formations of the area comprising Indiana, that he had the right idea of what the writer considers the true functions of a State Geologist—viz., the searching out and making known the undeveloped mineral resources of the State. In other words, he laid especial emphasis upon the economic features of his survey and did not, as did some of his successors, devote his time largely to the study and exploitation of the fossils of the regions which he covered.

In the introduction to his first report this feature of his work is set forth in the two following paragraphs:

"The science of Geology, of comparatively modern date, is now universally conceded to be one, not of mere curious inquiry, but of vast practical utility. It indicates, not only to the closest philosopher a boundless field of conjecture, whereon to erect theories of creation and systems of the world; but to the manufacturer, the raw material whence mineral riches are abundantly derived, and to the farmer, the means of improving soils that nature seems to have disfavored."

"I have considered it my duty, while surveying a country as new as ours, to remember that a State just settling is like a young man starting in life, whom it behoves to secure to himself a competency before he indulges in unproductive fancies. I have considered it the most important object to search out the hidden resources of the State, and open new fields of enterprise to her

citizens. That object effected, time enough will remain to institute inquiries of a less productive and more abstract character; inquiries which are interesting in a scientific rather than a commercial, point of view."

He then laid down very briefly the Leading Principles of Geology, outlining the divisions of stratified rocks, but, curiously enough, since the doctrine of evolution was not then set forth, beginning with the most recent or present alluvium and following backward to what he calls the "Blue Limestone (Lower Silurian) formation, instead of commencing with the lower and tracing forward to the later formations.

Since these two reports of Owen form the basis for most of the work since done in Indiana Geology, he laying the groundwork for future surveys much more accurately than probably even he suspected, and since they have long been out of print, I propose to give briefly yet somewhat in detail the principal facts set forth as to the formations which he found and in part named, and the mineral resources which he discovered or made known.

His first object, as he states, was to gain a correct and connected idea of the geology of the State as a whole. He therefore, in the spring and summer of 1837, ran a line from the mouth of the Wabash to the southeastern limit of the State, "keeping as close to the meanders of the Ohio River as possible, in order to take advantage of the sections exposed on the bluffs along its banks." This line, as he states, showed the following succession of formations in the counties bordering on the Ohio River:

We first find, he says, the coal formation, consisting of repetitions of beds of sandstone, shale, seams of coal, clays, bands and nodules of iron stone and occasional beds of limestone. This prevails through the counties of Posey, Vanderburgh, Warrick, Spencer and extends to Oil Creek in Perry County. At this point there appears above the drainage of the county a bed of limestone.

"This limestone must be considered as the uppermost member of a new series or group of the stratified rocks. A succession of the various members of this inferior group is to be found prevailing until we reach the extreme western boundary of Ohio. To this group may with propriety be applied the name *Subcarboniferous*, as indicating its position immediately beneath the coal or carboniferous group of Indiana."*

This was the first use of the term "subcarboniferous" in Indiana Geology, or for that matter, probably in the United States. From the wording we see that Owen included under the name all the sedimentary rocks below the coal measures found in the State. In the 1859 edition he restricted the term subcarboniferous to that "series of limestones with subordinate fine grained sandstones and shales," † lying between the coal measures and the New Albany black shale, and states "To this calcareous group I have applied the name subcarboniferous as indicating its position beneath the true coal measures, since

*1837 edition, p. 15.

†Reprint 1859, pp. 12 and 20.

in no instance, as yet, have any workable beds of coal been found associated with these limestones." He states that in the southern portion of its range through Indiana the subcarboniferous has numerous alternations of sandstones in its upper part (constituting the Huron formation of present nomenclature) and to that group of the subcarboniferous which we now call the Mitchell limestone he gave the name "Barren Limestones," because they prevail through the Barrens of Harrison, Orange and Lawrence Counties, which he states were covered with a stunted growth of black jack oak. He mentions the characteristic sink holes and disintegrated cherts which accompany this formation, and states that, though called barren, its surface is capable of producing excellent crops. This barren limestone "passes downward into fine-grained freestones with subordinate beds of gray shales to which the name of *Knobstone* may be appropriately applied, since these silicious strata weather into peculiar knobs or hills." In this sentence Dr. Owen therefore gave the name which it still holds to a prominent formation of southern-central Indiana and which, in his second report (1838) he correlates with the Waverly of Ohio. He states that it extends from Floyd and Harrison Counties northward through Jackson and parts of Monroe, Morgan and Hendricks Counties, thus mentioning most of its present known distribution.

"At the base of this knobstone," he continues, there "occurs an important stratum—the *black bituminous aluminous slate*—which is to be seen, when the water is low, at the New Albany Ferry-Boat landing. I call it an important stratum, because this black bituminous slate resembles, both in its external appearance and chemical composition, the coal shale; and since it takes fire and burns for some time, owing to the presence of bitumen and sulphuret of iron, it is frequently mistaken for indications of coal, and even for coal itself. In no instance have I ever found it associated with perfect seams of coal; and I have but little hesitation in asserting, that no true coal will ever be found associated with it in our section of the country." He emphasizes this latter statement by placing it in Italics in his summary at the end of his report, and the writer, while serving as State Geologist, had also to emphasize it, as on several occasions persons claimed that they had discovered coal in Johnson County, and companies were even organized to sink shafts for its development.

"Under the black slate," continues Dr. Owen, "and interposed between beds of crinoidal and coralline limestones is a valuable bed of hydraulic limestone varying in thickness from two to ten feet." This is our Silver Creek limestone afterward used so extensively in Clark County for the making of natural rock cement. He referred the black slate and accompanying underlying limestones to the Devonian system of rocks, the crinoidal layer being what is now known as the Sellersburg limestone while the coralline limestone we call the Jeffersonville. He next recorded the presence of the "Magnesian limestones" of the Upper Silurian group, and finally, as constituting the surface rocks of Switzerland, Dearborn and other counties of

south-eastern Indiana," the blue limestone with its associate beds of marlites and mudstone." This he correlated with the Lower Silurian, as the lowest Geological formation in Indiana.

We thus see that in this first cross section of southern Indiana, Dr. Owen recognized *all* the principal formations which we now retain, though some of them, as the Subcarboniferous and the Devonian, have been subdivided by more recent geologists.

After completing the line across the southern edge of the State, Dr. Owen ran a number of what he calls zigzag lines south of the National Road to determine the limits in the southern part of the State of the various formations above mentioned. As a result of these lines he located approximately yet fairly accurately the eastern limits of the coal area, stating that "from Oil Creek, Perry County, the line of junction between the coal formation and underlying subcarboniferous limestone runs pretty nearly north, a little west of Paoli, Bedford and Bloomington, thence it bears somewhat more to the west near Spencer, and crosses the National Road near Putnamville."

"It will therefore be a useless waste of time, money and labor to search for coal in any of the counties east of the second principal meridian, or east of the belt of limestones, that succeed to the coal formation on the east; because all experience goes to show that there are no workable beds of coal associated with these limestones, or any of the underlying formations, that crop out to the surface east of that formation. Therefore, *all search for coal in or beneath the black slate formation of Floyd, Clarke, Scott, Jackson, Bartholomew, Johnson and Marion Counties may be predicted as fruitless.*" This statement he also reiterates on page 57 of his second report, and time has proven the truth of his assertions.

From these zigzag lines he also outlined very accurately the approximate areas over which each of the formations above named constitute the surface rocks. For example, he states that the black aluminous slate (now known as the New Albany or Genesee shale) "extends through a great part of Clarke, Scott, Jennings, Jackson, Bartholomew, Shelby, Johnson and Marion Counties, towards Indianapolis; but in this neighborhood near the National Road, the strata are so completely covered by drift, that it is difficult to detect the original strata. Even the deepest wells have not penetrated through this drift."

In the fall of 1837, Dr. Owen continued his reconnaissance north of the National Road, where he "found the greater part of this northern country covered by a drift of sand, gravel, boulders and clay, sometimes to a very great depth." For this reason he found it difficult to locate outcrops and determine the formations, though he records, and correctly, that the eastern boundary of the coal formation crosses the Wabash near Attica and that the counties of Parke, Vermillion and parts of Warren and Fountain belong to that formation. He visited the border of Lake Michigan and mentions the

presence of the tenacious stiff blue clay which underlies the sand of the dune region, stating that it occurs for some miles back into the country and probably accounts for the retention of so much water in the Kankakee country.

The mineral deposits, soil and growth peculiar to each of the rock formations are next treated by Dr. Owen in his first report. One of his main objects seems to have been a search for deposits of iron ore as he states that "a good iron bank is of more value to the State than a mine of gold or silver." He located deposits of bog ore or limonite in St. Joseph, Tippecanoe, Warren, Putnam, Owen, Marion, Hancock, and Clark Counties, and of iron carbonate or siderite in Warren, Parke, Fountain and Vermillion Counties. He mentions briefly the extent and character of the well known deposits of potter's clay at Troy, Perry County, and records the mining of coal on a commercial scale in Perry, Pike and Vigo Counties.

Of the soils of the various formations and their growths of indigenous trees and shrubs, Dr. Owen gives brief descriptions, claiming that that of the blue limestone or marly clay formation (the Lower Silurian) of southeastern Indiana comprises the most fertile districts of the State. Boone County at that date was mostly a swamp, and the prairies of Benton, Newton and Tippecanoe were as yet too wet for cultivation, so that he did not recognize their future great productive possibilities. The least productive land, he states, "is that on the summits and upper slopes of the Knobstone formation." However, time has shown that that overlying the sandstones of the Carboniferous and Huron formations is not far behind it in lack of fertility.

An interesting change of opinion regarding the origin of the drift soils of northern Indiana, occurs in the second or revised edition of the first report. In the original 1837 edition he says: "The fertility of the soil in Indiana is universally admitted, yet few are aware that it arises mainly from its geological position. It is well known to the geologist that that soil is most productive which has been derived from the destruction of the greatest variety of different rocks, for thus only is produced the due mixture of gravel, sand, clay and limestone necessary to form a good medium for the retention and transmission of the nutritive fluids, be they liquid or aeriform, to the roots of plants. Now Indiana is situated near the middle of the Great Valley of Northwestern America, and far distant from the primitive range of mountains, and her soil is accordingly formed from the destruction of a vast variety of rock, both crystalline and sedimentary, which have been minutely divided and intimately blended together by the action of air and water. It has all the elements, therefore, of extraordinary fertility."

In the 1859 edition that paragraph is omitted and replaced by the following: "In regard to the soils resulting more particularly from drifted materials which occupy a great area in the northern part of the State, and on the slopes adjacent to our large streams, it may be remarked, that being the *transported debris* of a great variety of formations we may infer their general fertility,

since they must contain a mixture of the earthy ingredients, salts and bases, highly favorable for supplying the required elements for thrifty growth, and must possess, at the same time, the mechanical properties favorable for the retention of moisture, the permeation of air, and for the reception of the nitrogenous principals derived from the atmosphere."

This change of opinion was doubtless due to the fact that Agassiz and other geologists studied and evolved the glacial theory and the transportation of boulder soils in the early forties, and Agassiz's "Systeme Glaciarie," on which our modern knowledge of glacial action is mainly based, was issued in 1847. Before I learned that the 1859 edition of the report, which is the one I possess, was not a verbatim report but in part a revised edition, I thought that Owen had evolved the glacial theory of the transportation of soils ahead of Agassiz, but the wording of the original 1837 edition proves the contrary.

Not foreseeing the great railway development of the future or the use of fuels other than coal, he stated that "The western counties of Indiana must ultimately become the principal manufacturing districts of the State, from the fact of their geological position within the Indiana coal field; for all experience proves that manufactories have most generally sprung up and flourished in coal regions."

Of building stones he praised very highly what he called the "shell marble rock" of a quarry known as "Marble Hill," located fifteen miles below Madison, in Jefferson County, and belonging to the Niagara Division of the Upper Silurian. In the revised edition of the 1837 report no less than 14 of the 69 pages are devoted to a description of the building stone of this particular quarry. His only reference to the oolitic stone, now so famous as a building material, in the 1837 edition was as follows: "Most of the limestones in the oolitic series, that is those occurring in the counties of Crawford, Orange, Lawrence, Monroe, Owen and Putnam, make good building materials and the soil formed from them has a calcareous character and is admirably adapted for the growth of grass." In the 1859 edition this was revised to read: "Many of the beds of the Subcarboniferous limestone make good building stones. Some of the oolitic limestones take a polish and furnish a cream colored marble." For building purposes, aside from the stone of Marble Hill quarry he recommended only the freestones (sandstone) at the base of the coal formation in Warren, Fountain and Orange Counties. Also those of the Knobstone formation above the black slate and gray shales, but gave warning that these should be used only with proper precautions and by experienced stone masons.

He did not foresee the use of the shales of the Carboniferous or Knobstone formations for the making of clay products, but stated only that they "afford locally both argillaceous iron ore and carbonate of iron."

The wording of another paragraph in his summary impresses the geologist of to-day as rather curious, until he realizes that Owen's work was written before the doctrine of Evolution was set forth, and at a time when most people believed in Divine creation of the earth and its living forms. He was

therefore probably somewhat cautious about expressing his ideas of the origin of stratified rocks. It is as follows: "The greater part of Indiana *must have been*, at some period of the earth's history, covered by an ocean, for most of the fossils in the limestones are of marine origin." In the second report he put aside this caution and stated that the rocks of the blue limestone in southeastern Indiana are "remarkably interesting on account of their numerous marine fossils. Some of these are in a wonderful state of preservation, and so abundant that the rock is, in fact, almost an agglutinated mass of marine shells and corals, which lived, died and became entombed in the sediments and precipitates forming in the ocean during the earliest period to which geologists are able to trace back organic existences."

In his summary he truthfully states that: "None of the precious metals are likely to be found in Indiana, unless in minute portions in the bowlder drift, or in small quantities in combination with other metals; because the primitive and metamorphic formations, in which alone productive mines of gold and silver ore occur, do not exist in Indiana. The only metals which we need look for, are iron, lead, antimony, manganese, zinc, cobalt, and possibly some varieties of copper and arsenic ores." We now know that none of these except iron ore occur in the State.

In an Appendix to the First Report, Dr. Owen offers some "suggestions as to the methods of conducting future surveys" in the State, which were most excellent provided the legislature would furnish sufficient funds, which it has never been willing to do in the 80 years which have elapsed. These suggestions were as follows: "If it be desired to make a minute geological survey of the State, it would be necessary to make, with the aid of good instruments, correct topographical examinations and maps of all the ridges and water courses, to ascertain the succession, thickness, dip and course of the different strata; to collect diligently fossil organic remains; to analyze carefully all the ores, coal, cements, marl, clays and soils, so as to estimate their intrinsic relative value; to make experiments upon the durability of certain strata for building materials; to polish different specimens of such strata as seem likely to afford good marble; to endeavor to ascertain the correspondence, dip and prevalence of the various seams of coal, and accurately determine their thickness and succession, and those of the intervening strata of sandstone, shale, limestone and clay; to make a general collection of specimens, to be arranged and deposited at the seat of Government; to determine the nature and variety of the vegetation peculiar to each formation; and, 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."

"It will at once be seen that this is a work which can be fully accomplished only by the united labors of several individuals, by the expenditure of considerable capital, and by the consumption of much time. Whether Indiana would be warranted in carrying out, at the present juncture, so expensive an undertaking, it is not for me to determine. I can but express my opinion that it would ultimately amply repay all outlays and labor."

"A more economical, and, of course, a more superficial and less satisfactory course, might be pursued—a course similar to that which was necessarily adopted during the past season. It would be for the geologist to travel from place to place, make merely ocular, or perhaps partial surveys with instruments, of the various beds of rocks, and determine, by approximation, their thickness, dip, succession, etc.; to collect, as far as time and opportunity will permit, specimens and fossils; and to follow up the before mentioned objects as far as the time and exertions of one individual may suffice for that purpose."

"This plan, of course, could not pretend to the same accuracy of detail as the former. Still much that is important might be accomplished. The more extensive plan is that pursued in the Atlantic States, and which, I presume, will ultimately be adopted in Michigan and Ohio."

Those of us who have had to carry on geological work in the State of Indiana have always been compelled to adopt the more economical and more superficial plan mentioned by Dr. Owen, solely because the great State of Indiana was too niggardly in her offerings to enable us to do the better work.

In the second year (1838) Dr. Owen continued his work along economic lines, paying especial attention to the coals, iron ores and building stones of the State, and also making a special study of the conditions under which brine or salt water occurs, since salt at that time was an important commodity and difficult to obtain. As Owen's home was in southern Indiana, where outcrops of rock were frequent and easily studied, where most of the "public works" of that period were in progress and where coal and iron ores were most abundant, we find his second report, as was his first, mainly devoted to that region. He first took up briefly each of the southern counties and described its more important mineral resources. In the chapter on Posey County he mentioned especially the siliceous marl or marl-loess deposits which outcrop six to eight feet thick in many localities, giving their chemical analysis and recommending their use for improving some of the adjacent sandy soils. He gives sections of the exposed rocks in the coal formations of Posey, Vanderburg and Warrick Counties, mentions the fruitless search for silver in Dubois County, which, despite his early warnings, was continued as late as 1905. In the chapter on Dubois and Orange Counties, Dr. Owen gives the first description in geological literature of the now world famous French Lick Springs. His remarks are as follows:

"Near the termination of the sandstone formation, but rising through the inferior limestones at the French Lick, is a saline spring, strongly charged with sulphuretted hydrogen; so much so that, after sunset in a summer even-

ing, the odor arising from it can be perceived about half a mile from the Lick, and the ground over which it flows is black, owing to the iron which it contains being converted into a sulphuret of this metal.

"Those who reside in the immediate neighborhood of this spring and under the influence of this gas during the months of July and August are frequently attacked with fever and ague; while those living on the higher ground, and out of the influence of the immediate atmosphere of the sulphuretted hydrogen, remain quite healthy. This fact, which can be attested by all the inhabitants of this region, seems to prove that the existence of sulphuretted hydrogen in the atmosphere is one of the predisposing causes of intermittent fever."

Dr. Owen makes no referenee to the mosquitoes of the region which, in those days, doubtless bred by myriads in the pools along the streams below the outlet of the springs, the runoff water being comparatively fresh after its gases had escaped into the air.

Continuing, Dr. Owen describes briefly the whetstone rock formation near French Lick and under "Harrison County" mentions and explains the cause of the numerous sinkholes and caves of his so-called Barren Limestone (Mitchell) of the region. Under "Floyd County" he gives a detailed geologic section of the formation from the bed of Silver Creek to the top of the Knobs, and also one derived from borings through the black slate and underlying strata. Continuing farther eastward he gives a section of the noted railway cut near Madison, and states that he met Dr. Loeke, one of first Geologists of Ohio, with whom he traced the extent of the Magnesian limestone along the common boundary of the two states, from the Ohio River to Union County, Indiana. From here Dr. Owen passed on northwest to Wayne County, and from there to Muncietown and Andersontown, as they were then known. He describes the "white gritstones" outcropping at the falls near Pendleton and states that they might perhaps be fit for making glass, a use to which they were afterwards extensively put. Proceeding northward, he mentions the first appearance of a limestone formation on the head waters of the Wabash, ten or twelve miles west of the Ohio line, and states that "the Wabash then flows almost uniformly over ledges of rocks for about 100 miles to Delphi in Carroll County."

He considered it remarkable that a nearly flat prairie country should, in northern Indiana, form the dividing ridge between the waters flowing into the Great Lakes and those running into the Gulf of Mexico, and that the larger streams of that section, "instead of commencing by confined mountain torrents, should rise from widely expanded sluggish springs in Tamarack swamps, and flow for 30 or 40 miles with little perceptible fall." He states that there are many reasons for believing that the St. Joseph and the St. Marys, which unite near Fort Wayne and then turn and flow northeastward into Ohio, once flowed down the Wabash. Continuing southwestward, he mentions the rock, then as now, being worked in the extensive quarries at Kenneth, three miles below Logansport, and states that "The whole of the

rock formation which I have just been describing, I consider as belonging to the strata inferior to the black, bituminous, aluminous slate, and belonging to the Devonian and Upper Silurian Periods of European Geologists."

Under "Carroll County" he describes the black shale outcrops near Delphi, correlating them with those at New Albany, and under "Montgomery County" he mentions the notable crinoid beds near Crawfordsville. Sections of important coal deposits in Fountain, Parke and Vermillion Counties are then given and the deposit of iron ore near Brouillett's Creek, where a large blast furnace was afterward erected, he states is the finest he had seen in the State.

Continuing southward, he examined more closely the coal seams of Clay, Vigo and other counties, and gives much information regarding their thickness and quality. No mention is made, however, of the block coal afterward developed in Clay County.

Sometime during the summer of 1838 he made a trip to the then celebrated salt region of Virginia on the Kanawha River, in order to study the strata in which the salt was obtained. This study, he asserts, convinced him that the area in western Indiana, immediately adjacent to the base of the coal measures, is almost the equivalent of that on the Kanawha and Muskingum and that "there is a tolerably fair prospect that the formation at the margin of the coal fields of Indiana will yield a profitable brine." Bores were afterward sunk near the mouth of Coal Creek, Fountain County, and a good quality of brine which yielded a pound of salt to the gallon was obtained, at a depth of 700 feet; but the industry never developed into one of importance, the opening of the Wabash and Erie Canal bringing in the Onondaga salt and putting a stop to the enterprise.*

In his summary at the close of the Second Report, Dr. Owen states that the best coal which he had seen in the State was near the Sugar Creek foundry in Parke County, and that the two thickest seams observed are on the Patoka between Pike and Gibson Counties and on Brouillett's Creek in Vermillion County. He says that the bituminous coal of Indiana shows its vegetable origin more distinctly than any coal he ever inspected, and that along the eastern margin of the coal formation he found "excellent fire-clays, potter's clay, furnace hearth-stones and slates, from which copperas and alum can be manufactured on a large scale." Limestones, he says, "are not abundant in our coal formation but are locally present and often afford good material for macadamizing turnpikes," a statement borne out by tests the writer had made at the Road Material Laboratory at Washington in 1905.

One prophecy which Dr. Owen made, which has not been fulfilled, was that "When this country becomes older and produce more valuable, the marls of the Lower Silurian could be transported by water with great advantage from Jefferson, Switzerland and Dearborn, to the counties on the Ohio and Wabash, which are deficient in lime, phosphoric acid, potash and

*Report of R. T. Brown, 1853, 317.

clayey matter. This he says, "will undoubtedly, some day be done." Instead of transporting these marls we now grind very finely the Mitchell and allied limestones and utilize this ground material as a mineral manure. He stated that "most of the lowest beds of the Lower Silurian are vastly rich in fossils, a list and drawings of which can be furnished for publication, if required."

In this connection it may be remarked that the first edition of the 1837 report shows that he submitted with the text four charts and five plates of fossils characterizing the different rock formations. Following out the policy which I have mentioned, the legislature, to which he submitted his report, neither requested the list and drawings of fossils which he offered, nor authorized the publication of the charts. A colored geological map of the State which he prepared to accompany the second report was deposited without publication in the State Library, and all trace of both it and the charts is now lost.

Near the close of his second report, Dr. Owen states that he "considered the margin of the coal formation the mineral region of the State, and the one which, before all others, demands a minute topographical, geological survey, in order,

1. To lay down on the map accurately the boundary of the coal formation in all its meanders.
2. To examine thoroughly the saliferous rocks, and determine their exact thickness, extent, inclination and superposition.
3. To discover, if possible, new deposits of iron ore, which seem to be so frequent in this region.
4. To ascertain the extent of the freestones of this district which might be suitable for buildings.
5. To ascertain the number, thickness, relative superposition, equivalency and spaces which the various beds occupy relatively to each other, and the localities where each bed crops out on the surface.
6. To make observations on the exact dip of the coal measures, a discovery of which would indicate the depth at which any particular seam might be reached by shafts sunk in any part of the coal measures.
7. To endeavor to discover the most valuable beds of fire clays, potter's clays, grits and alum slates which appear to be common in these localities.
8. To collect and determine what may be the most characteristic fossils, not only of each system and formation, but of the different members of each group; an investigation which is intimately connected with the discovery of mineral wealth; especially with the discovery of workable coal beneath the drainage of the country.
9. To determine in what this formation agrees, and in what it differs from equivalent formations in other countries."

He ended his second report as follows:

"Although we may not be able to boast of the gold mines of Georgia and the Carolinas, or of as great a variety of metallic ores as Missouri and Tennes-

see; yet when we consider the area and probable thickness of our coal measures, with the number of beds of coal, and associate iron ores; their accessibility and proximity to the materials required for their reduction; the levelness, fertility and extent of the arable lands of Indiana; the prospects for an ample supply of salt, and that all these staple articles lie in the immediate vicinity of our principal navigable streams, we have every reason to be abundantly satisfied, not only with our agricultural advantages, but also with our mineral resources, which are, in fact, far greater than could be reasonably anticipated, considering our position near the center of the vast and fertile Valley of the Mississippi. Looking to the sources of wealth and the stimulants to industry which lie buried in the strata of our coal formation, we may confidently anticipate that our young and growing State will not only continue to rival her sister states as an agricultural people, but that she will also, ere long, be able to enjoy an equal share in all their commercial and manufacturing advantages."

Thus did he affirm his loyalty to his adopted State whose citizens, aside from her geologists, have never appreciated or given proper credit to the work which he did. He was the pioneer who in two years' time and in two brief reports laid the foundations of our geological knowledge of the State, and he laid them so well that in all the super-structures since erected, the builders have followed very closely his outlines and his plans.

The legislature of 1839 passed an act, approved on February 18, "Providing for an examination and report of the Mineral Resources of the State and for other purposes." The salary was continued at \$1,500 with \$250 for expenses. The appointee was to be a "person of suitable scientific and practical knowledge and acquirements" and was to hold his situation for only one year. In addition to examining in a detailed manner the "productive mineral resources of the State," he was to report whether in his opinion the raising of silk and the manufacture of sugar from the sugar beet can be successfully prosecuted in the State. The last section also provided that "it shall be a part of his duty to make examinations and experiments with the disease commonly called the 'Milk Sickness' with a view of the discovery of the causes and remedy of the same and to report the result of these experiments annually to the legislature."

We can find no record of the appointment being offered to Dr. Owen or to any one else. If offered to him he evidently turned it down, perhaps not relishing the new duties at the old munificent salary. It was, as we have noted, about this time that the "internal improvement" bubble fostered by the State went up in hot air. It is very probable that the office of State Geologist provided for in the act of February, 1839, went up with it.

Soon after terminating his survey of Indiana in 1838, Dr. Owen was appointed to make one of that part of the Northwest Territory now comprising the states of Wisconsin and Iowa and a part of Illinois. His report of this great undertaking was published at the expense of the Government in 1844, and is "noted for the beauty and correctness of its illustrations and the

felicity of its descriptions." In it he gives a chart of the Great Illinois Coal Field (Plate IV) which, on a small scale, shows by a map the extent and position of the coal measures of Indiana. This was the first map of what is now widely known as the "Eastern Interior Coal Field," which covers an area of 47,000 square miles in central and southern Illinois, southwestern Indiana and northwestern Kentucky.

FIRST DISCOVERY OF GOLD IN INDIANA.

The next fact of interest which can be found recorded regarding the Geology of Indiana was the first mention of the finding of gold in the State. This was in the *Journal of the Franklin Institute* for June, 1850, and was in part as follows:

"Professor Frazer read to the meeting (of the Franklin Institute, May 17, 1850) a letter from Prof. T. A. Wylie, of the University of Indiana, announcing the discovery of gold in the vicinity of that place, and exhibited specimens of the gold, and of the black sand in which it is found. 'The gold has been found in the beds of the rivulets in Morgan County, about twenty miles northeast; in Jackson County, about twenty miles southeast; in Brown County, about twenty miles east, and in Greene County, about fourteen miles west of Bloomington, as well as at certain intermediate points, but not in the immediate vicinity. Where it has been found it is always in connection with a black sand which the washers call "emery." This sand is found at the bottom of the streams, usually at the upper end of the sandbars or on the margins of the streams where there is a sudden turn, and in such places as it would be naturally deposited on account of its density. The coarse gravel is sifted and washed in the usual way until nothing remains but the dense black sand. On examining closely with the microscope, there are to be perceived interspersed through it red particles of different shades, and some few yellow and green particles; of the red particles some appear to be merely colored quartz, while others are plainly distinguished by their crystalline form as garnets, and some of the darkest probably pyrope. The black particles are readily separated into two sorts by the magnet. Those attracted by the magnet, which amount in some specimens to five per cent of the whole, are evidently magnetic oxide of iron. The remaining black grains agree precisely with Dr. Thompson's description of titanate of iron or menaccanite.' The gold is in flat scales, a good deal resembling in appearance that from California."

"Professor Frazer remarked that from the account of Professor Wylie, it did not appear that this new gold field was likely to prove profitable in the working, but that it was of great interest, both in a geological and mineralogical point of view, and gave rise to an interesting inquiry as to the original locality of the minerals associated with the gold, since they are of a nature inconsistent with the rock formations of that portion of the United States."

THE GEOLOGICAL SURVEY OF DR. R. T. BROWN.

By 1852 the State had recovered somewhat from its Internal Improvement venture.* A number of persons interested in the more rapid development of its resources began an agitation for the renewal of the Geological Survey, and we find that on January 12 a joint resolution was passed and approved providing "That our Senators in Congress be instructed and Representatives requested to use their votes and influence to effect the passage of a law giving to the States respectively, in which there is so much unsold public lands, one township in each land office district to be applied by the proper authorities of the State for the purpose of making a Geological, Agricultural and Topographical Survey of such State." The Governor was also requested to furnish one copy of this resolution to each of the Governors of the several States, and request them to lay the same before their legislatures.

Dr. Ryland T. Brown, a scientist of repute and a citizen at that time of Montgomery County, evidently did not believe in the delay which this joint resolution entailed and we find that on the evening of January 22, 1852, he delivered to the legislators in the Hall of the House of Representatives a lecture entitled "The Geology of Indiana as an Element of Wealth to the State," in which he set forth the need of a survey which "should not only embrace the geology and mineralogy of the State, but in which the topography of each county should be carefully examined and accurately marked on the map." He mentioned the great value of the coals of the State, the drift origin of most of the soils, and incidentally the occurrence of gold in the drift of Brown County. He asked that a liberal appropriation be immediately made to carry on the work, but there is no record of a bill introduced or passed to that effect.

It seems, however, that the State Board of Agriculture, which had been organized in May, 1851, had taken some action in the matter and had authorized Dr. Brown to act as its "Geological Agent," as we find on pages 299-332 of the Third (1853) Transactions of the State Agricultural Society, a letter from Dr. Brown to Governor Joseph A. Wright, president of the State Board of Agriculture, headed "Geological Survey of the State of Indiana," which is a very large title for such a brief paper. He starts out by saying: "In consenting to serve the State Board of Agriculture in the capacity of Geological Agent, I have done so without any very definite idea of what the precise duties were which the Board expected of me.

*In the Acts of that year we find one providing that so much of the public works heretofore constructed by the State, as has not been granted to any private company, be surrendered to the counties in which they lie. One section of that act is somewhat curious in that it provides that: "So much of the National Road within the State heretofore ceded to this State by the United States, as has not been granted to any company, together with all materials to or near the same and now the property of the State, shall on or before the first day of October next be put up at public auction, after due notice of sale, by the Auditor of State in convenient lots, and sold to the highest bidder; and the proceeds of such sale shall be paid into the State Treasury."

My instructions are very general in their character, and, if I rightly understand them, leave a wide margin to my discretion."

"With the limited means at the disposal of the Board, I suppose it was not their intention to undertake, at present, anything like a systematic survey, and mapping of the State by sections; but merely to institute such local examinations as will, with the least labor, develop the largest amount of facts in relation to the resources of the State, not only in mineral wealth, but also in regard to building material, including stone, lime and timber— and whatever else may tend to call attention to, and invite the investment of active capital in Indiana."

"The labors of Dr. Owen, some years ago, have furnished us with an outline map of the Geology of the State, so that the lines of outcrop of the several formations are pretty accurately defined. There will be therefore, no loss of time necessary in defining the boundaries of the different strata, and their associated mineral treasures."

His report then follows closely along the lines of Dr. Owen's 1837 report, which had been reprinted verbatim in 1853. He states that the "Cliff rock" of the Ohio Geologists is the equivalent of the "Niagara limestone" of New York, thus introducing for the first time that name into Indiana Geological literature. His statement (p. 303) that it underlies really more than half of the territory of the State is apt to be misunderstood, and is true only in the sense that it dips deeply beneath the overlying formations to the southwest, and not that it forms the surface rock over that much of the State's area. Several pages are devoted to the quarries which had been opened at Marble Hill, Vernon, Greensburg, Logansport and other points. He called "the especial attention of the many flourishing towns in the interior of the State with muddy sidewalks to the quarries at Sand Creek, Clifty and Flat Rock which were then furnishing "flagstone for pavements of almost any required dimensions and in quantities that cannot be exhausted for ages."

Dr. Brown did not recognize Owen's name of "Knobstone," for the formation now known under that name, but called it the "Argillaceous or Chemung sandstone," regarding it as identical with the Chemung of New York and the Great Devonian or old red sandstone of Europe, in both of which conclusions he was evidently wrong. He says "On a careful examination, I am convinced that this series will, with proper care, in the selections, furnish much valuable building material," a statement which has also not been borne out in the years that have passed.

The first account of Wyandotte Cave in an Indiana work is opened with the sentence: "A minute description of this great subterranean world would, perhaps be out of place in this report. Suffice it to say that the extreme distance attained, from the most southwardly to the most northwardly point, is seven miles." He states, as have a number of other writers, that the "whole number of miles in the explored cave is nineteen and a half," while accurate measurements made by myself in 1896 show that they are 4.21. I can, however, approve most highly his closing statement that "To the curious

and the lovers of the profoundly sublime, we would recommend a visit to Wyandotte Cave—it will amply repay the time, labor and expense of a visit.”

In this report of Dr. Brown we find also the first written words praising the qualities of the Indiana oolitic limestone. He states that at that time it was being shipped from a quarry near Bedford for use in the construction of the United States Custom House at Louisville, that the face of the quarry “exposes one stratum of eight feet in thickness without a seam, or the slightest fault. By means of wedges, blocks may be split the whole thickness and of any desirable length. The accuracy and ease with which it may be split, its softness when fresh from the quarry, its beautiful whiteness when dry, its durability and great strength renders it all that could be desired as a stone for building purposes. The same rock, with slight local variations, extends to Gosport; occupying a band of country about ten miles in width, traversed in its whole length by the New Albany and Salem Railroad. At Mount Tabor near Gosport, a variety of this stone is now being worked which receives a high polish, and presents a finely variegated appearance, being indeed an excellent and beautiful marble.”

Attention is called for the first time also to the Falls of Eel River and the statement made that he “knows of no place which combines greater advantages for manufacturing. The location is six miles southwest of the railroad, but a single lock of a six feet lift in a mill dam at Millgrove will connect the falls with the railroad by slack water. This location should be in the hands of a manufacturing company with capital sufficient to use all the power afforded.” These words were written 63 years ago and for that many years this source of power has been neglected.

Twelve of the 34 pages of the report are devoted by Dr. Brown to a description of the coal measures of the State, especially those north of the National Road, and the only illustration given is a double page geologic section on the Wabash River near Lodi, Fountain County, in which six veins of coal, ranging in thickness from 18 inches to 12 feet, are shown. The 12-foot vein probably includes some black shale or else Dr. Brown drew on his imagination, as later records show no such seam in that locality.

No mention is made of the block coal of Clay County, though it had been discovered in 1851. The statement is made that at that time (1853) coal was being mined more extensively near Cannelton, Perry County than at any other place in the State. “An able and energetic company under the title of the ‘American Cannel Coal Company,’ has possession of about 7,000 acres of coal lands on the immediate bank of the Ohio River. About 500,000 bushels of coal are mined annually at this point, the greater part of which is consumed by steamboats on the Ohio and Mississippi rivers. In the proximity of an infallible market, and in the energy and ample capital of the company, consists the main advantage of Cannelton as a mining locality. The principal, and indeed, the only workable seam of coal, is the equivalent of No. 3 in my Lodi section. Now, each section or square mile of this coal seam will yield about one hundred millions of bushels. Other localities in the State have at

least three workable seams lying one above another, making an aggregate of from 12 to 15 feet of coal, or more than three hundred millions of bushels per square mile. The price of coal, delivered on boat at Cannelton, is seven cents per bushel, or \$1.96 per ton."

"The Cannelton Cotton Mill Company, whose mill was constructed in 1849," he states, "have the honor of having first demonstrated that the cheap fuel, cheap transportation, and cheap living in the west, can fairly compete with manufactories anywhere. The mill is now running 10,800 spindles, and 378 power looms, making about 600 tons per annum, or two tons per day of brown sheetings. The factory is four stories high, with an attic—is 287 feet long and 65 feet wide, with two towers in front, each 106 feet high. It is built of new Red Sandstone of the Coal formations." This is a coal measure sandstone immediately overlying the Mansfield sandstone.

The area embraced in our new State Park, "Turkey Run," was first mentioned in geological literature by Dr. Brown as follows: "The lovers of the wild and romantic in scenery are especially invited to examine Sugar Creek from the mouth of Indian Creek to its junction with the Wabash. No region in the State furnishes so many frightful precipices, rugged cliffs and deep twilight gorges as Sugar Creek, in the neighborhood of the Narrows."

In 1857 Hamilton Smith, a member of the American Cannel Coal Co. of Cannelton, Ind., prepared for the State Board of Agriculture a paper of 33 printed pages entitled "Coal Mining in Indiana." This was published in the State Agricultural Report for 1856. In it he stated that the Cannel Coal Company, composed of foreign capitalists, after due investigation, had received a charter from the State and opened their mines near Cannelton in 1837, with the expectation of furnishing fuel to the many steamers plying up and down the Ohio River. When they were ready to deliver coal they found out that the engineers would not change from wood to coal, claiming that the latter would not make sufficient steam. For a long time they operated the mines at a loss, and after 20 years were just beginning to pay dividends. The paper was illustrated with eight plates of mining machinery and one geological section of the coal formations at Cannelton. The writer claimed that a thorough geologic survey of the western section of the State would be of infinite advantage to both producers and consumers. As a member of the legislature from Perry County, he did much toward bringing about the enactment of the law creating the survey authorized in 1859.

In 1857 a well was sunk in the courthouse square in the city of Lafayette to a depth of 230 feet. It proved to be an artesian well, with a strong flow of sulphur water. Dr. Chas. M. Wetherill prepared and published* in the American Journal of Science a report of 32 pages treating of artesian wells in general and the one at Lafayette in particular. It included a description of the strata, a full analysis of the water, etc., and was the first literature on artesian wells in the State.

*Vol. XXXII, Sec. Series, p. 241-249.

THE OWEN SURVEY OF 1859-1860.

In the Acts of the special session of 1858 we find that the following Joint Resolution was approved:

Whereas, The Indiana State Board of Agriculture have memorialized the General Assembly in reference to a Geological Survey, and have stated that the vast agricultural, mineral resources of the State are comparatively unknown, would be rapidly developed was such a survey made and published; therefore,

Be it resolved, The Senate concurring, that a joint committee of sixteen be appointed, corresponding with the districts arranged by said Board, of which nine shall be of the House and seven of the Senate, to whom the whole subject shall be referred.

No record of the report of this committee can be found, but the Acts of 1859, p. 112, contain the following:

AN ACT AUTHORIZING THE STATE BOARD OF AGRICULTURE TO CAUSE A GEOLOGICAL RECONNAISSANCE OF THE STATE TO BE MADE, TO MAKE COLLECTIONS AND ANALYSIS OF SPECIMENS AND MAKING APPROPRIATION THEREFOR.

Approved March 5, 1859.

Whereas, The State Board of Agriculture has memorialized the General Assembly for such aid, as a full Geological Survey of the State would give in furtherance of the object for which said Board was organized, and the finances of the State being not in condition to justify such an appropriation as the plan contemplated by the memorialists, and *whereas* it is now believed that the sum of \$5,000 granted by the State to such Board would be sufficient to make a geological reconnaissance of the State and the determination of the general boundaries of its Geological formations, and also to make collections and analysis of specimens of minerals, ores, earths and stones from every portion of the State, and thus prepare the way for a more full and systematic survey to be made under the direction of the State Executive.

Section 1.—Therefore, *Be it enacted by the General Assembly of the State of Indiana*, That the sum of \$5,000 is hereby appropriated out of the State Treasury and to be paid on the warrant of the Auditor of State for the purpose of making the Geological Reconnaissance, collecting and analysis of specimens of minerals, ores, earths and stones.

Sec. 2.—The Governor is hereby directed to select a suitable room in the Capitol or in any building that may be erected by the State, if a suitable one can be found, and if not to hire one suitable for the deposit of such minerals, soils, ores, fossils, maps, sketches, etc., as may be collected and made by direction of such Board, which room shall be placed under the control of said Board.

Sec. 3.—The State Board of Agriculture shall on or before the 15th of December, 1860, make a full report to the Governor of the expenditures of said appropriation with full vouchers thereof and of the results accomplished

thereby. The Governor shall have 2,000 copies of said report printed for the use of the next General Assembly.

Here will be seen again the demand of the law makers that the impossible be performed, viz., the making of a complete survey of the State and the analyzing of an unlimited number of ores, minerals and soils for \$5,000.

In accordance with the instructions of the Act the State Board appointed Dr. D. D. Owen for a second time as State Geologist and instructed him "to commence a thorough survey of the coal fields of Indiana as early in the spring as the weather will permit, and to procure the necessary outfit either by purchase or hire as may seem to him best, having a strict regard to economy."* Since his former connection with the Indiana Survey, Dr. Owen had, as we have noted, served the United States as Geologist of the Northwest Territory, and had also served as State Geologist of Kentucky and Arkansas.

Dr. Owen appointed his brother, Richard Owen, as chief assistant, Dr. Peter of Lexington, Kentucky, as chemical assistant, Leo Lesqueretux as Paleontologist and Joseph Lesley of Philadelphia as topographer. He wrote a general statement for the final report and a condensed report on the first year's work to the State Board of Agriculture, but when the survey was only partly finished he died of malarial fever at New Harmony, Indiana, on November 13, 1860. Of him W. T. Dennis, Secretary of the State Board of Agriculture wrote: "The death of Dr. D. D. Owen is a public calamity, widely felt and deeply deplored, occurring as it did just at the time of the preparation of his detailed report of the entire operations of the survey. * * * He was known to be a prodigy of scientific learning, an excellent chemist, a thorough mineralogist, a good civil engineer and as a geological surveyor had no equal. * * He possessed the best geological collection in the western country, and in him Indiana lost her most solid man of Science."†

The geological collection mentioned had as its nucleus a large portion of that extensive collection of minerals and fossils left by Wm. McClure. To this Dr. Owen had added by purchase and collecting until it contained 85,000 specimens. The entire collection was sold for \$25,000 some years after Owen's death, to Indiana University, and was almost wholly destroyed in 1883 when the museum, laboratory and library of that institution were burned.

The result of the work done in 1859 and 1860, under the supervision of David Dale Owen and later under that of his successor, Richard Owen, was published by the State in 1862, under the title "Report of a Geological Reconnaissance of Indiana made during the years 1859 and 1860, under the direction of the late David Dale Owen, M. D., State Geologist, by Richard Owen, Principal Assistant, now State Geologist." It forms a large octavo volume of 368 pages, illustrated with wood cuts of a number of localities of especial geologic interest in the State, and with two plates of Silurian and Carboniferous fossils. In the condensed report submitted by David Dale

*Condensed Report of the Geol. and Agr. Survey of the State of Indiana for 1859 and 1860, Doc. 5, Pt. II, H. J. 1861.

†Loc. Cit. p. 165.

Owen just before his death he had promised that one feature of the report would be chapters by himself on Agricultural Chemistry and on milk sickness, particularly the connection of the latter with peculiar geological formations. As Richard Owen states in his prefatory letter, these two papers as expected from his pen "might have greatly promoted the health of our population and increased the wealth derivable from our soil, through the useful practical suggestions designed to be conveyed." Especially of interest would have been the chapter on milk sickness, a strange and most fatal disease which has baffled the skill of the leading physicians of the country, both as to cause and cure. While much more prevalent in the days of a half century and more ago it yet occurs occasionally in the State, several deaths having resulted from it in the summer of 1916.

The first part of the Owen report, as published, begins with a preliminary chapter on the principles of geology, followed by a description of the character and sequence of each of the great rock formations which comprise or underlie the surface of the State. Beginning with the oldest of these, the Lower Silurian, it next takes up each in order, treating separately each county whose area mainly belongs to that formation. Of each it gives the main facts regarding its soils and mineral resources, such as building stone, clays, coal, mineral waters, etc., paying especial attention to the character of the soil derived from each kind of underlying rock and giving lists of fossils of each of the principal formations. It also mentions the principal crops grown, the prevailing kinds of timber, and the most prevalent diseases of each county. In fact, it is the only report yet published which, in a single volume, attempts to cover the entire State by counties in the manner described. Many of the counties are treated very briefly, a number of them not having been visited by either of the Owens, the data given having been obtained from other persons. While much valuable information of a general nature is given, there is in this part of the book not much original matter, and it impresses one as being more of a gazetteer than a scientific work on geology.

Richard Owen appears to have been more of a naturalist than a field geologist, as we find in the report many passages like the following: "On the Mississinewa, a tributary of the Wabash, we found, close to the residence of Godfrey, a son of a Miami chief, whose tribe left these fine lands only eighteen years since, bluffs in which the rocks have been weathered and water washed into fantastic pillars and natural cornices, which might serve to inspire the genius of a Michael Angelo with some new architectural design, to rival his St. Peter's at Rome. These bluffs or pillars, are here about 25 feet high, while nearer the ford they rise to 40 and 50 feet above low water. The bed of this interesting stream was, during our visit at this locality, full of confervae (simple jointed water weeds) and had more crawfish, dashing with their peculiar, quick backward movement from under the rocks into the sunshine, than I ever before saw in one stream. Various species of *Unio*, *Cyclas*, *Paludina* (chiefly dead) and *Melania* were also common; the latter leaving a track in the sand resembling that of a worm. Besides these, numerous

specimens of the larva of the Phryganea, or water moth, were seen dragging their wooden habitation of cemented sticks along the bottom of the shallow fresh water coves formed by the river."*

"In this camp we noted, besides, the usual timber, abundance of the Ohio Buckeye or American Horse Chestnut (*Pavia Ohioensis*) the buds of which, eaten in early spring by the cattle, frequently produce in them symptoms resembling an attack of "trembles or tires," in man called milk sickness."

There are brief lists of plants noted as growing in many of the counties visited. Under Boone County it is stated "corduroy roads, dog-fennel, smart weed and elder showed the necessity in some places of attention to drainage." Botanists of the present day do not class dog-fennel and elder as plants denoting wet soil.

The prevalence of milk sickness is noted in a number of counties and by Richard Owen is usually attributed to the presence of licks, or certain springs resorted to by cattle, as when these are fenced in the disease disappears. He states specifically however, that the disease did not occur in any of the drift covered counties north of the Wabash River.

Many localities in northern Indiana are mentioned where gold had been panned from the drift along the streams. Of the work then being done in Brown County in search of this metal Owen says: "The main localities in which success has attended the washings are on Hamlin's fork of Salt Creek, three-quarters of a mile in a direct line from the west limit of Bartholomew, near Mt. Moriah P. O. Here we found extensive preparations in the way of sluices and hose, rockers, and "Long Toms," picks and shovels, etc. Notwithstanding the rain we panned out enough to convince ourselves that the black sand in many of the pockets contains a considerable amount of gold particles. Judging from what I saw here and elsewhere in Indiana of the gold localities, I should venture the opinion that gold is invariably associated with drifted quaternary materials, derived from a matrix, which finds its mountain home at least from four to six hundred miles distant, and more probably double that distance, in a northerly direction."

The first mention in Indiana geologic literature of geodes, with a description of their structure and origin, and their prevalence in a certain limestone just above the Knobstone (now known as the Harrodsburgh Limestone) is given in the chapter on the counties of the Subcarboniferous limestone.

The first detailed account in any of the reports of the physical properties and chemical analysis of the Indiana Oolitic limestone is given under the Monroe County heading, the specimens having been taken from a quarry then operated near Stinesville, Monroe County. The caves at Hamer's Mills near Bedford, on or near the farm now owned by the State University, are also mentioned for the first time. A six page description of Wyandotte Cave with poor wood cut plates of Monument Mountain and the Pillar of

*It was here also that we captured a bull-frog for camp provisions and found, on dissection of its intestinal canal, that it contained a pebble weighing at least an ounce.

the Constitution, and the first map of the cave ever published is given in connection with the matter on Crawford County. The original draft of the map was made by Rev. Horace C. Hovey from measurements made by himself and other parties between 1857 and 1860.*

The counties comprising the coal area of the State are treated more in detail than any of the others, many sections of the coal measures and brief analyses of the coal being given which were afterwards used in the Cox and Ashley coal reports. The noted Indiana Block Coal of Clay and Parke Counties is mentioned for the first time under the name of "Splint or Bog head coal," and its analysis given. The only statement regarding its quality is that "The coal is used and much liked by the proprietors of the rolling mill at Indianapolis."

"Indian" and "Trinity" springs, well known resorts in Martin County, are described for the first time, and a quantitative analysis of the water given.

The first mention of the kaolinite of Lawrence and Martin Counties is in the following words: "Near Indian Springs a remarkable white Magnesian mineral, which cuts readily with a knife, and resembles the meerschau used for pipes, deserves an accurate quantitative analysis."

Under the heading "Counties of the Drift or Erratic Quaternary" twenty counties lying north of the Wabash River are included. In the first mention of the fresh water marl of the northern lakes and marshes (described in detail by the present writer in the report for 1900) Owen says: "The immense deposits of marl, sometimes replete with shells chiefly of the genera *Physa*, *Planorbis*, *Cyclas* and *Unio*, sometimes a clay marl, particularly in St. Joseph, LaPorte, Porter and Lake, are of great commercial and agricultural value, as well as for burning into lime, as for the fertilizing of the soil; but more particularly for the manufacture of artificial stone and brick; provided that enterprise, so successfully commenced, should extend itself as it promises." These marls have in recent years been used extensively as the carbonate of lime ingredient of Portland cement.

Emphasis is laid in several places upon the rich deposits of bog iron ore in these northern counties, but so far as known to the present writer, the only blast furnaces erected for their utilization were the ones then in operation at Mishawaka and Rochester, in which marl instead of limestone was used as a flux. These furnaces were long ago dismantled, cheap transportation by water of a higher grade of ore from northern Michigan preventing the development of the Indiana ores.

That Richard Owen was a poet-naturalist is shown by some of his descriptions, especially the following of a well known prairie plant: "In this boundless expanse, this ocean-like land, level sometimes as a floor, with perhaps no path to guide the traveler and scarcely any two objects which by comparison can enable him to estimate distances, nature has provided for the brave denizen of these American "Steppes" a diurnal polar star, a directive

*Proc. Amer. Assoc. Adv. Sci. XXXI, 1882.

sign, like the moss on the north side of trees to the backwoodsman, or almost like the compass to the wanderer on the trackless sea. A plant of the Compositae family grows abundantly in the prairies, with its thick, dry, resinous leaves, all flattened to one plane, as if fresh from the pressure of a herbarium, surmounted by a gay, yellow asteroid flower; and this plant, *Silphium lacineatum*, or rosin weed, even at its earliest exit from the soil, and ever afterwards, in its developments, ranges this broad foliaceous plane due north and south, thus presenting one face of the leaf east, the other west. Instead of an upper side covered with nature's varnish for protection, an under side presenting the breathing stomata of most leaf-bearing vegetation, these leaves are nearly the same on both sides, rough and resinous. To this peculiarity of ranging its leaf-plane north and south it owes the name of compass plant, and to its highly resinous composition the name of rosin-weed."

He states that about the lakes grow in abundance "Cedars, Pines, Tamaracks and Alders, the interspaces beneath dotted by such quantities of a genus from the Heath family, as to require a special train at the gathering season, under the name of Huckleberry (or Whortleberry) train; while another genus of the same family, the Cranberry, furnishes from otherwise useless swamps, the palatable relish to heighten the savory flesh of the native buffalo, deer or pinnated grouse, which formerly enlivened these vast plains or still rush and whirl through the prairie."

The first description which can be found of the Dune region is in the following words: "We found a small river, Trail Creek, with fifteen to twenty feet of water near its mouth and wide enough for a moderate sized vessel to turn in, cutting through a sand drift which has blown up to form a ridge from 100 to 176 feet high and in some places only twenty feet wide on the top. It extends west, we were informed, to Indiana City, and some asserted to Chicago, so closely washed by the waves that the sand lately rolled down in an arenaceous avalanche, denominated the Hoosier slide. Yet, in the early settlement of the country between the lake-waters and this sand ridge the mail stage and other carriages were driven undisturbed by the lake waters, along the beach, from Michigan City to Chicago."

The Northern Penitentiary then in course of construction by convict labor was next mentioned, and of Michigan City he said: "As a matter of home interest it seems highly desirable that Indiana should maintain here or at some other point, if there be a better, along her Lake-coast, a harbor worthy of the State; otherwise her commerce is necessarily diverted to outlets in the adjoining States, the cost of transportation thereby increased to our citizens, and the profits of the carrying trade also lost to them."

That the question of draining the Kankakee Marsh was under consideration 60 years ago is shown in a footnote in the Owen report which is as follows: "A company has been recently organized for the straightening of the Kankakee River, which in its windings is three times as long as the direct line; by means of which, and the removal of obstructions, they hope to deepen the channel and form a drain that will run off its high waters and that of its tributaries

more rapidly than now, and into which cross ditches can be cut, thereby rendering many thousand acres so much drier than at present, as to bring land up from three and four dollars per acre to thirty and forty."

That portion of the report devoted to the detailed descriptions of the counties closes with that of Benton County in the following words: "Flights of cranes were seen and we frequently shot, for camp use, the pinnated grouse, or, in the groves, the wild pigeon, besides startling the meadow lark and a few smaller birds from their prairie nests. For the geologist and physical geographer, the botanist and zoologist, as well as the lover of scenery such as the boundless vision of the day and the gorgeous sunset of the evening often afford, this ocean-like prairie region, and these island-like groves are replete with interest and instruction."

Chapter III of the report is entitled "The Physical Geography of Indiana," and deals with its altitudes, water sheds, and the part which the State plays as a part of the Hydrographic Basin of the Mississippi River. The most interesting portion of this chapter is that in which is set forth the evidence to prove that our prairies are but the beds of vast extinct fresh water lakes and estuaries; also to show that the muck and peat deposits of the northern part of the State are but forms of incipient coal.

Richard Owen closes his part of the report and this chapter with the following statement, dated Camp Tippecanoe, June 20, 1861: "It was the intention to subjoin a chapter on Drainage; also one on Paleontology, systematically arranging the fossils of Indiana obtained from the different formations, etc., then to follow with an exhibit of the main facts collected regarding the localities, causes and other concomitants connected with milk-sickness, and finally to close with a miscellaneous chapter containing suggestions with regard to the best mode of prosecuting the Survey, the most useful manner of arranging the State collection for reference, lithologically, paleontologically and zoologically, as well as recommendations regarding the formation of minor illustrative collections for public schools; but a call to serve my country in maintaining the Union and the Constitution precludes the possibility of completing that design, and compels me to close the report."

He returned from the war with the rank of Colonel, was afterward, until 1879 at the head of the Department of Natural Sciences in the State University, and died at New Harmony, Indiana, on March 21, 1890.

Following Owen's report in the volume of 1862 is a Report of the chemical analysis of thirty-three Soils of Indiana, by Dr. Robert Peter, Professor of Chemistry at Lexington, Kentucky. Soils from each of the great rock formations of the State are analyzed and the tables of constituents were accompanied by valuable introductory and explanatory remarks, setting forth the now well known facts "that certain elements, essential to vegetable and animal development, are gradually consumed from the soil in the crops—that the soil is not a unit in composition—that while the great bulk of it acts only mechanically, or physically, in the support of vegetables, the mineral elements which are essential for the nourishment and growth of organic beings,

vegetable or animal, are found in it only in relatively small proportion, and must be carefully husbanded and restored to it in order to maintain constant fertility. Such a process as this, by which the land would be constantly kept up to the height of fertility and would annually yield abundant crops without any diminution of its richness, would be the perfection of agriculture."

In other words, if only a single element of a plant's food is absent from the soil, that soil is barren as far as the growth of that particular plant is concerned. For example, the muck soils of northern Indiana will not produce corn or wheat because they are deficient in potash. The work done by Owen and Peter was the first serious effort of the State's scientific workers to show the farmers of the State the value of a chemical analysis to determine what element of plant food is lacking in their soils. Not one farmer in a hundred read that report or paid any attention to its teachings. The legislators of that day did not appreciate this chapter in Owen's work, and made no move toward continuing the study of the soils of the State. As a consequence millions of dollars have been spent in the 60 years that have passed for fertilizers that were worthless to the persons buying them because they did not contain the constituent needed, and in almost every county thousands of acres of land are left untilled or are tilled at a loss because of a lack of a certain element of fertility which is unknown to the owner and therefore not supplied by him.

The brief chapter on soils in the report of 1862 is followed by one entitled "Report on the Distribution of the Geological Strata in the Coal Measures of Indiana," by Leo Lesquereux, the noted paleo-botanist of that period. This was the first attempt to correlate and properly place the various coal veins in different parts of the State by a study of the plant remains in the coal itself, or in its overlying or underlying strata. Prof. Lesquereux, whose home was in Columbus, Ohio, spent but five weeks in the field. His paper of approximately 50 pages was for a time regarded as probably of more scientific value than any other in the report, but his conclusions have only in part been adopted by more recent students of the coal geology of the State.

When David Dale Owen in 1859 accepted the directorship of this second Geological Survey, with its princely appropriation of \$5,000 for all salaries and expenses, he evidently assumed that if he could make a good showing for the sum expended the next legislature would continue the Survey and increase the appropriation. One of his day dreams, which is set forth in several places in his 1837 and 1838 reports and also in the condensed report made in 1860, was that a topographical survey would eventually be authorized which in time would cover the entire State. Since not one legislator in twenty would know the difference between a topographical map and a map of the moon, he concluded to prepare for them an object lesson, and so employed J. Lesley of Philadelphia to prepare a topographical map of a portion of Perry County. In the brief report of Mr. Lesley which accompanied the map, he stated "that the cost of extending such a series of examinations over the whole State of Indiana I estimate at \$150 per township—field and office work included." Of the map itself Richard Owen says: "The beautiful map executed

by that accomplished Topographical Geologist, Mr. J. Lesley, is now framed and suspended in the Geological Room of our State Capitol." Where it is now only the Gods of the past know and they are forever silent. In his coal report of 1898, George H. Ashley commented on this work of Mr. Lesley as follows: "It is of no small interest that Mr. Owen, almost simultaneously with the starting of the reconnaissance of the State, should start a detailed topographical map of its area. Unfortunately the lapsing of the survey prevented further work of the kind and as a result the State has paid out in the past for successive partial reports on the same areas more than enough to have made complete detailed maps and reports, showing topography, location, extent and value of all rocks or minerals of economic importance, surface geology and distribution of soils."

On account of the Civil War and the questions of importance which arose immediately after its close, we have little to record of Geological activities in Indiana between 1862 and 1869.*

In 1866 there appeared a pamphlet of 30 pages, the title page of which was as follows: "Report of a Geological Examination made on the lands of the Wabash Petroleum and Coal Mining Company, in Warren, Fountain and Parke Counties, Indiana, by Richard Owen, Professor of Natural Science, Indiana State University and State Geologist of Indiana. Analyses of the Ores, by E. T. Cox, Chemical Geologist."

The pamphlet was issued by the company and was an advertising of their holdings in the counties mentioned. It contains analyses of many coals, iron ores, limestones and clays; also of the bituminous shales above the coal, which the company proposed to grind and use in making roofing.

Dr. Ryland T. Brown appears to have been the leader in geological and scientific work in the State during that period. There was published in the State Agricultural Report of 1867 a paper by him entitled "An Essay on the Natural Resources of Indiana." In it he speaks very highly of the oölitic stone, by that time being quarried extensively in Lawrence, Monroe and Owen Counties. He also stated that Prof. Lesquereux "has the honor of inaugurating the great work of the systematic examination of the Coal Measures of Indiana."

In 1868 there was issued for private distribution a pamphlet entitled "Indiana and her Resources," compiled at the request of Conrad Baker, Acting Governor of the State, by R. T. Brown.

In 1869 the legislature of the State, at the earnest solicitation of Dr. Brown and the leading members of the State Board of Agriculture passed an act authorizing a Geological Survey, creating the office of State Geologist, etc. Since that date the office of State Geologist has been in continuous operation, though the title of the office, the duties imposed and the salaries and expenses allowed have, as we shall see, been changed on several occasions

*A geological map of the State on the scale of five miles to the inch is said to have been published at Cincinnati by N. Saylor in 1865, but the writer has never been able to see a copy of it.

to meet political and other exigencies. The act creating the office, approved March 5, 1869, was as follows:

An Act providing for a Geological Survey and for the collecting and preserving of a Geological and Mineralogical Cabinet of the Natural History of this State, and creating the Office of State Geologist, defining his duties, fixing his salary, and appropriating a sufficient sum of money to defray the necessary expenses of said Survey and for the collection and preservation of said Cabinet.

(Approved March 5, 1869.)

Section 1.—*Be it enacted by the General Assembly of the State of Indiana,* That a Department of Geology and Natural Science is hereby established in connection with and under the control of the Indiana State Board of Agriculture for the collection and dissemination of information in relation to Geology and other Scientific investigations, to be made as hereinafter provided for the promotion of Agriculture, mining, the arts and manufacturing.

Sec. 2.—The Governor is hereby authorized to appoint a suitable person as State Geologist to take charge of said Department, and said Geologist shall hold his office for a term of two years and until his successor shall be appointed as aforesaid, with an annual compensation of \$1,800 to be paid in quarterly payments; and in addition said Geologist shall be paid also for the necessary traveling expenses incurred while engaged in prosecuting the field surveys and for the chemical reagents used in the analytic work.

Sec. 3.—Said State Geologist shall have a thorough practical knowledge of Geology and Analytical Chemistry, and shall establish his office at Indianapolis in a room or rooms furnished him by the State Board of Agriculture and he shall be required to supply himself *free of cost to the State*, with all the apparatus necessary to fit up an analytical laboratory, adapted to making chemical analyses of soils, ores, metals, mineral waters, or any other substances that may be thought of value or of general interest to the citizens of the State.

Sec. 4.—Said State Geologist shall from time to time make a survey of a portion of the State in order to be able to complete a thorough geological survey of the whole State, and it shall be his duty also to collect, properly label and arrange in the Agricultural rooms, specimens of the ores, coals, building stones, clays, soils and organic remains of quadrupeds, birds, reptiles, fishes, crustaceans, mollusca, insects and all other objects of natural history peculiar to the State, and as far as practicable of other States and countries also.

Sec. 5.—The State Geologist shall also be required to issue Annual Reports to the Indiana State Board of Agriculture, embracing the full results of his labors each year; which reports shall be published along with the Proceedings of the said State Board of Agriculture.

Sec. 6.—That in order to carry the provisions of this act into effect, the sum of \$5,000 be and is hereby annually appropriated and placed in charge

of the State Board of Agriculture for their disbursement in accordance with the provisions herein made and provided and it shall be the duty of the State Geologist to file with the State Board of Agriculture a detailed statement, accompanied with the proper vouchers for all moneys expended by him in carrying out the provisions of the act.

Sec. 7.—That there shall be printed and bound annually in separate volumes 2,500 copies of the Report of the State Geologist, to be paid for as provided by law for the printing, binding and distribution of the laws and journals.

Sec. 8.—Emergency clause.

THE COX SURVEY, 1869-1879.

In accordance with the act above cited, Governor Baker appointed Edward Travers Cox of New Harmony, Ind., to the office of State Geologist. That gentleman had been a chemical and geological assistant of David Dale Owen on both the Kentucky and Arkansas Surveys and had done some work on the Illinois Coal Survey. In the introduction to his first report, that for 1869, Mr. Cox says: "Soon after receiving the appointment I proceeded to pack my large and valuable collection of minerals, fossils, shells and other objects of natural history, also my chemicals and chemical apparatus, etc., etc., preparatory to making my residence in Indianapolis and with a view of arranging them in the rooms of the Geological Department at the State House. On arriving at the Capitol with this collection, it was soon made manifest that the room set apart for the use of the State Geologist was totally inadequate to hold the natural history specimens and chemical apparatus, and to be used at the same time, as office and laboratory. From a high appreciation of the importance of the labor to be performed, the State officers, with one accord, decided to have a small addition, suitable for a chemical laboratory, built on the east side of the State House, adjoining the rooms of the Indiana State Board of Agriculture." This was on the site of the present State House. When the new building was begun, the laboratory of Mr. Cox and the nucleus of the present State Museum, which he and his assistants had gotten together, were moved to the building at the southeast corner of Market Street and Capitol Avenue, and from there the Museum was moved to its present quarters in the State House. Continuing, Mr. Cox says: "The limited amount of funds at my disposal would only admit of the employment of a small corps of assistants, who were kept at work but a small portion of the season." One of these was Dr. G. M. Levette, one of the best naturalists ever connected with the State Survey and who continued with it for a number of years. Another was Dr. Rufus Haymond of Brookville, who prepared the report on the Geology of Franklin County. Of that county Mr. Cox says: "Although neither valuable metalliferous ores nor coal are to be found in this county, the law contemplates a complete survey of the entire State, and it was therefore deemed necessary to pay some attention to the resources

of such counties as well as those more favored with mineral wealth. Franklin County was selected on account of being the home of the assistant, who was thus enabled to accomplish the same amount of work at a less cost than if sent to some distant county."

"Prof. Frank H. Bradley, late of Hanover College, Ind., was engaged to make a survey of Vermillion County, he having previously acquired an extensive knowledge of the geology of that county from examinations made while surveying the adjoining counties in the State of Illinois."

Thus was begun a survey of the State by single counties often isolated one from another, and often selected to satisfy the demands of some politician or other person of temporary prominence. The rocks and mineral resources of Indiana were formed or deposited where they now lie when the only boundary lines were those of the ocean's beach, and the only politician the "fittest" inhabitant of the seas. Therefore a county boundary line and a politician have, or rather should have, no connection whatever with a geological survey. The county boundary line was in great part banished from the Survey in 1895. The politician still has much to say regarding the office and at present I see no practical way of getting rid of him.

The first mention of Indiana Block Coal under that name is also made in the Introduction to his first report by Mr. Cox, as follows: "On my first visit to Brazil, in Clay County, the general impression seemed to prevail that the peculiar variety of coal familiarly known as 'block coal,' or 'Brazil coal,' was confined to a small basin, isolated from the great bituminous coal fields of Indiana and Illinois, and limited to an area of a few square miles. Indeed, I found at Brazil, those who were presuming enough to stand in the door of Rigby's Hotel and point out to me the extreme limits of the "Block coal" field in every direction. Of the fallacy of this prevailing opinion I felt it to be my first duty to disabuse the public mind, and the splint or 'block coal' has been traced from the southern limits of Greene County to Warren County on the north." It has since been shown that the true block coal extends northward from Brazil only to Raccoon Creek in Parke County and that the coals farther north mentioned by Mr. Cox are a semi-block of somewhat inferior quality.

The body of the first or 1869 Report of Cox is largely devoted to the geology of the coal fields and iron deposits of Clay, Greene, Parke, Warren and Fountain Counties, prepared by himself, and those of Vermillion County by Prof. Bradley. It was accompanied by a portfolio containing outline maps of Greene, Clay and Vermillion Counties, on which were shown the approximate bounds of each of the workable veins, and the location of all mines and outcrops of coal and iron ores. A colored "vertical section of the geological formations from Greencastle to Terre Haute, made from outcrops and sections of bores along the line of the T. H. & I. (now Vandalia) railroad" was also included.

Regarding the character and value of the surveys of the various coal-bearing counties published in the reports of the State Geologist from 1869 to

1883 and made under the supervision of Mr. Cox and his successor, John Collett, I quote as follows from Dr. George H. Ashley, who, as a specialist in that line, is much more competent to judge than I. Mr. Ashley says:* "The character of the field work in the various counties varied greatly. Several of the counties never received more than a preliminary survey. Thus in Warrick County three sections were obtained, the coal from one mine analyzed and four pages of descriptive text given. On the other hand, in some of the counties, the field work extended over several seasons and the reports on these counties were, as a rule, correspondingly complete and detailed. In such cases the abundant columnar sections obtained, especially those by Mr. Collett, have proven of inestimable value in the present survey. The correlation of the coals and the location of points on the maps appear to have been, to too large an extent, guess work, and this factor of unreliability prevented more than an occasional use of those parts of the reports in my survey. * * No attempt at colored geological maps was made in connection with the reports of the coal counties. As stated above, the field work was more of the character of an examination than a survey, the maps as a rule showing only the points at which data were obtained, without attempting to show the distribution of particular coal beds or formations. A large part of the errors in stratigraphy of the earlier surveys are doubtless due to lack of surveying methods or the systematic tracing of the coal beds and their accompanying strata."

The paper of Dr. Haymond on Franklin County in the 1869 report of Cox is devoted mainly to its physical geography, there being within its bound no economic resources other than the soils and flagstones afterward quarried extensively near Laurel. He includes a list of the principal trees and descriptions of the ancient earthworks of the county. Following his regular report, however, are two papers of more than passing interest to the naturalist. These are entitled "Mammals found at the Present Time in Franklin County," and "Birds of Franklin County, Indiana." Full notes on the habits of the 31 species of mammals and 163 of birds listed show Dr. Haymond to have been a close and careful observer. These two papers were the first of many which have since appeared treating of the fauna or flora of the State, most of which have been published either in the annual reports of the State Geologist or in the Proceedings of the Indiana Academy of Science.

SECOND REPORT OF COX.

The Second Report of Cox, covering the work done on the Survey in 1870, was issued in 1871. It contained an excellent lithograph frontispiece of the "jug rock" near Shoals, Martin County; also lithograph plates of the large frame hotel, bath house and creek at Indian Springs, the first hotel at West Baden, and of blast furnaces in Clay and Vigo Counties. Except for the crude

*23rd Ann. Rep. Ind. Dept. Geol. & Nat. Resources, 1898, pp. 8 and 9.

plates in Owen's '62 report, these were the first full page illustrations showing features connected with the geology or resources of Indiana.

In the introduction, Cox states that the summer's work "proves the continuance of the Block or iron smelting coal from the northern limits of the Indiana coal basin to the Ohio River, a geological discovery of incalculable advantage to the State, as the day cannot be far distant when this coal, which is unequalled for smelting iron, will induce the building of blast furnaces along the entire eastern margin of the coal basin." Subsequent surveys have proven this statement to be wrong, the true "block coal field" being limited to Clay and the southern third of Parke Counties and a small area near Patricksburgh, Owen County.

In the introduction we find also the first mention of a new assistant who, for a number of years thereafter, was closely connected with the history and development of Indiana Geology. Of him Mr. Cox says: "To Prof. John Collett, of Vermillion County, was assigned the duty of making a detailed survey of Sullivan County, a labor which he has performed in a highly satisfactory manner, as the able and minute report of the geology of that county, published in this volume, will bear testimony. He has made known many interesting facts in the stratigraphy of the coals, and collected a large number of organic remains, which serve to increase our knowledge of the vertical range of the fauna and flora of the coal measures."

Several railways had by this time been constructed or were being built through portions of the coal area. Among these was a part of what is now known as the Evansville and Indianapolis railway. Col. J. W. Foster of Chicago had made an examination and report of the resources along this proposed line, and Prof. Cox felicitates himself regarding this as follows: "It is highly flattering to me that this able report bears testimony to the accuracy of my previous geological work, and fully confirms all that I have said in regard to the value of the block coal for the manufacture of iron and steel, and sets forth the incalculable advantages possessed by Indiana for controlling the iron market of the new West, and for conducting the most gigantic metallurgical operations in the country."

The body of Cox's second (1870) report is devoted almost wholly to the geology of the coal districts, the reports on Daviess, Martin and Sullivan Counties being in detail and accompanied by maps, while several other counties were treated more briefly. A full account of the mineral waters at Indian, Trinity, French Lick and West Baden springs, including quantitative analyses, was given. There is also a section of an artesian well, 1629 feet in depth, put down on the river bank at Terre Haute, and a statement regarding two oil wells in the same city, as follows: "The first, or Rose well, was sunk to a depth of seventeen hundred and ninety-three feet. It was bored for water, and strict attention was not paid to the character of the rocks after passing through the coals in the upper part of the section. At 1,629 feet a vein of oil was struck which yielded about two barrels per day. The oil was shut out and the bore continued to a depth of 1,793 feet, having reached an abundant

flow of good sulphur water. The second well was bored on the bank of the Wabash River, about one mile west of the first. This work was undertaken by a company expressly for oil. Experienced borers were employed and the record of the strata passed through may be relied on as accurate. A little oil was found, but not enough to justify pumping."

"A third well was bored by the same company a quarter of a mile east of the first, which passed through the same succession of strata detailed in the section. The black slate was passed through at 1,600 feet; and 25 feet lower down, in limestone, which I refer to the Corniferous, a vein of oil was found which yields twenty-five barrels per day."

These were the first deep wells producing crude petroleum in commercial quantities in the State of Indiana, and were the subject of a paper entitled "On the Oil Wells at Terre Haute," by Dr. T. Sterry Hunt, a noted oil specialist of Montreal, Canada. This paper he read at the Indianapolis meeting of the American Association in August, 1871, and it is reprinted in part by Cox in his second report. Cox also included a paper entitled "Western Coal Measures and Indiana Coal" which he had read before the same meeting of the Association.

The final paper in the 1870 report was the first local list of plants published in the State. It was entitled "Manual of the Botany of Jefferson County, by A. H. Young of Hanover College, Ind.", and enumerated with notes 609 species representing 315 genera and 87 families.

THIRD AND FOURTH REPORTS OF COX.

The third and fourth reports of Cox, treating of the work done in 1871 and 1872, were published in one volume in the latter year. His assistants during these years were John Collett, Barnabas C. Hobbs, Prof. R. B. Warder and Dr. Levette. The beginning paragraph of the introduction to the volume is as follows: "It gives me pleasure to be able to note the continued prosperity and rapid extension of our mining and manufacturing industries. Districts that were but yesterday covered by a primeval forest, or only broken here and there by the quiet pursuits of the husbandman, have been awakened by the whistle of the locomotive and the puffs of the stationary engine; coal begrimed miners throng the streets of mining villages of a year's growth, and the work of mining and shipping coal is pushed forward with an energy and zeal that is unprecedented in the West, and far outstripping the hopes of the most sanguine utilitarian."

He states that Perry, Dubois, Pike, Parke, Dearborn, Ohio and Switzerland Counties were surveyed in detail and preliminary examinations made in eleven other counties, most of which were in northern Indiana. The volume was accompanied by a portfolio of maps of the counties surveyed in detail. These were uncolored, and exhibited the same kind of data as did those of the first and second reports.

Cox describes a new blast furnace which had been erected near Shoals to

utilize the iron ore of the vicinity. It was the last one of twelve which were built in the State, all of which went out of blast many years ago. Eastern furnaces with lower railroad rates and better facilities for handling ore, and the opening of the great ore deposits of the Superior region led to the dismantling of all these pioneer furnaces of Indiana.

As with the two preceding volumes, this one also was largely devoted to the geology of the coal measures, treating them by counties and not as a whole. Many analyses and sections of coal were given, and the paper by Hamilton Smith, previously mentioned, was included. Under Dubois County there is first mention of the deposit of tripoli near Ferdinand, which for a number of years was sold for polishing purposes.

An illustrated paper most interesting to naturalists is included in the 1872 volume. It is a "Report on the Wyandotte Cave and its Fauna," by that eminent scientist, E. D. Cope of Philadelphia. While attending the meeting of the American Association at Indianapolis, he made a side trip to Wyandotte, and collected the forms of life which he could find therein, sixteen species in all. Five of these, an arachnid, three crustacea and a myriopod, he described as new, notable among these being the blind crayfish of our southern Indiana caves. The descriptions of three beetles from the cave, two of them blind, which were drawn up by Dr. Geo. H. Horn, are also included in Cope's paper.

Following the county reports in the volume is one entitled "Meteorology of Vevay, Switzerland County," by Chas. G. Boerner, and another illustrated one on the "Manufacture of Spiegeleisen, Speculum or Glittering Iron," by Hugh Hartmann, Ph. D., of Omaha, Nebraska, who for many years was an assistant in the Spiegeleisen works of Hanover, Prussia. This form of iron ore, used in the production of Bessemer steel, was at that time made only in Germany, and Cox was attempting to get a factory started in Indiana.

FIFTH REPORT OF COX.

The fifth report of Cox, embracing the observations made in 1873, was published in 1874. It was a volume of 494 pages, with maps of Clark, Floyd, Lawrence, Knox, Gibson, and Warren Counties in a pocket at the end, and a frontispiece map of "Bone Bank", a noted aboriginal burying place on the eastern bank of the Wabash in Posey County. Mr. Cox had been appointed by Gov. Hendricks to represent the State at the Universal Exposition held in Vienna, Austria, in 1873. He took with him a small display of native Indiana woods, and also a collection of the mineral resources, of which he says: "Large characteristic specimens of caking coal, block coal, and cannel coal were obtained from mines in various counties of the State. Along with the coals were specimens of pig-iron smelted with raw block coal, clay, ironstone from the coal measures, fire clay, fire brick made from the clay, building stone and specimens of various colored ochres from Owen, Green, Martin and Dubois Counties."

"In addition to the natural products of the State I prepared a pamphlet, of which 8,000 copies were published in English and German, for distribution along with the Geological, Agricultural and School Superintendent's Reports. Col. W. R. Holloway also sent over a box of 'Holloway's History of Indianapolis,' to be given to those who desired them. In the distribution of books treating of the mineral, agricultural and educational advantages of this country, our State was unsurpassed, and it cannot fail in producing good results."

"The coal and iron, especially the fine large cubes of block coal, were examined with the greatest interest by the European iron masters, and was of no less interest to the International jury who were appointed to examine into the character and merits of all minerals on exhibition. This jury was made up of distinguished geologists and mining engineers from different countries, and after a careful examination of its merits made the State an award of a medal."

The first 70 pages of the report are devoted to an account of the exposition, in part written by Hugh Hartmann, who also has a second article on the manufacture of Spiegeleisen. The remainder of the volume is devoted to the geology of the counties whose maps were included as mentioned above. Under Clark County, the ancient stone fortifications and mounds on the Ohio River, three miles east of Charleston, are described in detail, as is also the "old stone fort" at the mouth of Fourteen Mile Creek, and the "Bone Bank" above mentioned. The latter was said to be 1,500 feet long, 80 feet wide and 35 feet above low water.

The report on Clark and Floyd Counties is well written, and was prepared by W. W. Borden, an eccentric scientific character of southern Indiana, who afterwards made a fortune in Western mining ventures and established a large museum at Borden, Clark County. He gives the first detailed account of the hydraulic limestone used for making natural rock cement, and states that in 1873, 391,000 barrels were manufactured in Clark County. He also describes in detail and gives analyses, of both the New Albany black shale and the Knobstone, which have abundant outcrops in the counties which he surveyed. He states that at one time a large factory was erected at New Albany in which the black shale was ground, mixed with coal tar and spread on felt for roofing, but experience showed that it would not stand exposure, and the enterprise was soon abandoned.

The surveys of Lawrence, Knox, Gibson and Warren Counties were made by John Collett. They give the detailed sections of many outcrops, and numerous lists of fossils from the different formations.

In a thin, laminated sandstone found beneath some black shale near the base of the coal measures on Pine Creek, Warren County, Collett discovered what he called "reptilian tracks." One fragment of the stone showed four tracks, each having five toes, while other slabs contained one or two tracks each. Cox named the animal from the tracks alone, *Colletosaurus indianaensis*. He published a full page plate of the track and called them "fossil footprints of an air-breathing reptile," yet states that "two pairs of tracks of hind and fore

feet are quite distinct and from their position seem to indicate that the animal was allied to the Batrachians, and progressed like a frog, by jumps, while on the other hand the five digits on either foot relate it to the Salamanders." At the present time, reptiles and batrachians are classified as belonging to very distinct orders. The giving of a scientific name to an animal of which no trace is left except its "footprints on the sands of time," brings to mind Rafinesque and the scientific names he gave to seven varieties of thunder and lightning.

Under Lawrence County, Collett describes briefly Shiloh, Dry, Grinstaff's, Connelly's, Hamers and Donnelson's caves, and mentions one blind fish, five crustaceans and four insects as inhabiting them. He states that "many wells in this region are fed by the underground brooks, and from these it is not unusual to draw up eyeless fish and crustaceans, inhabitants of the adjoining caves."

Since Orange and Lawrence Counties are at present coming rapidly to the front as one of the leading apple growing districts of the State, the following paragraph, written by Collett forty-three years ago, is of more than passing interest. "Advantage is taken by the enterprising citizens of the equalization of temperature found to exist on the summit of the surrounding sharp hills, which are 200 to 250 feet high, to plant extensive orchards, which produce highly remunerative crops of excellent fruit. It has been frequently observed here that in cold weather ice of considerable thickness forms in the valley, when no frost has fallen upon the hills just above. This arises from the fact that cold air is heavier than warm air, and in obedience to gravitation descends, and may fill the valley, leaving the peaks above bathed in warmth. Such facts invite the attention of fruit growers."

Under Knox County there is in this report a full page lithograph plate of the "Pyramid Mound" near Vincennes, with descriptions of it and other mounds, and of the kitchen middens or shell heaps near Edwardsport and Vincennes. Collett, who was a man of vivid imagination and fluent powers of description, says of the kitchen middens: "They signify the permanent residence of a people relying on agriculture and aquatic life for sustenance; hence we infer, that the people whose existence is indicated by these shell heaps, were not related to our savages. Again, stone cists and vaults containing the bones of many persons of all ages and sexes, irregularly mingled with remains of funeral fish food, are often found, sometimes as intrusive sepulchres on sides or tops of the mounds; we conclude that these are the remains of the conquerors of the most ancient people who were afterwards themselves dispossessed by the Indians—An intermediate littoral 'Race of Fishermen,' who to some extent adopted the habits, usages and even religion of the conquered."

Of the mound builders he continues: "More ancient than these shell heaps, dating back beyond the thousand years noted by the annual growth of our forests, are numerous monumental remains of which the past is silent. 'Not entirely voiceless,' they tell us of a people who once possessed the valley

of the continent. Peaceful and law-abiding, they were skilled in agriculture and the arts of the 'stone age,' and executed works that required the united and persistent efforts of thousands, under the direction of a well matured design. In the comparative absence of warlike implements, we conclude that this work was a labor of love, and not of fear; that it was inaugurated and directed by a Regal Priesthood, to erect votive temples in honor of the Sun, a visible Creator of comfort, food and life."

Following the work of Collett, the volume contains also a brief paper by Dr. Joseph Gardner on the Tripoli of Dubois County, in which he states that tripoli has for its basis the "silicified skeletons of organic bodies," of which he figures five, and also that the Dubois County material is made up almost exclusively of the skeletons of sponges.

The volume is ended with a "Report of Observations" made in seven counties of northern Indiana by G. M. Levette. These refer mainly to the streams, lakes, artificial mounds, bog iron ore, marl and peat deposits of the region. Just now, when the high cost of living is the main problem of existence, and coal at times threatens to become as high priced as its sister diamond, the following words, written by Levette are worthy of quotation: "Immense deposits of peat occur in the lower lands, along the marshes and over the 'bridged lakes.' A partly completed fill of the Baltimore, Pittsburg & Chicago Railroad broke through the crust of a subterranean lake, a half mile west of the town of Albion, and exposed a deposit of peat 18 feet in thickness. In the dim, distant future when the wants of a dense population shall demand the cultivation of every available foot of this fertile section of country and fuel shall have become the costliest item of household economy, these deposits of peat will be sources of wealth to the owners and objects of practical interest to those who consider the success and well being of the community."

SIXTH REPORT OF COX.

The work done by the Cox Survey, during the year 1874 was described in his Sixth Report, issued in 1875. Scott and Jackson Counties were surveyed and mapped by Borden, Brown County by Collett and Jackson County by Cox. In the introduction Cox says: "Previous to this year we have not been able to find any fossils in the Black Shale except some small species of *Lingula* and *Discina* which are so closely allied to Carboniferous species that it was not considered prudent to rely upon them for the identification of the age of the strata. During the year, 1874, however, Mr. Borden has had the good fortune to find in the Black Shale at Lexington, Scott County, a large number of well preserved fossils from which we can, with propriety, refer the New Albany Black Shale to the Genesee, and the Goniatite shale, which rests upon it, to the Kinderhook group of Illinois."

The white kaolin of Lawrence, Owen and Martin Counties, though mentioned by Owen in 1862, was not recognized as a clay until 1874. Near Huron, Lawrence County, the outcropping kaolin had long been known to

its natives as mineral tallow and the locality as Anderson's "taller bank." Some workmen, while digging out the underlying iron ore for the blast furnace at Shoals, laid bare, in the summer of 1874, the full thickness of the stratum of kaolin and the attention of Mr. Cox was called to it. In his introduction to the Sixth Report he devotes eleven pages to a description of the kaolin, which he named "indianaité," and of its variety allophane, giving analyses and his theory of their origin. The latter is of interest as coming from a chemist of his repute. He says: "The clay lies immediately beneath the Millstone grit or pebbly conglomerate of the coal measures and here occupies the place of a bed of Archimedes limestone which is seen in *situ* about two miles southeast of the mine. The overlying sandstone is very ferruginous and the base, where exposed to the weather, has decomposed and covered the clay in places to a depth of eight or ten feet with ferruginous sand and pebbles. There is a constant oozing of water from this sandstone which has, no doubt, played an important part in the chemistry of the clay and hematite deposit, for, though similar in its chemical composition to kaolin, this Lawrence County clay differs physically and owes its origin to an entirely distinct set of causes and effects. While kaolin is derived from the decomposition of the feldspar of feldspathic rocks, such as granite, porphyry, etc., the porcelain clay of Lawrence County has resulted from the decomposition, by chemical waters, of a bed of limestone and the mutual interchange of molecules in the solution, brought about by chemical precipitation and affinity."

In other words, he asserted that the Lawrence County kaolin, which has a clay base of 45% silica, 38% alumina and 16% combined water, is the result of the chemical action of water percolating through a sandstone upon the beds of limestone. How such water can change the elements calcium and carbon into silica and alumina passeth understanding.

The most plausible explanation of the origin of the Indiana kaolin is that set forth by Ashley,* which was based upon a theory of Lesquereux, viz., that the kaolin occupies the horizon of Coal 1, the coal and kaolin being never found at the same place though often they occur but a short distance apart, and that the kaolin was formed by the burning of a vein of coal immediately above a vein of underclay, the impurities of the latter being consumed and the kaolin left as a residue.

This kaolin was used for a time for making porcelain ware but, being wholly non-plastic, was not found suitable for the purpose and so Cox's prophecy that: "The importance of the discovery of this clay can hardly be overestimated, since it places within our reach the means of becoming independent of Europe for fine grades of chinaware," was not fulfilled. It was afterwards shipped for ten years to Philadelphia and used in the making of alum cake, a product used in paper manufacturing. For the last 20 years or more the deposits have not been worked.

*23rd Ann. Rep. Ind. Dept. Geol. 1898, 931.

About 20 pages and four plates of the 1874 report are given to a chapter on "Antiquities," based upon an investigation made by Mr. Cox and F. W. Putnam of the Peabody Museum in the fall of 1874. A full description of the stone fort at the mouth of Fourteen Mile Creek and of other earthworks in Clark and Jefferson Counties is given, with illustrations of their plans, and of stone pipes and other objects taken from them and other mounds throughout the State.

Under his description of Jackson County, Cox states that in the vicinity of Rockford a thin limestone "passes upward into greenish gray, hard, calcereous shale, filled with fossil cephalopod shells, in a fine state of preservation. The *Goniatites* and *Nautili* of this locality are among the most interesting fossils found in the country. They are eagerly sought for by collectors and have given to Rockford a world wide notoriety. The rock is easily decomposed when exposed to the air and its fossils are found ready weathered out on the newly exposed surface after floods in the river. The children of the village keep a sharp lookout for them and the outcrop, which is only two or three feet thick, and from 150 to 200 feet long, is diligently searched from day to day after each freshet or heavy rain. Large numbers are collected and sold, for what they can get, to the scientists who are attracted to the locality. They go by the name of "snake rocks" and if you ask for *Goniatites* or *Nautili*, as I did, you will be told that they know nothing about such things, but on the other hand, if you inquire for "snake rocks" you will find that nearly every boy and girl in the village will have a few and are ready for a trade."

In the report on Brown County, Collett tells how the ridges of Knobstone withstood the onward movement of the first glacial invasion of the State, so that all the land directly southward comprises a driftless area. He says: "Approaching the central areas from the east, from the west and from the valley of Bean Blossom Creek at the north, it was found that the county was enclosed by a wall of hills ranging from 350 to 450 feet in height. In valleys to east, west and north, glacial drift was present, mounting well up on the sides of the hills. But within this walled space the scarcity or entire absence of boulders showed that the ice drift had only for a short period, or never intruded, Bean Blossom Ridge marking the extreme southern limit of the local glacier foot. Against and upon this wall-like ridge the stranded ice seems to have been continually massed and melted by each recurring summer's sun. It sent torrents of water south across the county, wearing slight depressions in the ridge as at Low Gap and the source of Greasy Creek, bearing fine sediment, some gold dust and black sand, and but few or no pebbles or boulders. The long continued melting of ice loaded with the most enduring debris of the Laurentian rocks, as greenstone, quartzite, quartz, gold and magnetite, deposited large quantities of these imported materials in Bean Blossom Valley. The rapid current of the ice water would naturally carry down stream the lighter sand and gravel, and sort out and leave behind the heavier rocks, gold and magnetite in considerable quantities. Still above the outside wall of the county, several peaks, notably the Weed Patch Knob, rise from 50

to 125 feet. Around their sides the ice water has deposited slight terraces containing minute pebbles and some imported material, as if to record the highest flood upon this meter of the great glacial river; while white and bare, these storm scarred summits looked out over the winter wild, and saw that rigid river of ice menace their base, or turn to right and left into the two White River Valleys, and float by in a stream of ghostly silver. Remarkable as witnesses of the early Quaternary, their elevation above the ocean reaches back beyond the time which saw the Carboniferous, Mesozoic and Tertiary seas to the west, bury their treasures of warmth and wondrous animal life as they shrunk from existence." And on a later page he adds: "The summit of Weed Patch Hill has not been under water since it emerged from the subcarboniferous ocean, and, from all the evidence seen, it was an unconcerned spectator of the grand phenomenon which signalized the glacial age. It takes its name from the fact that just before it was first visited by the early pioneer, a tornado had scalped some 100 acres of the tip-top plateau, prostrating a magnificent forest of large poplar, oak, walnut and cherry trees. Weeds and grass succeeded in luxuriant growth, which, together with the trunks and branches of the fallen trees, were burned by each summer's fire, and commenced a miniature prairie; weeds and vines became the prevailing vegetable growth, and hence the name."

In his report on Scott County, Borden states that "Resting on the New Albany black shale are found large fossil trees. Some of these specimens are of great size; all are silicified and so hard that a fragment with a sharp edge will scratch glass. One which was exhumed and exhibited at the Indianapolis Exposition of 1873, measured over 16 feet in length and two feet in diameter, and had a jointed structure, which is a characteristic feature of all these fossil trees. Another measuring 19 feet in length and three feet in the broadest part, being somewhat flattened, was taken from the black shale, a short distance northeast of Vienna, and exhibited at the Indianapolis Exposition for 1874." He concludes his report with a list of fossils taken from the Black Shale, and also a list of those found in the Lower and Upper Silurian rocks of Jefferson County by Dr. W. J. S. Cornett of Madison.

Following the report of Borden are the first two papers ever published on the fishes of Indiana. They are also among the first, if not the first, ever written by their author, the world-renowned Ichthyologist, David Starr Jordan. One is entitled "The Sisco of Lake Tippecanoe and its Relatives." The Sisco, he states, are fishes belonging to the Salmonidae or trout family, a group distinguished at "once among our fresh water fishes by the presence of the so-called 'adipose' fin, behind the dorsal fin, in connection with a scaly body and naked head with no barbels about the mouth." Those found in the northern Indiana lakes inhabit the deepest water except in the spawning season late in autumn, when, says Jordan, "they come in myriads into the streams which enter the lakes. There are large numbers of persons who are engaged night and day taking them with small dip nets. Those who live in the neighborhood put up large quantities of them, they being the only

fish caught in the lakes that will bear salting." In the paper he described as new, the Indiana species, and mentions with full notes its nearest relatives, one of which is the well known "white fish" or lake herring of the markets.

The second paper is a "Synopsis of the Genera of Fishes to be looked for in Indiana." This includes a key to 81 genera and is followed by a list of 88 species, with notes on distribution, common names, etc.

The final paper of the 1874 report is entitled "A Partial List of the Flora of Jefferson County, Indiana," by John M. Coulter of Hanover College, in which he lists with full notes 721 species belonging to 367 genera. This also was one of the author's first ventures, and we have thus, side by side, in this Sixth Report of Cox, the initial efforts of two of the country's greatest scientists in their respective lines.

SEVENTH REPORT OF COX.

In the preface to his Seventh Report, published in 1876, Cox complains of the meagreness of the appropriation allotted for State Printing, stating that "it has been found impossible to publish more than a part of the county geological maps and the numerous horizontal sections that have been prepared to show the continuity of the seams of coal and associated beds of shales, sandstones and limestones. These sections are of great importance to present the geology in a clear and comprehensive manner. It is hoped, therefore, that the legislature will make a special and adequate appropriation to enable the geologists hereafter not only to publish what maps and sections are needed to make comprehensive the dynamical geology of the various counties, but also to cover the necessary expenses of engraving and publishing plates containing figures of the characteristic fossils of the various geological formations as this will render the report more useful to students in the universities, colleges and high schools of Indiana."

The legislature failed to comply with his request, and his next report was not printed until 1879. This was one of the causes which led up to his quitting the Survey in the latter year. The first 77 pages of his Seventh Report were devoted to a discussion of the combustible properties and analyses of Indiana coals. Next comes reports on the surveys of Vigo* and Huntington Counties by Cox himself.

Of the Niagara limestone near Huntington he says: "The great disorder of the strata, mainly due to false bedding or peculiar arrangement of the material constituting the present rocks, has led many to infer that this irregularity was due to earthquake or volcanic action. This is the more deceptive

*In the report on Vigo County Cox states that Col. Francis Vigo, in honor of whom Vigo County was named, had moved from St. Louis to Vincennes, prior to the capture of the latter place by George Rogers Clarke, that he conveyed to that officer the information which enabled him to capture the post, and advanced money to feed and clothe his suffering army. This money was not recovered until after Vigo's death, but the latter left a clause in this will that in event of its recovery \$500 "should be given to the county which had honored him by adopting his name, to be expended in buying a bell for its courthouse."

since the apparent elevations have their surfaces capped with enduring beds of chert or impure flint. Huntington is located on one of these flint ridges and the locality was known to the Indians by the name of 'We-pe-cha-angan-ge' or flint place. The flint of this locality was of great value to the Indians as the material of which they fashioned their arrow points, spear points and flint knives." The Niagara stone itself was then, as now, extensively used at Huntington in the making of lime, 617,000 bushels having been produced in 1875.

Following Cox's reports on the counties mentioned is a paper by Lesquereux entitled "Species of Fossil Marine Plants from the Carboniferous Measures," in which are described and illustrated with two plates, five species of crinoids, one of which he named after Cox.

The geology of Jennings and Ripley Counties is next treated in detail by W. W. Borden, and that of Orange County by Drs. M. N. Elrod and E. S. McIntire of Orleans, Indiana. Dr. Elrod continued at intervals as an assistant on the survey until 1895.

Reports accompanied by maps on Vanderburg, Owen and Montgomery Counties, by John Collett, follow next in order. In that flow of language for which Collett was noted he says of the Ohio River at Evansville: "It is the 'Belle Riviere' of the early French adventurers—the beautiful river of song and story. Always navigable, without interruption from drought or winter's ice at this point, it is the great artery of trade and economic life to the bordering region, and bears upon its bosom a fleet of steamers equalling in value and tonnage that of some internal seas. Belted by broad alluvial plains or high bluffs, from which interesting views full of picturesque beauty may be attained, the river and valley have been compared by tourists to that Mecca of travelers, the Rhine of Europe."

Of the new State Park on McCormack Creek, Owen County, he writes: "Springs seeping from crevices in the rock, or springing from the summit, cool the air and reach the bottom in a cloud of spray, the wild, romantic scenery, reverberating roar of falling water, cool air breathed by the cavernous rocks, renders the valley a favorite picnic ground, while disciples of Walton are greeted by their finny friends. Still ascending the creek, a wild, rattling roar, intensified by quick, sharp echoes, shakes the air, confusing the mind by its overwhelming ubiquity. The falls would be insignificant in a wider valley, but in this narrow canyon it is full of never tiring interest."

He also described in detail the Cataract Falls of Owen County, stating that "the river, within a distance of three-fourths of a mile, by two plunges, falls 81 feet, passing through a deep, narrow channel cut in St. Louis limestone," and also that "these cataracts of Eel are the grandest falls in this region of the West. In winter they put on their festal robes. The trickling springs flute and corrugate the sides of the chasm with moldings, columns and pilasters of ice. The trailing bushes and limbs of trees are coated by the ever rising spray, and every terminal twig is gemmed with lustrous crystals, which, in the sunshine, blaze with a thousand tiny rainbows."

In the long and detailed report on Montgomery County, Collett has ten or twelve pages devoted to the "Glacial Epoch," in which he gives an interesting account of the changes wrought in that region by the moving and melting ice. He states that "East of Sugar Creek and south of Crawfordsville was an extensive body of water, covering nearly 100 square miles, the silt and shore line of which is so plainly lacustral and marked that its existence could not have terminated more than a few thousand years ago. The phenomena of this basin have long been noticed and studied by Col. James H. Harney, in whose honor as the discoverer I have given it the name of Ancient Lake Harney."

He includes a "List of 110 Species of Fossils found in the Keokuk (Harrodsburgh) Group at Crawfordsville," most of which are crinoids from the famous beds near that city. Of the area now known as the "Shades of Death" he says: "Little Ranty, flowing from the south, approaches in a flume-like passway cut 50 feet deep in heavy sandstone, and thence rushes in a filmy sheet 45 feet down an almost perpendicular bank of dark shale, like an endless ribbon with warp of silver and woof of sparkling crystals. The cascade is nestled away in an amphitheater, 200 feet in diameter, crowded with shrubs, ferns and tenderest wild plants, here untrodden and unseen. Traveling ferns creep over and cling to the ragged masses of tufa, which guard the narrow entrance from the eye of the careless observer. More than 100 feet above, tall oaks and pines, encircling the rim, swing their branches together across the cove and chasm. At the 'rookery' all the buzzards living within ten or fifteen miles, meet each summer evening for information, converse and mutual assistance."

Following Collett's papers in the Seventh Report there is one of 35 pages by G. M. Levette, entitled "Observations on the Depth and Temperature of some of the Lakes of Northern Indiana." In gathering data for this paper Levette had been accompanied by Caleb Cooke, one of the Curators of Peabody Museum at Salem, Massachusetts. Together they dredged and sounded 15 lakes in Fulton, LaPorte, Kosciusko, Noble, LaGrange and Steuben Counties. Of the origin and future of these lakes Levette said: "They are without exception mere basins or depressions in the glacial clay. No stratified rocks have been found in the bottom or on the shores in a single instance, but, on the contrary, the numerous deep bores which have been made in that region, from time to time, prove that from 80 to 200 feet of glacial drift overlies the stratified rocks throughout the entire lake region of northern Indiana."

"Wet boggy marshes and small lakes which have become dry and arable within the memory of white men; extensive deposits of peat, from five to 50 feet in depth; blind lakes or bodies of water which are covered with a few feet of peaty soil, some of which sustain a growth of forest trees; the annually receding shores of many of the smaller lakes, and the perceptible yearly accumulation of 'marl' or fresh water lime in the shallow portions of many of them, all lead to the inference that at no very distant period in the past,

the lake area of this region was two or three times its present extent; and further, that if the agencies now at work continue to accumulate material on their shores and beds, not many centuries will elapse before these now numerous and interesting gems of the landscape will be known only to the students of ancient geography."

A list of the Mollusea and turtles taken in the lakes is given at the end of Levette's paper. The fishes and crustacea were turned over to the Peabody Museum, where, says Levette, they were to "be examined by Prof. Putnam, free of cost to the Geological Survey, and full suites of all the species collected, properly labeled, and returned to the State Museum at Indianapolis, and all new species figured and described for publication in this or a subsequent report," but we can find no record of them in this or following reports.

The final paper in the volume is a "Catalogue of the Flora of the Wabash Valley below the mouth of White River and Observations thereon," by Dr. J. Schneck, of Mt. Carmel, Illinois. In the introduction Dr. Schneck gives much information of value regarding the physical characteristics of the region, the time of leafing and flowering of many species, a table of measurements of the larger trees, a mention of the plants which had recently become extinct, etc. In the list proper he mentions with notes 867 species representing 444 genera as occurring in the area covered.

The writer had the pleasure on several occasions of spending a day or two at a time in company with Dr. Schneck in a study of the Cypress swamp of Knox County and in the region south of the Patoka River in Gibson County. He was a most agreeable companion, a botanist of learning, especially regarding the oaks and other trees of that portion of the State. Of the oaks he furnished foliage and fruit to many of the eastern botanists and Schneck's red oak, *Quercus schneckii* Britton, which occurs from Ohio and southern Indiana west and south to Iowa, Missouri, Florida and Texas, was named in his honor.

EIGHTH, NINTH AND TENTH REPORTS OF COX.

The results of the work done by the Indiana Survey during the years 1876-'77 and '78 were not printed until 1879, when they appeared in a single volume of 541 pages as the "Eighth, Ninth and Tenth Reports of Cox." The first 170 pages of the volume are devoted to a general discussion of the Geology and Archaeology of the State. This Cox starts out by controverting to some extent the statement of the wise man with which I begun this paper, viz., that the "Geology of the surface of Indiana is simple." He says that "The geological history of Indiana appears tame and devoid of the marvelous interest which attaches to those regions of country where the forces generated in the earth's laboratory have made themselves conspicuous by the metamorphism of the rocks, and the tilting, folding and fracturing of its crust. Here the elements concerned in the building up of strata leave no trace of violent cataclysms, and the rocks presented to view lie regularly bedded at

an inclination or dip, to the westward and northward, so gentle that its existence can only be made known by observations extended to points that are far distant from one another. Not a single true fault, or upward or downward break and displacement of the strata has yet been discovered. From this, then, one might be led to suppose that the geologist would have but little trouble in tracing and making up a complete and accurate record of the geological history of the State. But this very monotony of action and uniformity of strata is, perhaps, more perplexing and defiant to deal with and read correctly, than where turbulence prevailed and marked the pages of geological time with bold and well defined characters. There is also another great drawback to investigations in Indiana, due to the immense deposit of glacial clay, sand, gravel and boulders which spread over so large a portion of the State, and cover up the beds of stratified rock."

He introduces for the first time, Mr. S. A. Miller of Cincinnati, Ohio, stating that he has "very obligingly, at my request, furnished a complete catalogue of all the fossils which have been found in the Lower Silurian rocks over a portion of Ohio, Indiana and Kentucky. Mr. Miller's work on the American Paleozoic Fossils, has very justly won for him the reputation of the very highest authority on American fossils, and this list, coming as it does first from his pen, cannot fail to be of incalculable value to collectors of Lower Silurian fossils."

With this introduction began that period in the history of the Geological Survey of the State which continued until 1895, in which paleontology rather than economic geology became the predominant subject treated. Miller, Hall, White and others described thousands of species of fossils from all formations of this and adjoining states, and published altogether 191 plates in the Indiana reports.

The Catalogue of Miller, with bibliographical notes, comprises pages 22 to 56 of the volume. He includes with it the minutes of a special meeting of the then flourishing Cincinnati Society of Natural History, held Jan. 23, 1879, at which its more prominent members passed a resolution eliminating from geological nomenclature the term "Cincinnati Group," which had previously been extensively used to designate the Trenton, Utica shale and Hudson River formations in southeastern Indiana and the adjoining portions of Ohio and Kentucky. Of this resolution Miller says: "The Cincinnati geologists, neglecting the study of the Trenton Group of Kentucky, and overlooking the evidences pointing to the Utica slate age of the small exposures in the banks of the Ohio near Cincinnati, contented themselves, with the study of the richer fields, in the exposures of the Hudson River Group in Ohio and Indiana, and permitted geologists from abroad who knew little or nothing of the rocks in question, to flatter them with a local name until the absurdity of the position became so manifest and the injury to science so apparent that they resolved, notwithstanding their local pride, to abandon the worse than useless synonym, and to raise their voices in behalf of exact science and the well established law of priority in geological nomenclature."

In this introductory chapter, Cox treated at length the hydraulic cement rocks of southern Indiana, giving many analyses of the rocks and cement. The pages devoted to Archaeology are of interest in that they describe somewhat in detail and show maps of prehistoric forts and mounds near the junction of the Miami and Ohio Rivers in Indiana and Hamilton County, Ohio, and also those on the White River near Anderson, Indiana, which are now part of a public park belonging to that city.

This introductory part of the volume is followed by reports, accompanied by maps, of Wayne County, by Cox, and Harrison and Crawford Counties by Collett. In the Wayne County report is included a sketch of "Observations on the Prehistoric Earthworks of Wayne County, Ind.," by J. C. McPherson, which is illustrated by three maps, and in which he quotes two stanzas of a poem by John Finly, author of the "Hoosier's Nest," which was inspired by the discovery of a skeleton in one of the mounds. They are as follows:

"Year after year its course has sped,
Age after age has passed away,
And generations born and dead,
Have mingled with their kindred clay,
Since this rude pile, to memory dear,
Was watered by affection's tear.

* * * * *

No legend tells thy hidden tale,
Thou relic of a race unknown!
Oblivion's deepest, darkest veil
Around thy history is thrown;
Fate, with arbitrary hand,
Inscribed thy story on the sand."

The Wayne County report also includes a section of interest to botanists, it being, a list of the ferns, mosses, hepaticae and lichens of that county, by Mrs. Mary P. Haines of Richmond in which 17 species of ferns, 84 of mosses, 20 of liverworts and 29 of lichens are enumerated.

Between the Wayne and Harrison County reports are interpolated a table comprising 36 pages of altitudes in Indiana and adjoining states, by Jesse L. Williams of Fort Wayne, Ind.; and also a "Catalogue and Check List of the Trees and Woody Shrubs of America North of Mexico," by John W. Byrkit of Indianapolis.

In his report on Harrison County, Collett includes a List of Fossils of the Carboniferous and underlying formations of the county, and a list and description of new species of "fishes teeth," by Dr. J. S. Newberry. An interesting account, covering six pages and including analyses of the frag-

ments is given of a large meteorite which fell near Buena Vista, Harrison County, in 1859, the larger pieces of which, called the "Indiana Meteorite," are now in the British Museum at London.

The report on Crawford County is largely devoted to the numerous caves, large and small, found in the limestone rocks, Cope's paper on the fauna of Wyandotte being reprinted. Of Little Wyandotte, Collett gives the length as "about 2,000 feet." Accurate measurements by the writer showed it to be 415 feet. A new map of Wyandotte, prepared by Collett and illustrated on the margin with seven lithographs of views within the cave, accompany the report. "A table of distances measured and estimated by Washington Rothrock, a guide of 28 years' experience" (Collett, in a footnote, says they are "generally estimated") is printed on the map, and gives the total length as 23.5 miles. In the description of the Pillared Palace is a sentence which the average scientist of today will accept "eum grano salis." "Ceiling, cornices and shelves" Collett says, "are fringed with stalagmites and frosted with a never ending medley of strange, crooked, writhing, twisting, unsymmetrical sprigs of white limestone, *pushed out of the solid rock and still growing by propulsion from the bottom.*"

All told, Prof. Cox issued, while serving as State Geologist, ten reports, published in seven volumes, comprising 2,954 printed pages, 25 plates and accompanying maps of 30 counties.* His works contain hundreds of geologic sections and chemical analyses, and a vast store of information regarding the stratigraphy, economic resources, paleontology, botany and natural history of the State, but, in the opinion of the author of his biography† "they contained little that was new or impressive." Their main defect is *repetition*, the same facts regarding the drift, the stratigraphy, the paleontology, the caves and many other subjects being repeated again and again. This was due to the treatment under county headings by a score of assistants, each having his own views which he wished to get before the public. Could the contents of the Cox reports be assorted, assimilated, condensed and, under the proper headings, be republished in one or two volumes, they would furnish a work replete in interest and most valuable as a reference work in our schools and colleges.

After closing his work on the Indiana Survey in 1880, Cox opened an office in New York City as a consulting geologist. He afterward moved to Albion, Florida and became the geologist of a large company engaged in the mining of phosphate. He died in Jacksonville, Florida, Jan. 6, 1907, at the ripe old age of 86 years.

*The counties mapped were Brown, Clark, Clay, Crawford, Daviess, Dearborn, Dubois, Floyd, Gibson, Greene, Harrison, Jackson, Jefferson, Knox, Lawrence, Martin, Montgomery, Ohio, Owen, Parke, Perry, Pike, Scott, Sullivan, Switzerland, Warren, Wayne, Vanderburgh, Vermillion, and Vigo.

†Smithsonian Miscellaneous Collections, LII, 1910, p. 84.

THE COLLETT SURVEY, 1880-1884.

As has already been noted, the act passed in 1869 established a "Department of Geology and Natural Science" and created the office of State Geologist which Cox filled for ten years. It fixed the salary at \$1,800 and appropriated \$5,000 per annum, out of which this salary and all other expenses were paid. This appropriation was, in 1873, increased to \$8,000 per annum.

For some time there had been a demand that a bureau of Statistics be established in the State. Jas. D. ("Blue Jeans") Williams had become Governor in 1876. He was noted for his frugality, and was opposed to creating a new department. A compromise was finally effected by which the new Bureau was to be combined with that of the already existing Department of Geology, and an act was passed and approved March 29, 1879 "establishing a State Bureau of Statistics and Geology." Those sections of this act which pertain especially to this paper are as follows:

Section. 1.—*Be it enacted by the General Assembly of the State of Indiana,* That a Department of Statistics and Geology is hereby established for the collection and dissemination of information, hereinafter provided, by annual printed reports made to the Governor and Legislature of the State.

Sec. 2.—The Governor is hereby authorized to appoint, as soon after the passage of this act as convenient, and thereafter biennially, some suitable person to act as Chief, who shall have power to employ such assistants as he may deem necessary, and said officer and assistants shall constitute the Indiana Bureau of Statistics and Geology, with headquarters to be furnished by the State; *Provided,* That such Chief of the Bureau of Statistics shall be an expert in the sciences of geology and chemistry.

Sec. 3.—The duties of said bureau shall be to collect, systematize, tabulate and present in annual reports, as hereinafter provided, statistical information and details relating to agriculture, manufacturing, mining, commerce, education, labor, social and sanitary conditions, vital statistics, marriages and deaths, and to the permanent prosperity of the productive industry of the people of the State.

Sec. 5.—The Chief of said Bureau shall be the curator of the geological cabinet, museum, chemical laboratory, apparatus and library, and shall, from time to time, as may be practicable, add specimens to the cabinet of minerals, organic remains, and other objects of natural history peculiar to the State and other States and countries.

Sec. 6.—The annual compensation of the Chief of said Bureau shall be twelve hundred dollars, to be paid out of the Treasury of the State, as provided by law for similar expenditures; and in addition thereto, the sum of twenty-five hundred dollars be and the same is hereby annually appropriated out of any funds in the State Treasury, not otherwise appropriated, for two years, to be expended, or so much of it as may become necessary in the discretion of the Chief of said Bureau, in carrying out the purpose of said Department, as herein provided. It shall be the duty of the Chief of said

Department to render annually to the Governor a detailed statement, accompanied with proper vouchers for all moneys expended by him in carrying out the provisions of this act: *And Provided further*, That no greater expenditure of money, or liability therefor, shall be made or incurred by the Chief of said Bureau, or his assistants, than the sum herein appropriated for carrying into effect the provisions of this act.

Here was frugality exemplified to a standstill. For \$3,700 per annum for all salaries and expenses, the Chief of that Bureau was expected to carry on the work now done by the Department of Geology, The Bureau of Statistics and the State Board of Health, for section 3 provided that statistical information relating to social and sanitary conditions, vital statistics, marriage, death, etc., should be collected, tabulated, etc. Cox refused to continue the work and on April 25, 1879, John Collett received his commission as chief of the Department of Statistics and Geology for the official term of two years. Collett at first retained G. M. Levette, who had served through Cox's regime, as chief assistant, but, says Collett, on "June 30th, Assistant Levette withdrew, when John T. Campbell was installed in his place as First Assistant with John N. Hurty, Chemical Assistant, and Geo. K. Green, Geological Assistant, on special duty.

The First Annual Report of the new Department was issued in 1880. It was a volume of 514 pages, devoted almost wholly to statistics, the introductory chapter only being headed:

"THE STATE OF INDIANA"

"GENERAL INFORMATION FOR INTENDING IMMIGRANTS AND INVESTORS OF CAPITAL—SOIL, PRODUCTS, STONE, COAL AND NATURAL AND COMMERCIAL ADVANTAGES."

Pages 450 to 496 inclusive were under the heading "Vital Statistics and Sanitary Reports," and comprise the first "Report of the Indiana State Health Commission," now the State Board of Health. This report included a brief paper by E. T. Cox entitled "Influence of Geology upon Local Diseases," from which I quote as follows: "I will at this time call attention to a disease which once prevailed in special localities, and remnants of it may still be found in some parts of the State. I allude to what is commonly called milk sickness. This disease was variously attributed to plants, or the water, or the poisonous exhalations from some mineral substance contained in the soil. The origin of this disease could often be traced to circumscribed limits, and this seemed to favor the theory that it was due to one or the other of the above substances. While employed under the late Dr. D. D. Owen on the geological survey of Kentucky, in 1857, it was made a special point to examine the water chemically for metallic poisons and other substances, and the mineral character of the land where this disease prevailed among the cattle. The localities in that State and at that time were alarmingly numerous, and we were given an abundance of work to do in the analysis of water. Though hundreds of

samples were thus examined, in no single instance were we able to detect the presence of mineral poisons in the quantity of water possible to submit to analysis in the field. And the various plants which it was claimed would, if eaten by cattle, bring on the disease, when put to the crucial test, were likewise found to be harmless."

"I am sorry that the notes taken while engaged in this investigation have been mislaid or lost, and cannot be referred to now. The investigation led us to this conclusion, that, though the cause could not be attributed to the vegetation or poisons in the water, that the prevailing formation in the neighborhood of the disease was argillaceous shales—and that the disease was brought about by some form of miasma similar to that which produces chills and ague; in other words, it is zymotic; and that the clay shales, which are microscopic in an eminent degree, had or may have had something to do with its formation."

COLLETT'S FIRST REPORT ON GEOLOGY.

The second volume issued by the Bureau of Statistics and Geology contained 164 pages and 11 plates devoted to the latter subject. Two thousand copies of the portion on Geology, were printed separately, and the work is therefore known as Collett's first report on Geology. Issued in 1881, it contained the results of the geological work done in 1879 and 1880, which, on account of the small sum available, was very little; Collett giving the expenditures for the geological work done in the two years as follows:

Traveling expenses of Chief of Bureau.....	\$65.00
Survey of Monroe County, Mr. Greene.	150.00
Surveys in other districts, Mr. Greene.....	15.00
Drawing figures for Prof. White's paper, Mr. McConnell.	65.00
Drawing maps, Mr. Morrison.....	20.00
Synopsis of Mollusea, Dr. Stein.....	25.00
Increase of cabinet	50.00
	<hr/>
Total.....	\$505.00

In a brief introductory chapter headed "Geology of Indiana," he states that "During the last year a company was organized at South Bend, which has since been engaged in the manufacture of Portland cement from the gray clays and calcareous marls found along the shores of the ancient lakes of St. Joseph County." This was the pioneer Portland cement factory in Indiana, and was the first one in the United States to successfully use marl and clay as the cement ingredients. It was operated on a small scale until 1894, the output never exceeding 20,000 barrels a year, or about one-third the amount produced each day by the large mills now operating at Mitchell, Indiana. Collett gives the results of analyses of the raw materials and the completed product, made by Hurty, together with those of tests showing the tensile strength of the latter, and states that "the tests afford convincing

proof that here in Indiana is made a Portland cement fairly rivaling the best foreign brands," a statement which was afterward substantiated by the United States Government, which annually purchased much of the output for use in the arsenal at Rock Island, Illinois.

In this introductory there are two pages devoted to the Mammoth and Mastodon in Indiana, in which it is stated that the remains of 25 mammoths and 30 mastodons had, up to that date, been found in the State. There are also accounts of the excavations of large pre-historic mounds at Vincennes and Worthington, with descriptions and illustrations of the objects found in them.

The first Geological map of the State published in or with any of the reports was a single page one in connections with this chapter. Of it Collett says: "The outline geological map of the State, printed herewith, is upon so small a scale that it must be regarded as merely a rough sketch. It shows, however, with reasonable accuracy, the surface exposures of the rocks of the several geological formations."

Following the introduction, there was a report on the Geology of Putnam County by Collett, and of Monroe County by Geo. K. Greene, each with a double page outline map. In the former is given an account of the quarries, then extensively operated for flags, bridge, dimension and rubble stones at Putnamville, and located on lands now forming a part of the new "Penal Farm." Collett gives an analysis of the stone and a section of the quarry. Since it is soon to be extensively operated by the State, the following paragraph is quoted from his account: "The product has been in use, severely exposed to the extreme vicissitudes of our variable climate, including changes of 60° of temperature in a single day, for over forty years. It has shown capacity to resist the action of frosts, fire and ice. Samples, taken as a rule, from the exposed parts of the quarry when first opened in 1838-'40, may be seen in piers, etc., of the bridges and culverts on the National road and in the locks of the canal, the steps of the mother and branch Banks of State, at Indianapolis, and also the steps of the Terre Haute House at Terre Haute, and of the old University Building at Greencastle. As pavement, step stones, and for curbs it is unrivaled. Its quality of hardness renders it desirable for piers and rip-raps exposed to the action of ice and waves."

A "Synopsis of the Molluscous Fauna of Indiana," by Dr. Frederick Stein of Indianapolis follows the report on Monroe County. It gives the names and distribution in the State of 181 species of land and fresh water shells, and was the only check list of the Mollusca of the State available until the one prepared by L. E. Daniels was published in 1903.*

The final paper in the volume is one on Paleontology by Dr. C. A. White of the Smithsonian Institution, and is entitled "Fossils of the Indiana Rocks." It includes full descriptions, accompanied by 11 plates of figures, of a few

*27th Rep Indiana Dept. Geol. & Nat. Resources, 1903, pp. 629-652.

of the more important species characteristic of each of the great rock formations of the State.

In the introduction of this Second volume, Collett sets forth the needs of the Bureau of Statistics and Geology, and asks that a total of \$12,000 be appropriated by the Legislature of 1881; \$6,000 for the Division of Statistics; \$5,000 for that of Geology and \$1,000 for "increase of the State Museum." Hon. Albert G. Porter had been chosen Governor in 1880. A man of education and of progressive tendencies, he understood the need and value of scientific work, and favored, therefore, an increase of the sum appropriated for such purpose. The legislature was responsive, and we find a separation of the Departments of Statistics and Geology, and by an act, approved April 14, 1881, the establishment of a Department of Geology and Natural History, which was as follows:

AN ACT TO PROVIDE FOR THE ESTABLISHMENT OF A DEPARTMENT OF GEOLOGY AND NATURAL HISTORY IN THIS STATE.

(Approved April 14, 1881.)

Section 1.—*Be it enacted by the General Assembly of the State of Indiana,* That a Department of Geology and Natural History is hereby established for the purpose of continuing the geological and scientific survey of this State, of discovering and developing its natural resources, and disseminating information in regard to its agricultural, mining and manufacturing advantages.

Sec. 2.—That the Governor shall appoint a competent and suitable person who shall be skillful in geology and natural science, as State Geologist, and who shall be the Chief of said Department; and said Chief shall have the power and be authorized to call to his assistance such help as he may deem necessary, but in no case to exceed the amount of expenditure authorized by the General Assembly. Said State Geologist, when commissioned by the Governor, shall take an oath of office as other officers, and shall serve for a term of four years; but said State Geologist may be removed by the Governor for cause, and a successor appointed in his stead, and the Governor shall fill any vacancy which may occur from any cause. The compensation of said State Geologist shall be \$1,800 per year, which shall be paid as other salaries are required by law to be paid.

Sec. 3.—It shall be the duty of said State Geologist to continue the geological survey of the State, by counties or districts, and to complete and revise the same, as may be practicable. He shall give special attention to the discovery of minerals, stones, or other natural substances useful in agriculture, manufacture or the mechanical arts; he shall be curator of the geological cabinet, museum, apparatus and library, and shall, from time to time, as may be practicable, add specimens to the cabinet of minerals, organic remains and other objects of natural history peculiar to this State and other states and countries.

Sec. 4.—The offices of the geological department shall be in such rooms as may be assigned for this purpose and he shall keep such office and the State Museum open during the usual business hours of other offices of the State, when not engaged in field or other work requiring his absence therefrom.

Sec. 5.—The State Geologist shall make to the Governor an annual report of his labors and discoveries, and of all useful information he may have obtained in such service, including such descriptions and figures in geology, paleontology and archaeology as may promote science and aid in the diffusion of knowledge; and 5,000 copies of such report shall be printed and published in like manner as other official reports.

Sec. 6.—An appropriation of \$5,000 annually shall be, and is hereby, made for the next succeeding two years, which shall include the salaries of the State Geologist and his paid assistant, and if any part thereof shall remain unexpended, it shall remain a part of the general fund of the State, to be used as other general funds of the State are used.

Sec. 7.—All acts and parts of acts inconsistent herewith are hereby repealed.

We find in this act four facts of importance, viz, (a) the change of name to "Department of Geology and Natural History;" (b) the increase of the length of term of the State Geologist from two to four years; (c) the first recognition of a "State Museum" under that name; (d) an appropriation of \$5,000 per annum to carry on the work.

Collett was reappointed State Geologist by Governor Porter, and in his first report of the new department, that for 1881, published in 1882, has the following statement regarding the State Museum: "Additional cases were procured through funds appropriated for geological purposes, in the hands of the State Board of Agriculture and Mr. Geo. K. Greene was engaged to arrange the fossils and specimens in their proper cases. The cabinet, when first received from my predecessor, by actual enumeration, consisted of 8,912 specimens, mostly undressed fossils, generally without labels. At present it embraces, well arranged, properly classified and labeled, 44,424 specimens."

"Doc" Hurty, who was connected with the new department as "special chemist to the Geologist," must have taken an interest in the museum, for on the next page Collett continues: "There is now on exhibition a pretty full set of germs, minerals and crystalline rocks, implements of the 'mound builder,' or stone age, fishes and reptiles of northern Indiana, etc., land and fresh water shells, and beetles; fossils of the coal measures and Lower Carboniferous periods. In fossils of the Lower Silurian, Upper Silurian and Devonian ages, the collection is a nearly complete exhibit of the specimens peculiar to the State, and may not be readily excelled." On second thought, however, we conclude that the printer must have been to blame and put in an "r" where it did not belong.

SECOND REPORT OF COLLETT.

As usual, Collett begins the report with a chapter on the general "Geology of Indiana," including a table on the quarry industries of the State, compiled by the U. S. Census Bureau, a chapter on oolitic limestone, with analyses, another embodying the results of the physical tests showing the "transverse strength and elasticity of all building stones" from Indiana and other States, made for the State House Commissioners before letting the contract for the present edifice.

Following these are reports on Shelby County by Collett, Fountain County by R. T. Brown, Delaware County by A. J. Phinney and Bartholomew County by Dr. M. N. Elrod, each accompanied by a double page outline map.

Under Shelby County, Collett describes what he called the "Collett Glacial River," so named by Dr. J. L. Campbell, Prof. of Geology and Civil Engineering in Wabash College, and former president of the Academy of Science, who at that time was also connected with the U. S. Geodetic Survey. He furnished Collett a letter published in the report on Shelby County, giving the main facts regarding this old valley. Of it Collett says: "Crossing the western bounds of Shelby County, this great stream of water and icebergs impinges against and is obstructed by the hilly district of Brown and Johnson Counties having an elevation of 400 to 500 feet above the valley, and is deflected south perpendicular to the dip or along the strike of the rocks to the southern boundary of the State at Jeffersonville. This valley is a wonderful exhibition of energy and forces which have ceased to exist. The volume may be estimated by the amount of the erosion, which exhibits a width of five to ten miles, and depth of 300 to 500 feet as measured by the wall-like bluffs of the adjoining high lands. The mighty ships which sailed upon this river sea were silvery bergs of ice, scattering boulders along its shore line, or in its depths as discovered in deep wells in Scott and Clark Counties, its broad eastern pathway indicated by Lower Silurian fossils, found in Ohio and eastern Indiana. Economically it furnished an inclined plane, utilized as the roadway of the railroad from Indianapolis to Jeffersonville" and Campbell closes his letter with the following paragraph: "This wide valley was cut in the otherwise level plane by the mighty river, wide and deep, whose life continued during the melting of the glacier, in the period intermediate between the geologic and the modern, but its tracings furnish an interesting feature in the topography of the State."

In the report on Bartholomew County, Dr. Elrod also devoted two or three pages to this same "glacial valley," he having added the name Valley to the one used by Campbell and Collett.

The last 200 pages of the volume, as well as 55 accompanying plates, are devoted to two papers on paleontology. The first is a reprint of Prof. James Hall's paper entitled "Descriptions of the species of Fossils found in

the Niagara Group at Waldron, Indiana,"* with 36 plates. The second is "Fossils of the Indiana Rocks, No. 2" by Dr. C. A. White, with 19 plates, 12 of which were of fossil corals, drawn and engraved but never published by John W. Van Cleve of Dayton, Ohio. The majority of these corals were from the Devonian formation and the most of them occur in the noted bed of that age at the falls of the Ohio near Jeffersonville.

THIRD REPORT OF COLLETT.

The next report of Collett, covering the work done in 1882, was issued in 1883. On page 7 he states that "The total number of specimens in the State Museum at the time of last year's report was 44,424. Additions made during the year give at present a grand maximum of over 100,000 specimens, valued by distinguished experts—Prof. Hall, State Geologist of New York, and others—at more than one hundred thousand dollars." This statement is of especial interest when taken in connection with another in the final volume issued by Collett.

The first part of the report contains two short papers of scientific interest. One, entitled "United States Survey and Growth of Timber," explains the system used by the first Government Surveyors of the State, and includes a reprint of the "General Instructions of the Surveyor General to Deputy Surveyors." It may not be known to all members of the Academy that the original township sheets made by these early surveyors are in the land department of the State Auditor's office, and much use was made of them in getting up the maps, accompanying the geological reports issued between 1895 and 1910.

The second paper referred to was by H. W. Beekwith of Danville, Illinois, and is entitled "Indian names of Water Courses in the State of Indiana."

The body of the volume contains Geological reports on the following counties: Newton and Jasper by Collett; Marion by R. T. Brown; Decatur by M. N. Elrod; Jay by David S. McCaslin and Randolph by A. J. Phinney. Following the report on Randolph County, Dr. Phinney has a paper entitled "Catalogue of the Flora of Central-Eastern Indiana," which he designates as the "Alpine or elevated District of the State." It covers Delaware, Randolph, Jay and Wayne Counties, and lists with time of blooming and local distribution 789 species belonging to 370 genera.

About one half of the volume is devoted to Paleontology. There is a continuation of "Van Cleve's Fossil Corals," identified and compiled by Prof. Jas. Hall, with 14 plates; also descriptions of new species of corals by Hall, with 14 plates, and a paper on the Spergen Hill Fossils by the same author with four plates. The final paper is entitled "The Diatoms of the Waters of Indiana," by Rev. G. L. Curtis. It comprises only eight pages of matter pertaining to diatoms in general, and is accompanied by six plates on which are shown figures of 108 species, none of which are described in the text.

*First printed in the 28th Report of the Regents of New York University.

Collett, however, in the introduction to the volume, mentions this paper as follows: "The Rev. Dr. Curtis has given the results of years of careful research in the microscopic study of the animalcules which have their habitat in the potable waters of Indianapolis and vicinity. By these figures every one can see the forms of the animals which it delights his soul to swallow. These drawings have been submitted for criticism to the best experts in diatomacean forms, and are pronounced by them to be good, while the accompanying descriptions and nomenclature are fully up with the advanced knowledge in natural history."

FOURTH REPORT OF COLLETT.

The fourth report of Collett, entitled "The Thirteenth Annual Report of the Indiana Department of Geology," was issued in 1884. It was accompanied by the first colored Geological Map of the State issued by a State Geologist. This was on a scale of nine miles to the inch and showed on the margins a vertical section of the exposed strata of the State, and a horizontal section across the State from Vincennes to Lawrenceburg, near the Ohio and Mississippi (now the B. & O. S. W.) railway. Of this map Collett wrote: "The accompanying geological map of Indiana gives a fair exhibit of the surface geology of the State. It is a compilation of all the labors of my distinguished predecessors and their assistants. Much of the geology of the northern and northwestern areas is given, not accessible before the surveys of Newton and Jasper Counties. The map comprises over one hundred years of labor and study of these devotees to science, as well as the results of thousands of miles of travel with pick and hammer. It is believed that it will be appreciated by our citizens as a chart giving years of study and labor, condensed in a single sheet, and invaluable to teacher, student and citizen."

In the introductory portion of the volume G. M. Levette has an article on the "Fuel Value of Coals," accompanied by tables of 392 analyses of Indiana coals compiled from the reports of Owen and Cox, and 57 analyses of coals from other States for comparison.

This is followed by the usual county reports, viz., Posey County by Collett; Morgan, by R. T. Brown; Rush, by M. N. Elrod; Johnson, by D. S. McCaslin and Grant by A. J. Phinney. These were each and all of the usual type of county reports in the Cox and Collett volumes, and contain nothing worthy of especial mention in this review.

A "Glossary of Terms commonly used in Geological Reports," suggested and largely prepared by Dr. W. T. S. Cornett of Madison, Indiana, follows and ends Part I of the volume.

Part II is devoted to Paleontology and embraces two papers. The first, entitled "Principles of Paleozoic Botany," by Leo Lesquereux, is accompanied by 22 plates illustrating the remains of the more important plants of the coal measures of the State. Collett in an introduction says: "As the greatest riches of the minerals of Indiana lie in its coal beds, which are en-

tirely composed of plants, I have thought it advisable to give an exposition of the vegetable remains, which found in connection with coal beds, indicate the nature of their compounds. The only man deeply versed in that part of Natural History is Prof. Leo Lesquereux, of Columbus, Ohio, who, as an intimate friend and fellow citizen of Prof. Agassiz, was encouraged by him to come to America, and, who, since his arrival here in 1848, has given the most of his time to the study of the fossil plants of North America. His studies, published in numerous State and Government Reports, fill many volumes, and as a Paleontologist, Lesquereux is as widely known in Europe as he is in this country. I have, therefore, proposed to him to prepare for this report a Manual on the Principles of Vegetable Paleontology, and I now offer it to the State as a work which will be of great value to the students and colleges of Indiana, and to those of the United States, and which at the same time may be read with pleasure and profit by all persons interested in the coal beds."

The second paper is a continuation of those of Dr. White on the fossils of the Indiana rocks, this being No. 3. It is entitled "Fauna of the Coal Measures," and comprises 158 pages and 17 plates. Both papers contain valuable introductory matter on the general features of the Carboniferous period, the origin of coal, etc.

FIFTH REPORT OF COLLETT.

The legislature of 1883 failed to pass a General Appropriation bill, and says Collett in his fifth and last report, filed on November 2, 1884, "There has been no public fund for expenses whatever since May, 1883, as the special appropriation of \$5,000 per annum ended at that time." He also states that his term of office expires by law in April, 1885. I earnestly urge that such an office should be maintained and filled by a competent man, on whom citizens may call, without money or price, for information as to their mistakes or discoveries, and where those from abroad can obtain information of the wealth and resources of Indiana. This is believed to be more important to the State than additional field work or Paleontological descriptions and discoveries."

Regarding the State Museum he says: "It has constantly increased. Several thousand specimens are in boxes and cases not on the shelves, for want of funds to clean them. These will more than fill the cases when the present Chief removes the contents of the twenty cases which are his private property."

It is well to remember here that he had stated in the 1882 report that the museum contained over 100,000 specimens valued at \$100,000. The specimens which he here says were in boxes and cases were mostly duplicates of those on display. When he left the office he took with him the contents of the 20 cases, or the "more than 50,000 specimens" which were added in 1882. These and other withdrawals made before 1895, left a number of empty

cases, so that in that year there were probably not over 30,000 specimens, though no actual count or catalogue of them has been made in recent years.

On account of the failure of the appropriation, the report for 1884 was necessarily brief. A reprint of the geological map was made and sent out with the volume. The latter contains what are called "Geological and Topographical Surveys of Hamilton and Madison Counties, by R. T. Brown, and Fayette and Union Counties by M. N. Elrod." Why the word "topographical" was added to the title, unless to fill space in a brief volume, is beyond comprehension.

A small cave was discovered in 1884 near Greencastle, Putnam County, and under the title "University Cave," a description of it is given. Two other brief papers are entitled "Fish Culture in Indiana" by R. T. Brown, and "How to Prepare and Cook Fish and other Animal Food," by E. T. Cox.

"The Drift Deposits of Indiana" by Dr. J. S. Newberry, and a chapter on the "Ohio River Floods of 1884," together with a reprint of the glossary of the preceding report, complete the 122 pages of the first part of the volume.

The second part is made up of a paper entitled "Post-Pliocene Vertebrates of Indiana" by E. D. Cope and Jacob L. Wortman. The names of the authors are a sufficient guaranty of its value. In their letter of transmittal they state that "It has been our endeavors to present in the following list a popular account of each species, detailing at the same time, in cases of extinct ones, whatever legitimate inferences can be drawn in regard to their size, probable habits, range and relations to living allies."

Keys, full descriptions, accompanied by six plates, together with popular accounts of their habits, give much knowledge regarding those strange mammals that moved backward and forward in unison with the advancing and receding glaciers, over the area which we now call Indiana.

It was at this period that politics began to play an important part in the history of the Indiana Geological Survey. Collett, a republican, had first been appointed by Jas. D. Williams, a democrat, and afterward, for four years, by A. G. Porter, a republican. Isaac P. Gray, a democrat, was elected Governor in the fall of 1884, and Collett, when he wrote the last paragraph I have quoted about the State Museum, had evidently seen the "hand-writing upon the wall." According to a strict interpretation of the law, the Governor was obliged to choose some one for the place, "who shall be skillful in geology and natural science." Such a person was somewhat difficult to find among worthy democrats in those days, as all of Collett's assistants, who had had experience in the work, were republicans.

THE THOMPSON SURVEY, 1885-1888.

Maurice Thompson of Crawfordsville, a civil engineer and popular writer of short stories, afterward the author of "Alice of Old Vincennes" and other novels, was finally picked for the place. Regarding Geology and Natural Science, the only writing which he had done up to that date, as far as I can

learn, was a small pamphlet entitled "The Redheaded Family," which treated of the habits of our common woodpeckers.

Thompson was appointed in the spring of 1885, and naming three assistants of democratic proclivities, namely, W. H. Thompson, his brother, S. S. Gorby, and Stephen E. Lee, and retaining Phinney and Brown, he began searching for those facts which had remained undiscovered since the days of David Dale Owen.

FIRST REPORT OF THOMPSON.

Thompson's first report, the "Fifteenth Annual Report of the Department," covering the work done in 1885 and 1886, was issued in the fall of the latter year. In his preface he mentions his discovery of the "Wabash Arch," concerning which Gorby had a special paper in the report. Of it Thompson says: "A few years ago, while engaged in making some preliminary railroad surveys, I noted at a number of points in northern Indiana evidences of a line of disturbance affecting the rock strata across the State, in a direction generally east and west." This supposed upheaval or arch, which was discussed in detail in the next three or four volumes issued by the Department, has been shown by Phinney and Kindle to be a "figment of the fancy." Phinney's conclusions will be given under another heading, and Kindle, writing of it, says: "Many of the dips recorded by the author of this hypothetical arch afford evidence against it. About half of them are east or west dips, while the supposed arch has an east and west axis, which calls for north and south dips and fails to explain the others." On a later page Kindle, in discussing the domes or tilted rocks at Wabash, Delphi and Kentland, which furnished the main evidence on which Thompson and Gorby based their supposed arch, continues: "There is at present no positive evidence as to the nature of the forces which produced these domes. It seems probable, however, that they may be analogous in origin to the 'mud lumps' at the mouth of the Mississippi. The study of these interesting masses of the recently elevated sea bottom shows that they rise up in domes or anti-clinals and preserve their regular bedding. Whatever the cause may have been which produced the Indiana domes, there is clear evidence that they were developed about the close of the Niagara period."*

Thompson began his report proper with what he calls a "Compendium of the Geology and Mineralogy of Indiana," which in his preface he states is aimed "To present in the shortest form a clear outline sketch of all that has been discovered and reported upon by my own corps and by predecessors in office, so that this volume might, in a certain degree, place the student who cannot get the earlier reports, in a situation to fairly understand the geology of Indiana." He followed the custom of his predecessors and continued the survey of isolated counties, his "compendium" of 60 pages being succeeded by reports on the Geology of Tippecanoe, Washington and Benton Counties by

*28th Rep. Ind. Dept. of Geol. & Nat. Resources, 1903, pp. 404-411.

Gorby; Henry County by Phinney; Clinton, Marshall and Starke Counties by W. H. Thompson; Boone County by Gorby and Lee, and Hancock County by R. T. Brown.

These county reports are followed by a paper of especial interest to botanists, and probably the only one of permanent scientific value in the volume, entitled "The Origin of the Indiana Flora," by John M. Coulter and Harvey Thompson. After a discussion of the topographical features of Indiana, they divided the State into "seven distinct botanical regions, each differing from all the others in conditions of soil, moisture and topography and consequently in climate and vegetation." A list of the most characteristic plants of each region was then given. Following these lists is a discussion of the main causes and means of the migration of plants and the origin of the North American flora. This was succeeded by a list of 342 plants common to the northeastern United States and Europe. Of plant migration into Indiana they say: "Lying, as the State does, in the very central northern part of the country, it became the common meeting ground of migrations from various directions. As the glacial times were beginning, and streams of migrations began to set in from the north, the hardy invaders began to take possession of the soil and the more tender natives retired southward before the same conditions. Two distinct streams of northern migration have been made out, one from the northeast, the other from the northwest, the former being the first in point of time and apparently the most important in results. With the coming on of warmer conditions, and the consequent melting and retreat of the glaciers, these arctic plants were compelled to move northward again, some as has been said, finding suitable conditions of growth in our deep valleys or highlands. The more southern forms spread northward again within the State, but never regained the foothold they had lost."

"Plants from the east and south that have since come in, and are still coming to us, have mostly reached us by the great river systems of the Ohio and Mississippi. Plants from the west, the most recent of our invaders, have come chiefly along lines of railroad, most important lines for plant advance. At least five distinct directions have thus been clearly made out from which our plants have come to us. First, from the northeast; second, from the northwest; third and fourth, from the east and south; and fifth, from the west." They then give lists of the species which came in from each of these directions and conclude that of the 1191 plants then known from the State more than four-fifths have a range north and east of Indiana.

In the latter part of the year 1886 Natural Gas was first discovered in Indiana, and the final paper of the Thompson Report was devoted to a discussion of this then little known fuel. Of it Thompson wrote: "The discovery of gas at Findlay and at other points in northwestern Ohio, created a furor for well boring, which ran all over Indiana, and the drill began its work at whatever point money was to be had to pay for the expensive operation. The consequence has been a loss to the citizens of Indiana of many thousands of dollars. The State Geologist was not consulted, save in two or three in-

stances where work had already been begun. Everybody took it for granted that because Ohio had great reservoirs of subterraneous gas, Indiana also possessed them, whereas it is true that of wells bored but a short distance apart, even in the best areas of the Ohio gas region, some are successful while others are utter failures."

While the report was in press gas was struck in Indiana at Eaton, Delaware County, and Kokomo, Howard County, and the paper ends with sections of each well and remarks on the character of the Indiana gas. It also includes a section of the well 2,730 feet in depth put down in the court house yard at Bloomington, Indiana, in search of artesian water.

With the completion of his second report in December, 1888, Maurice Thompson, "on account of continued bad health was compelled to resign as State Geologist," and S. S. Gorby was appointed to fill the vacancy. He edited the report of Thompson, which did not appear until the latter part of 1889. It was accompanied by a colored geological map of the State, based upon the one issued by Collett but showing the various supposed natural gas areas of the State.

SECOND REPORT OF THOMPSON.

The volume begins with the usual introductory chapter, in which Thompson mentions that the State Museum had been "transferred to its present rooms in the State House and all the specimens of the vast collection relabeled, rearranged and reset in the new cases." He then adds the following paragraph: "The notion that the chief end of geological study is to collect fossils and classify them should be driven from the mind of every student. Paleontology has its place of practical utility as a sign language by which the rocks impart their secrets to us, and through which we may reach the significance of things otherwise meaningless; but, on the whole, the discovery of a ledge of good building stone is more to be prized than a mine of erinoids or a hill full of trilobites, pentamites and the rest. The discovery of the potato was of more value to mankind than all the works of Darwin, Huxley, Tyndall and Agassiz combined. Nor is this belittling these great men. It simply means that though one should make plain as day the origin of life it would be as nothing compared with a discovery of cheaper food for the poor and shorter hours of labor for the toilers. Abstract study is for the man and woman of leisure; the concrete is for the busy, earnest worker. The greatest good to the greatest number is a maxim which would force the report of a State Geologist into a practical channel; still the larger part of the literature of even popular science must deal with the technical rather than with the untechnical, and we must depend upon the intelligence of the people to enforce a system of education which shall set the popular thought on a level with enlightened investigation. It is by such means that civilization is broadened and bettered year by year." We see from this statement that Thompson's views were sound as to the

chief functions of a State Geologist, and that they differed widely from those of his immediate predecessor and successor in the office.

Thompson followed the introductory, from which I have quoted, with an article entitled "The Drift Beds of Indiana." The numerous bores sunk for gas in 1887 and 1888 had developed a large amount of information regarding the thickness and character of the drift in different parts of the State, much of which he incorporates in this paper.

In a section devoted to the "Wabash Arch" he again sets forth his arguments in favor of its presence, stating that: "Careful study of the rock outcrops and of the sections obtained from gas wells in northern Indiana have fully confirmed the report made by Prof. Gorby in which evidence of a notable disturbance in the Niagara strata was traced across Indiana far into Illinois."

"The name *Wabash Arch* has been objected to by the State Geologist of Ohio, Prof. Orton; but we shall keep it, notwithstanding. If men who claim to be devoting their lives to science would trouble themselves less about the jargon of nomenclature and more about gathering facts, we should see much better progress in the direction of practical scientific success. We have given the name *Wabash Arch* to the upheaval in Indiana, and *Wabash Arch* it shall be. If Prof. Orton takes away the name, he must take away the upheaval along with it."

A paper on "Fossils and their Value" by W. H. Thompson includes "A Corrected List of the Fossils found at Crawfordsville, Ind." by Chas. Beecher. "An Outline Sketch of the most Valuable Minerals of Indiana" was also prepared by W. H. Thompson, in which he asserts his belief in the theory first set forth by Cox, that the kaolin beds of Indiana were formed by the action of water charged with silicates and alumina upon beds of limestone, and states that "Next to our coals, our natural gas and our building stones, these magnificent beds of kaolin will in the future be the greatest source of our mineral wealth."

Dr. Chas. R. Dryer enters the arena of Indiana Departmental Geology for the first time in this volume, where he has reports upon the Geology of DeKalb and Allen Counties, in which the data obtainable regarding the moraines, and lakes, kames and other features of the glacial formed topography are excellently set forth.

A partial report on Marshall, Starke, Pulaski and White Counties by W. H. Thompson contains many notes of interest, regarding the Kankakee and Tippecanoe Rivers. Of the latter stream he says: "There are many fine streams in the State of Indiana, but not one that can be compared with this river. Its rare beauty, its splendid fishing, the good shooting to be had along its banks, the numberless cold springs that bubble out of the high bluffs, the small green islands that are met at almost every turn of the stream, the clear water flowing over the assorted sand and boulders of the northern drift, or the masses of heavy green grass attached to the bottom and waving in the moving water like a tiny forest in a 'broad and equal blowing wind,' lend a charm against which few hearts are proof."

The present writer has traveled this stream in a row boat from Tippecanoe Lake to its mouth. He has also traveled every other large stream of the State except the Whitewater in like manner. He can, therefore, from actual experience assert that W. H. Thompson was right when he said that no other stream in the State can compare with the Tippecanoe in the variety and beauty of its scenery.

S. S. Gorby the new State Geologist, contributed to the second report of Thompson a paper on the Geology of Miami County; also one on "Natural Gas and Petroleum," and a third on "The Structural Features of Indiana," the last named is based largely upon data obtained from the records of the hundreds of gas wells which had been recently sunk in the State, the object of the paper being to show the approximate depth at which Trenton Rock, the oil and gas bearing formation, would be found in the different sections of the State.

The final paper of the volume is one on paleontology by S. A. Miller and is entitled: "The Structures, Classification and Arrangement of American Paleozoic Crinoids into Families." It includes the characters of the families and genera and descriptions, accompanied by ten plates of figures, of many new species.

Between 1888, the date of issue of Thompson's second report, and 1892, the date of appearance of the next report of the Department of Geology, politics and Geology were badly mixed. Maurice Thompson was evidently wise when he resigned in December, 1888, and we suspect that politics had more to do with his resignation than did the state of his health. As we have noted, S. S. Gorby was appointed by Governor Gray to fill the vacancy.

In the election in November, 1888, General A. P. Hovey, a republican, had been chosen Governor and all the candidates for State office on the republican ticket had also been successful. The Democrats, however, had carried the legislature by a good working majority, and when that body met in January, 1889, it immediately proceeded to make the Governor as much of a nonentity as possible, by taking from him the most of his appointive offices and vesting them in itself. On February 26 it passed, over the Governor's veto, a bill with the following title;

"An Act establishing a Department of Geology and Natural Resources in the State of Indiana, and providing for a Director of the Department; abolishing the Department of Geology and Natural History, and the office of State Geologist connected therewith; abolishing the offices of Mine Inspector and State Inspector of Oils; repealing all laws or parts of laws conflicting with any of the provisions of this act, and declaring an emergency."

Those sections of this act which pertain especially to the office and duties of the State Geologist were in part as follows:

Section 1.—*Be it enacted by the General Assembly of the State of Indiana,* That a Department of Geology and Natural Resources is hereby established for the purpose of continuing and perfecting the geological and scientific survey of this State, of discovering, developing and preserving its natural

resources; recommending and securing the enforcement of laws providing for the health and personal safety of all persons engaged in developing or using the products of its natural resources, and collecting and disseminating information concerning its agricultural, mining and manufacturing advantages. The said Department shall comprise four divisions, as follows:

First. The Division of Geology and Natural Science.

Second. The Division of Mines and Mining.

Third. The Division of Mineral Oils.

Fourth. The Division of Natural Gas.

Sec. 2.—The General Assembly shall, immediately after the taking effect of this act, elect a competent and suitable person, skilled in geology and natural sciences, Director of the Department of Geology and Natural Resources, who shall be State Geologist and Curator of the Museum and Chief of the Division of Geology and Natural Science. He shall take an oath of office, as other officers and hold his office for a term of four years, and until his successor is elected and qualified. He shall appoint the chiefs of divisions provided for in this act, and such other assistants as he may deem necessary in prosecution of the work in the Division of Geology and Natural Science, but in no case shall the expenditures under his direction exceed the amount authorized by the General Assembly. The compensation of the Director of the Department shall be two thousand dollars per year, to be paid as other salaries are required by law to be paid.

Sec. 3.—It shall be the duty of said Director to continue the geological survey of the State, by counties or districts, and to complete and revise the same as may be practicable. He shall give special attention to the discovery of minerals, stones or other natural substances useful in agriculture, manufacture or the mechanical arts. He shall be curator of the Geological Cabinet, Museum, apparatus and Library, and shall, from time to time, as may be practicable, add specimens to the cabinet of minerals, organic remains and other objects of natural history peculiar to this State and other States and countries. He shall also have general supervision of the work in the several divisions herein provided.

Sec. 4.—The offices and Museum of the Department shall be in the rooms now occupied by the same in the State House, and the same shall be kept open during the usual business hours of other offices of State, except when the Director may be engaged in field work or other business requiring his absence.

Sec. 9.—The Director of the Department shall make to the Governor an annual report of his labors, together with the reports from the various divisions, including all discoveries and useful information he may have obtained in such service, including such maps, figures and descriptions in geology, paleontology and archaeology as may promote science, and in the diffusion of knowledge, and assist in advertising the natural resources of the State; and eight thousand copies of such reports shall be printed and published in like manner as other official reports."

From the title and from the first two sections quoted it will be seen, that for political reasons only the name of the Department was changed, that the legislature took upon itself the appointment of State Geologist and changed his title to "Director of the Department." It also took from the Governor, by abolishing their offices and creating new ones under different names, the appointments of State Mine Inspector and State Supervisor of Oils. It gave the appointments of these officers to the State Geologist and at the same time created (by a section of the act not quoted) the office of Inspector of Natural Gas, the filling of which it also vested in him.

On the next day after the passage of the act, the legislature appointed Gorby State Geologist for a term of four years, and he immediately appointed the heads of the new divisions provided for in the law.

Governor Hovey refused to recognize the validity of the act as passed and in May, 1889, appointed John Collett as State Geologist; Gorby having possession, refused to give up the office and the matter went to the courts. It seems to have been pushed through rapidly, for in November, 1889, we find a decision of the Supreme Court* in which that august body held that the legislature had no power to create an office and then fill it; that when created the office must be filled either by appointment by the Governor or by some other State officer designated by the legislature, and if that body did not so designate the appointive power, the office must be filled by an election by the people; that in creating the office of "Director of the Department of Geology" and then attempting to fill it unconstitutionally left the office vacant without an appointive power being designated, and that the Governor had the right to fill the vacancy until the next general election. It held, moreover, that the office of State Geologist was an administrative one and therefore should, according to the constitution, be elective and that the act of 1889, aside from the clauses taking from the Governor the power to fill the vacancies when the offices were created, was valid and would stand as law.

By that decision and not by any act passed by the legislature the office has continued to be and is to-day an elective one, and Indiana is the only State in the Union, and we believe the only country on earth where a Geologist is so chosen. For some unexplained reason Collett did not attempt † to take over the office, and the case was kept in court by Gorby's lawyers until the next summer, when there was a further decision by the supreme court on some minor points. Meanwhile Gorby had been nominated by the democrats for State Geologist for a term of four years, and our worthy brother member, John M. Coulter, had received the nomination from the republicans. The people of the State, in November, 1890, turned John M. down and Gorby continued to hold the office and draw the salary.

*The State ex. rel. Collett vs. Gorby. Supreme Court Rep. 122, p. 17.

†John Collett died at Indianapolis March 15, 1899, aged 71 years. He was a graduate of Wabash College in the class of 1847, and received from his Alma Mater a Ph. D. degree in 1879. He was elected a State Senator in 1870, and was appointed a State House Commissioner in 1878.

THE GORBY SURVEY, 1889-1894.

Since politics and not rocks had been the chief subject of discussion in the interim, it was four years between the issue of the sixteenth report, the last one put out by Thompson, and the seventeenth, the first one published by Gorby. The latter was a volume of 705 pages without an index. The usual introduction is followed by a paper of 96 pages entitled "A Report upon the various Stones used for Building purposes and found in Indiana," by Maurice Thompson who, in spite of his health, continued to act as chief assistant. One half of the paper is given to detailed statistics of the quarries of the State. Reports upon the geology of Steuben and Whitley Counties by Chas. R. Dryer, Carroll County by Maurice Thompson and Wabash County by M. N. Elrod and A. C. Benedict follow in the order mentioned. The report on Steuben County includes "A Partial Catalogue of the Flora of the County," by E. Bradner, 729 species being mentioned.

These county reports are followed by those of the State Inspector of Mines, the State Supervisor of Oils and the State Supervisor of Natural Gas, these officers having been made appointees of the State Geologist during the political turmoil of the past four years.

As crude petroleum had been discovered in paying quantities in the Trenton Rocks of Indiana in 1891, there is a short paper entitled "Petroleum in Indiana," by A. C. Benedict, in which the facts regarding the discovery are set forth and the history of petroleum from the earliest time treated somewhat in detail.

The reports of these officers are followed by two papers of interest to the zoologist. The first, "A Catalogue of the Butterflies known to Occur in Indiana," was by the present writer. It comprised 44 pages in which 108 species were listed, with synonymy and notes on distribution and life habits. In the quarter of a century that has passed, but three additional species have been recorded from the State.

"The Batrachians and Reptiles of the State of Indiana," by Dr. O. P. Hay, then Professor of Zoology in Butler University, was a more extended paper, comprising keys, full descriptions and life histories of all the known Indiana species of this interesting group of vertebrates.

The final paper on paleontology is by S. A. Miller. It is devoted wholly to the descriptions of new species from Indiana, Missouri and other states, and is accompanied by 20 plates. The author must have had as much trouble in finding new names for his species as does the Pullman Company at the present time for its sleeping cars, as 13 are named *gorbyi*, five *benedicti*, three *colletti* and nine *indianacensis*.

SECOND REPORT OF GORBY.

The second volume issued by Gorby appeared in 1894 and contained 356 pages and 12 plates. In it Dr. Chas. R. Dryer, published the results of his work in 1893 upon the Geology of Noble and LaGrange Counties, and

also a paper entitled "The Drift of the Wabash-Erie Region," accompanied by a map of the "Drift Deposits of Northeastern Indiana." This is a summary of the results of his study of the drift in the six counties surveyed by him for the Thompson-Gorby reports, viz., Allen, DeKalb, Whitley, Steuben, Noble and LaGrange, in the order mentioned. Taken as a whole, the work of Dryer as set forth in these reports is the most accurate and valuable exposition extant of the great drift region of northeastern Indiana.

The report on Noble County was accompanied by a paper on the flora of the county by W. B. Van Gorder, which lists, with notes on local distribution, 724 species, representing 363 genera.

Another paper in the volume of value at the time it appeared, especially to those interested in the search for Trenton Rock gas and oil, is that of E. P. Cubberly, entitled "Indiana's structural Features as Revealed by the Drill." From the records of hundreds of bores put down in the State in search of these bitumens, Cubberly prepared 16 colored sections on a horizontal scale of 30 miles and a vertical scale of 500 feet to the inch, each crossing a different portion of the State. Each section showed the relative depth and thickness of each of the geological formations of the State at certain points along its course, and thus enabled one to determine the different elevations or depressions of the Trenton Rock referred to sea level.

The final paper, as usual, was by S. A. Miller, on paleontology. It was illustrated with 12 plates, and descriptive wholly of new species of different families of fossils, many from outside the State. Seven were named in honor of Gorby, four after Greene and three each after Benedict and Collett.

THIRD REPORT OF GORBY.

During his six years' service as State Geologist, Gorby issued but three reports. The third, which appeared in 1894, contains 296 pages, and comprises a paper on the "Geology of Cass County" by Elrod and Benedict, the reports of the Inspectors of Mines, Gas and Oil, and a paper of 150 pages entitled "The Lampreys and Fishes of Indiana," by Dr. O. P. Hay. The latter was a valuable contribution to the zoological literature of the State, giving keys, full descriptions, distribution, feeding habits and food value of the 150 species of lampreys and fishes found in Indiana.

MISCELLANEOUS WORK FROM 1869 TO 1910.

Before taking up the work accomplished by the Department of Geology from 1895 to date, we will mention briefly some of that done in the State by individuals not connected with the Department, between the beginning of the Cox Survey and 1910. The papers published during the first ten years of this period were mostly archaeological rather than geological in nature. One entitled "Mounds at Merom and Hutsonville on the Wabash," by F. W. Putnam, appeared in the Proceedings of the Boston Society of Natural

History for 1872, and contains a description of the remains of the "Fort Aztalin" of Collett, a prehistoric fortification on the river bluff at Merom, Sullivan County. It encloses five small mounds and 45 large circular depressions or pits, varying in width from ten to thirty feet. These, says Putnam, "were the houses of the inhabitants or defenders of the fort who were probably further protected from the elements and the arrows of assailants by a roof of logs and bark or boughs." Other interesting details of the fort are given, as well as a diagram showing its outlines and the location of the enclosed pits and mounds.

In 1873 there was published in the Annual Report of the Smithsonian Institution a paper on the "Antiquities of Knox County, Indiana and Lawrence County, Illinois," by A. Patton, in which he describes excavations he made in three large artificial mounds near Vincennes, Ind. He calls them "three of the most beautiful mounds in the West." Sugar Loaf being 70 feet high and 1,000 feet in circumference at base, Pyramid 43 feet high and 714 feet in circumference and North mound 36 feet in height and 847 feet in circumference. Besides numerous skeletons and a few arrow heads, he found many varieties of small shells, some of the specimens having no living representatives in this locality or any climate as far north as this, which indicates either that the mounds were constructed when the locality enjoyed a warmer climate than now, or that the shells were brought from the south. From the numerous small mounds in the vicinity he concludes that "The beautiful little valley in which Vincennes now stands was doubtless once the site of a great city occupied by the mound builders, and their villages and farms were scattered over the country as ours at present."

The Smithsonian Reports of 1881 and 1882 also contain papers on the mounds and earthworks of Vanderburgh and Franklin Counties by S. Floyd and G. W. Homsher.

Dr. T. W. Chamberlain, the well known head of the Department of Geology in Chicago University, published, between 1881 and 1884, several noteworthy papers in the Annual Reports of the Director of the U. S. Geological Survey and in the American Journal of Science, in parts of which he gave the results of studies he had made on the moraines and other drift deposits of Indiana. In the principal one of these papers, entitled "The Terminal Moraine of the Second Glacial Epoch," he describes in detail two moraines which are prominent in Indiana. The first one he calls the Moraine of the Lake Michigan Glacier, 200 miles in length and 90 to 150 miles in width, shaped like an immense U, embracing the great lake between its arms, the southern extremity of the U crossing Lake, Porter and LaPorte Counties, Indiana. The second he termed the Moraine of the Maumee Glacier whose southern boundary crosses the State through Parke, Montgomery, Putnam, Morgan, Bartholomew and Fayette Counties. In describing the latter he recognizes Collett's "Glacial River," mentioned in the second report of Collett, stating that it "was one of the great avenues of discharge from the ice

border, and has left its record in broad belts of gravel gathering into a great trunk stream.”*

In April, 1881, the legislature passed an act providing for a survey of the Kankakee region, and Dr. John L. Campbell of Wabash College was appointed by Governor Porter as Chief Engineer. He began the field work in July, 1882, with John M. Coulter, Albert B. Anderson‡ and Alfred R. Orton as chief assistants. The results of his work are set forth in a pamphlet with accompanying map, published in 1883, entitled “Report upon the Improvement of the Kankakee River and the Drainage of the Marsh Lands in Indiana.” He found that the difference in level between the source in St. Joseph County and the point where it leaves the State, a distance of 77 miles as the crow flies, or 240 by the meanderings of the stream as it was then, was but 97.3 feet, or a fall of but 1.3 feet to the mile in a straight line or only 5 inches to the mile along the line of flow and that in August, 1882, at average low water, the volume of discharge at the State line was 1,271 cubic feet per second, while during the spring floods it is estimated at 25,000 cubic feet per second. The area drained by the river and its tributaries in Indiana is over 1,600 square miles, or approximately one million acres. As a result of his survey he reported that “The drainage and recovering of the Kankakee marshes will include (a) the construction of a better main channel than now exists for the flow of the river; (b) the straightening and deepening of the beds of the streams which flow into the main stream; (c) the digging of a large number of lateral ditches through the swamps to the improved channels. The portion of the work which seems properly to belong to State and National Supervision is the improvement of the main stream. The other parts of the work may be left to the owners of the land, to be executed under our general drainage laws.” He estimated the cost of reclaiming the marsh lands under the plans proposed at that date, as about \$315,000, or less than \$2.00 an acre for the 160,000 acres which would be drained.

In 1884 there was published under the auspices of the Western Reserve Historical Society a paper of 86 pages entitled “The Glacial Boundary in Ohio, Indiana and Kentucky,” by Prof. G. Frederick Wright of Oberlin College, Ohio. In this paper there was a map showing for the first time the southern limits of the glacial drift in Indiana, though they had been approximately set forth the year before by Dr. Chamberlain in his paper on terminal moraines. In the opening paragraph Prof. Wright says: “When, ten years ago, I began my investigations concerning the kames of the Merrimac valley in Eastern Massachusetts, I little thought to what it would lead; and, after having traced the boundary of the glaciated area from the Atlantic Ocean to the southern part of Illinois, I am equally in doubt as to what the future has in store in this most interesting line of exploration.” Of the glacial boundary in Indiana he says: “The boundary line enters Indiana from Kentucky a little below Aurora. In Indiana the line still continues to bear in a southerly

*Third Ann. Rep. U. S. Geol. Surv. 1883, p. 333.

‡Now Judge of the Federal Court at Indianapolis.

direction through Ohio and Jefferson Counties, grazing the edge of Kentucky again opposite Madison and reaching its southernmost point near Charleston, in Clark County, Indiana. From here it bears again to the north through Scott and Jackson Counties to the line between Bartholomew and Brown and follows this to the northeast corner of Brown. There again it turns to the southwest, touching the northeast corner of Monroe, where it again bears north for ten miles, to near Martinsville in Morgan County. Here again the line turns west and south, passing diagonally through Owen, Greene, Knox and Gibson Counties, and into Posey as far as New Harmony, where, for the present, I have left it." Farther on he says: "Everywhere over the glaciated region the till, or ground moraine, has been forced like putty into the gorges formed by the erosion of pre-glacial streams, so that nothing is more common throughout this region than to find that the old channels have been buried, and the streams forced to flow in new channels of modern date." Several of these old preglacial channels are in eastern Indiana and were discovered and their courses traced for scores of miles, during the boring for gas and oil between 1888 and 1910.

In 1890 this pamphlet by Prof. Wright, illustrated, much enlarged, and with an extended introduction by Dr. Chamberlain, was published as Bulletin No. 58 of the U. S. Geological Survey. Prof. Wright had in the meantime traced the boundary line of the glacier across Illinois to the Mississippi River, and in this bulletin he describes in detail the character of the drift in each of the Indiana counties which the boundary line crosses.

In 1886, Dr. J. C. Branner, then Prof. of Geology in Indiana University, published a small colored geological map of the State.

The "Hoosier Mineralogist and Archaeologist," a small magazine published in Indianapolis in 1885 and 1886, contained a number of short articles of interest on the mounds of Decatur, Rush and other counties. There were also two on the "Archaeology of Wyandotte Cave," by Rev. H. C. Hovey. In the January, 1886, number of this magazine there is an account of the first annual meeting of the Indiana Academy of Science.

Between 1882 and 1891, C. S. Beechler, of Crawfordsville, published in the *American Geologist*, several papers on the "Keokuk Group," giving notes on stratigraphy, lists of fossils found near Crawfordsville, etc.

The discovery of gas in Indiana in 1888 and petroleum in 1891, furnished a theme for a number of papers which treated of these bitumens. One of the first of these was by Frank Leverett, who has since become noted as a student and authority on glacial geology. It appeared in the *American Geologist* for July, 1889, was entitled "Studies in the Indiana Natural Gas Field," and gave records of the numerous bores first sunk for gas in Indiana, with conclusions based thereon. He gave the approximate outlines and general trend of the "Cincinnati Anticline," stated that there was "probably an axis of upheaval running from Royal Center west to Kentland," and suggested the possibility that thorough exploration "might bring to light one or more profitable oil fields in Indiana."

In 1889 there appeared from the pen of Edward Orton, then State Geologist of Ohio, a notable paper of 188 quarto pages* and seven maps and sections, entitled "The Trenton Limestone as a Source of Petroleum and Natural Gas in Ohio and Indiana," in which he discussed in detail all theories respecting the origin of gas and petroleum, and gave the early history of the Ohio and Indiana fields, accompanied by a colored double page map of the then producing areas. He described fully the geology of the formations in which gas and oil were found, giving especial attention to the Trenton limestone and to the geological structure of the Cincinnati uplift or "Cincinnati Axis" of Newberry, a great broad antiline which, beginning in Tennessee and Kentucky, extended north and north-westward through southwestern Ohio and eastern Indiana and is supposed to have had much to do with the general distribution of petroleum in the Trenton rock area of the latter State.

In his remarks on the Indiana gas field as then known, Orton wrote: "The heart of the Indiana gas field, as has been shown, is in six counties, viz.: Delaware, Blackford, Madison, Grant, Howard and Hamilton. These counties embrace an area as fertile and beautiful as any of equal extent in the noble state to which they belong. Wealth has been rapidly accumulated in them from agricultural sources since the country was first occupied. Thriving towns have sprung up; manufactories have been established on a large scale. It is not often that great mineral wealth is directly associated with great agricultural resources, but in this case the wonderful stocks of power that have so recently been discovered are added to regions that were already preeminent for the wealth of their soils and forests. These favored districts ought to reap an enormous advantage from the addition that has thus been made to their resources. *To this end it is necessary that they speedily learn the real nature of their newly discovered sources of power and speedily introduce a wise economy in the use of the same.* A vandal-like waste has characterized the early exploitation of most of the subdivisions of the field."

Thus as early as 1889 did Edward Orton, one of the greatest of the Geologists of the Central-west, warn the citizens of the Indiana gas field of the danger of the waste. Did they heed that warning? Never! During the next six years they came to believe that they had the world by the tail. They were the discoverers—the owners, the users, the wasters of a fuel supply which, in their opinion, would never fail. The boom of the gas belt days! Who that lived there then will ever forget it? Flambeaux lighted the highways and byways by night so that they gleamed more brilliantly than the "broadways and brightways" of the Hoosier capital to-day. Crossroad hamlets of a score of inhabitants came to count their citizens by the thousand. Villages and towns of a few hundreds grew into cities of thirty thousand. Factories by the hundreds were induced to locate, the promise of free gas which should be perpetual being the lode-star which attracted them from far

*Eighth Ann. Rep. U. S. Geol. Survey, 1889, Pt. II, pp. 475-668.

and wide. The wild-catter and the oil and gas producer, urged on by the town-site promoter, and the city lot speculator, continued to delve deep into the depths of the Hoosier State in search of those riches of stored power, there hidden since the sun gave up its heat and light to the plant cells of the old Silurian seas. With their iron drills they sunk for gas alone in fifteen years, twelve thousand vents to the Trenton rock. Through these there poured natural gas valued, even at the extremely low price at which it was sold, at \$81,213,911. So greedy were they, so ignorant of the real value of this gaseous fuel and the manner of its formation, so reckless in its consumption, that at the end of a quarter of a century there remains only the dregs of the plenty that has been.

One of the most valuable and extensive papers ever published on Indiana gas was the one entitled "The Natural Gas Field of Indiana," by Dr. A. J. Phinney, then of Muncie, who had been an assistant on the State Survey under Thompson and Gorby. It appeared in 1891 in the Eleventh Annual Report of the U. S. Geological Survey, and contained an introduction by W. J. McGee on "Rock Gas and Related Bitumens," in which he says: "When exploitation for gas began in Ohio, in 1886, the geologist literally sat at the feet of the prospector, gathering such crumbs as fell from his hands, and found himself utterly unable either to guide efforts or to predict results. Less than two years later the laws governing the distribution and accumulation of gas and oil were so fully developed that the rock gas problem claimed a solution as satisfactory as that of the well known artesian water problem; and to-day the geologist predicts the success or failure of a prospect bore for gas or oil about as readily and reliably as he can prognosticate artesian water or coal."

With all due respect to the opinion of Dr. McGee we must consider the latter part of this statement strongly overdrawn. If the supposed gas or oil field be in a hilly or mountainous country where the outcrops and anticlines can be readily traced it is probably true, but if in a comparatively level country or in one in which the surface is deeply covered with drift, the geologist cannot accurately predict the success or failure of any bore unless it be in a partly developed field, where he has been able, by a series of accurate surface levels to trace the trend and width of the anticline of the productive formation. Even then the texture of the producing rock may vary greatly and cause many wrong predictions. Had the statement of Dr. McGee proven true, the great majority of working geologists in the United States would have long since adopted petroleum geology as a specialty and would be no longer concerned about the high cost of living.

Continuing, Dr. McGee says: "The solution of the problem of rock gas and petroleum marks an era in science no less than in industry. Millions of dollars were probably spent by prospectors in gathering data, but the credit for the solution of the problem belongs chiefly to three individuals: I. C. White of the University of West Virginia; Edward Orton, State Geologist

of Ohio, and A. J. Phinney, a practicing physician and amateur geologist of Indiana."

Dr. Phinney's paper of 126 quarto pages was accompanied by a colored geologic map of the State on a scale of 20 miles to the inch, showing the outlines of the principal formations and the area of the then known gas field, and also by a Hypsographic map on the same scale showing the approximate distance above or below sea level of the Trenton rock or gas producing rock in all parts of the State. He treats his subject under the following chapter headings: "History of the Investigation;" "Geologic Structure of Indiana;" "Conditions of Gas Accumulations;" "Gas Pressure and Measurement;" "The Gas Field and the Borings within it;" "Record of Borings outside the Gas Field," and "The Care of Gas Wells."

Under the head of Geologic Structure he showed the fallacy of Gorby and Thompson's supposed "Wabash Arch," stating that the "phenomena which have given rise to the hypothesis of its existence are to be attributed to the building up of coral reefs and rocky prominences or to inequalities in the sea bottom," and that, "in view of the supposed bearing of this hypothetical arch upon the gas supply of northern Indiana, it seems well to emphasize the fact that the supposed axis of upheaval is at its nearest point ten miles distant from the most northerly point where gas has been found in paying quantities."

In 1896 Frank Leverett published in the Seventeenth Annual Report of the Director of the U. S. Geological Survey an extended paper, accompanied by six colored, double page maps, entitled "The Water Resources of Illinois, in which he gives considerable data relating to western Indiana, especially that portion drained by the Kankakee and Wabash Rivers and their main tributaries. He calls the first map a "Topographic Map of Illinois and Western Indiana," the contour lines shown on the Illinois portion being omitted from the Indiana side for obvious reasons. He includes also a "Map of the Pleistocene Deposits" covering the same territory on which is shown the area covered by each of the more important divisions of such deposits as "glacial ridges," "till plains," "loess covered till," etc. The drainage area of the Kankakee River is given as 5,302 square miles, of which 3,207 are in Indiana. The river itself is "remarkably regular in its flow, because of the great marsh along the first 90 miles of its course through which it flows and which acts as a storage reservoir and constant feeder for the lower course." A third map shows the "Geologic formations of Illinois and Western Indiana," the Indiana portion being based upon "Phinney's map" of 1890, while a fourth map he designates as a "Hypsographic Map of the St. Peter Sandstone showing the distribution of Artesian Wells and Deep Borings," the data regarding the Indiana wells shown being given in an accompanying table.

In 1897, Leverett published a similar paper entitled "The Water Resources of Ohio and Indiana,"* that portion devoted to the latter State being the most

*28th Ann. Rep. U. S. Geol. Survey, 1897, pp. 419-559.

complete monograph as yet issued on its streams, deep wells and other sources of the water supply. In a chapter on the physical features of the two states, he gives the mean altitude of Indiana as estimated by Henry Gannett to be 700 feet above tide, but 2,850 square miles of the State being above the 1,000-foot contour and but 4,700 below the 500-foot contour. He states that "the large area of Devonian shale in northern Indiana, though covered now with a drift to a height of 200 to 400 feet above Lake Michigan, has a rock surface about as low as the lake level."

Indirectly he eliminates the "Collett Glacial River theory of Campbell, Collett, Elrod and Chamberlain in the following words: "The Knobstone or Waverly formation on the west border of the basin occupied by the Devonian shale has an abrupt and nearly continuous relief of 300 to 400 feet, with occasional knobs 500 to 600 feet above the basin. This escarpment is so abrupt in the unglaciated districts from Brown County southward to the Ohio River as to resemble a river bluff and it is but natural that this feature, taken in connection with the rapid descent from the Niagara to the Devonian shale on the east border, should have led some of the earlier students to consider the low tract occupied by the Devonian shale to be due to a large river."

A full discussion of each of the great drainage systems of the State is given with data regarding the length, depth, gradient, rock floor and other features of each of the larger streams. In one place he says that "arrangements are being made by the U. S. Survey for a special investigation of the water powers of Indiana," but such investigation has not as yet come to pass. The statement that "It has long been known that the Wabash once received the drainage from the portion of Indiana now tributary to Lake Erie, the channel connecting the Maumee with the Wabash being still a plainly marked feature along the Wabash railway from Fort Wayne to Huntington," recalls David Dale Owen's remarks, made in 1837, regarding this fact.

The average fall of the Wabash is given as $16\frac{1}{2}$ inches per mile, and its approximate length 500 miles, while the west fork of the White, with a length of 275 miles has a fall of three feet to the mile. He does not give the measurement of the sink which is now the most noticeable phenomenon along the course of the latter stream between Indianapolis and Gosport.

Valuable information is given in the paper regarding the deep-well water supply of each of 57 cities and towns of the State, Tables, including data, regarding the supply of those cities and towns which use surface water from streams, lakes or shallow wells are also given; the analysis of the water being shown in a number of instances. The paper is accompanied by three double page colored maps showing respectively the topography, the geologic formations and the pleistocene deposits of the two states.

In 1899 this paper on the "Water Resources of Indiana" was followed by two supplemental papers* by Leverett entitled "Wells of Northern Indiana," and "Wells of Southern Indiana," in which much additional detailed information, especially regarding shallow wells in the country regions, is given.

*Water supply and Irrigation papers of the U. S. Geo. Surv., Nos. 21 and 26.

There was issued by the Chicago Academy of Science* in 1897, an illustrated paper by Leverett entitled "The Pleistocene Features and Deposits of the Chicago Area," which includes much valuable information regarding the drift topography of the northern portions of Lake, Porter and LaPorte Counties, Indiana. Full details are given regarding the Valparaiso Moraine, which "consists of a more or less complex belt of the Wisconsin Drift Sheets and receives its name from the city of Valparaiso, Porter County, which is situated on its crest." The old beaches of the southern end of Lake Michigan are also fully described and much information given concerning the present beaches of the lake and the dune area along its border.

Another paper by Leverett, issued in 1899 as Monograph XXXVIII of the U. S. Geological Survey and entitled "The Illinois Glacial Lobe" is invaluable to all students of the glacial geology of Indiana. It is a quarto volume of 817 pages, with 24 maps and plates, which discusses in detail the drift deposits of the first invasion of a great ice sheet which "extended south and southeast to the unglaciated tracts of southern Illinois and southern Indiana." The border line of the drift is traced in detail over its tortuous course across Indiana and colored maps showing the glacial boundary and present drainage of southwestern and south-central Indiana are included.

The Valparaiso Moraine system which, as already noted, covers a portion of northwestern Indiana, and the old "Glacial Lake Chicago," a large extinct lake of the same area also receives much attention in this volume.

In 1902 Geo. H. Ashley, then connected with the U. S. Geological Survey, published‡ a paper on the "Eastern Interior Coal Field," which was accompanied by two double quarto-page colored maps showing the exact boundaries of that field which comprises the coal areas of Indiana, Illinois and northwestern Kentucky. Of the field he says: "It is estimated to have a total area of 46,000 square miles, of which 6,500 occupying parts or all of 26 counties, lie in Indiana, 35,000 in Illinois, and 4,500 in Kentucky." Accounts are given of the stratigraphy of the coal-bearing rocks and the general structure of the field, which "is that of an elongated basin whose lowest portion is in southeastern Illinois, toward which the strata dip from every direction. * * * The dip in Indiana averages about 24 feet to the mile running up to 100 feet to the mile in a few places."

There are also sections devoted to the number and extent of workable beds and the character of the coal in each State. He says that in Indiana "Coal has been found at 20 horizons, as many as 17 beds having been struck in a single drilling within a vertical distance of 800 feet, most of them being thin, but beds sufficiently thick to be workable occur at eight different horizons, though as a rule not over three are workable at any one point."

The U. S. Geological Survey in 1882 began the making of parts of a topographic map of the entire United States. This map is published in atlas sheets of widely scattered areas. Each sheet is of convenient size, 20 x 16½

*Bull. No. II of the Geol. and Nat. Hist. Survey.

‡22nd Ann. Rep. U. S. Geol. Surv. 1902, pp. 265-305.

inches, and is bounded by parallels and meridians. Each four cornered division of land, corresponding to an atlas sheet, is called a "quadrangle," and the scale used is usually two miles to an inch. On these sheets are shown three groups of features: (1) *water*, including streams, lakes, ponds, canals, etc. (2) *relief*, shown by contour lines of mountains, hills, valleys, etc.; (3) *culture* or works of man, as towns, cities, roads, railroads, etc. This topographic sheet is the base on which the facts of geology and the mineral resources of the quadrangle are represented. The topographic and geologic maps of a quadrangle are finally bound together and with descriptive text, form a folio of the "Geologic Atlas of the United States."

In 1902, the first one of these completed folios, treating of a quadrangle wholly within the State of Indiana, was issued.* It treated topographically and geologically a quadrangle of 938 square miles in southwestern Indiana and included nearly the whole of Pike County and considerable portions of Gibson, Vanderburgh, Warriek, Spencer and Dubois Counties. It was called the Ditney folio, since the quadrangle included the Ditney Hills, which are a prominent topographic feature in the southwestern part of the area covered. The general and pleistocene geology of the Ditney folio were worked out and mapped by Myron L. Fuller, and the economic geology by George H. Ashley. Both are given in great detail and the folio furnishes a permanent and most valuable reference work on the area covered.

Another notable work on glacial geology was issued by Frank Leverett in 1902.† It is a quarto volume of 802 pages and 26 maps and plates and is entitled "Glacial Formations and Drainage Features of the Erie and Ohio Basins." He includes much information of interest and value on the Illinoian drift of southeastern Indiana, on the early Wisconsin drift of the same region, on the drainage systems of the State and on the great Glacial Lake Maumee, a portion of which once extended into northeastern Indiana and drained into the Wabash River. One valuable feature of the volume is a Bibliography of Glacial Geology of the U. S. brought down to the year 1900.

A second folio of the U. S. atlas was issued in 1904 which covered a quadrangle of 938 square miles in southwestern Indiana and southeastern Illinois, and included the greater parts of Vanderburg, Posey and Gibson Counties in the former state. It is called the Patoka folio, after the town and river of that name in Gibson County. The area covered adjoins that of the Ditney folio on the west and takes in the cypress swamp area of southwestern Knox County. The geologic work was done by M. L. Fuller and F. G. Clapp. Very full notes on the glacial economic geology of this region are given, and it also includes a list, with measurements, of the larger trees and shrubs

*In the making of these quadrangle maps and folios the U. S. Survey properly ignores all state and county boundaries. A folio put out in 1900, and known as the Danville folio, included a narrow strip along the western side of Warren and Vermillion Counties, Indiana, and a second, known as the Chicago folio, issued in 1902, comprised a part of the northwestern corner of Lake County.

†Monograph XLI, U. S. Geol. Survey.

of the area, this being in large part compiled from the writings of Dr. J. Schneck and Robert Ridgeway.

In addition to the Ditney and Patoka folios, the U. S. Survey has to date completed the topographic map sheets of twelve quadrangles in southwestern Indiana, the region covered comprising parts or all of most of the coal measure counties south of the National Road. The names of these quadrangles, each of which covers about 930 square miles, are as follows: Clay City, Vincennes, Petersburg, Princeton, Boonville, Haubstadt, Velpen, St. Meinrad, De Gonia Springs, Mt. Carmel, New Harmony and Owensboro. They have also issued topographic sheets of the Bloomington quadrangle* which covers the western half of Monroe, southeastern corner of Owen and the eastern third of Greene County, and in northwestern Indiana the Tolleston quadrangle covering the northern third of Lake County and a portion of the southern end of Lake Michigan. It is presumed that the folios of these respective quadrangles will be issued as fast as the geologic work on them is completed.

The above constitute the more important papers relating to the geology and archaeology of Indiana published outside the State Reports between 1869 and 1910. Other short ones of minor importance published before 1893 are mentioned by Marsters and Kindle in their "Geologic Literature of Indiana (Stratigraphic and Economic)," a bibliographic paper published in the Proceedings of the Academy for 1893. A number have also appeared in the different volumes of the U. S. Geological Survey and the Proceedings of the Indiana Academy, where they can be readily found by anyone interested.

THE BLATCHLEY SURVEY, 1895-1910.

In April, 1894, the present writer, then serving as the "Head of the Department of Science in the Terre Haute High School," was chosen in the State Convention from a field of four as the candidate for State Geologist on the Republican ticket. Looking back from a viewpoint of 22 years, the recipient of that honor realizes that in that convention he had the only real political battle of his life, and that his victory was won not by himself (for in political lore he was then the veriest tyro) but by the combined efforts of his friends, chief among whom were a score or more of the older members of this Indiana Academy of Science, to whom today he takes pleasure in giving due credit for his first nomination. In November, 1894, he was elected over his Democratic opponent, Mr. E. T. J. Jordan, for a term of four years, and was renominated and re-elected in 1898, 1902 and 1906, and renominated but defeated at the polls in 1910. His successor, Mr. Edward Barrett of Plainfield, is also a member of your Academy, and has served as State Geologist since January 1st, 1911.

Of the value of the work accomplished by the Department of Geology

*The Geology of this quadrangle by J. W. Beede, with colored map, was published in the 39th (1914) Report of the Ind. Dept. of Geol. and Nat. Resources, pp. 190-312.

during the sixteen years of the writer's service as Director it is more meet that others should give testimony, therefore only a few facts regarding its nature will be mentioned. Its results were published in sixteen annual reports and one bulletin, aggregating 15,039 octavo pages of text, 557 plates and 44 folded maps included in the volumes, 38 of the maps being colored. In addition there was issued separately a colored sectional geological map of the State, five feet, nine inches by three feet, eight inches in size, on a scale of four miles to the inch, and also a colored wall chart of the Indiana coal fields, 3 x 4 feet in size on a scale of four miles to the inch.

The first sentence of the first report issued by the writer sets forth his views of what the founders of the Department of Geology had in mind when by law they created the Department. That sentence is as follows: "The Department of Geology was primarily instituted to determine the location and extent of those natural resources of the State which are of economic importance, and to make known to the world at large the leading facts concerning their accessibility and value for commercial, agricultural or manufacturing purposes." The sentence as written and quoted embodies the *economic* or most important duties which he deemed it imperative to perform. The next sentence brought out the *scientific* phase and was as follows: "A secondary duty which falls to the Department is the gathering and disseminating of accurate knowledge concerning the origin or formation of such resources and the publishing of descriptions of such fossils and objects of natural history as are found to accompany them or are of general scientific interest." These two sentences are all that will be quoted from the sixteen annual reports which were issued between 1895 and 1911.

To fulfill in the best manner possible, with the limited means at command, the duties as set forth in these two sentences, made necessary the abandonment in great part of the old county survey system and the adopting of that of taking up each resource separately and issuing a monograph or detailed report on its distribution, economic value, etc. Following this plan, the results of studies of the clays and sandstones of the coal measure formation were published in the 1895 report, those of the petroleum fields in 1896, 1903, 1906 and 1910; the oolitic limestone in 1896, with a revision in 1907; the coal deposits in 1898, with a supplemental report in 1908; the Niagara limestones in 1896, 1897 and 1899; the marls of northern Indiana and other materials for making Portland cement and the hydraulic cement rocks in 1900; the mineral waters and the Knobstone shales in 1901; the Lower Carboniferous limestones in 1902; the lime industry in 1903; the clays and shales of the entire State in 1904; the roads and road materials in 1905; the peat and iron ore deposits in 1906; the soils in 1907, 1908 and 1909 and the water powers in 1910. The years mentioned are those of the report in which the paper is published. In a number of instances, as in that of the papers on coal and road materials, the results of two or three years' work done by a number of assistants, are incorporated in a single monograph. During the soil survey, begun in 1907 and continued in 1908 and 1909, the soils of 32 counties in

southern Indiana were studied and classified, and the area covered by each of the type soils shown on accompanying maps. Surveys had previously been made of eight counties by the U. S. Bureau of Soils so that the survey of 40 counties had been completed by 1910. Mr. Barrett has since continued the soil survey work and has covered most of the remainder of the State. In addition to the more important economic papers above mentioned, there were numerous shorter ones scattered throughout the volumes.

Now the writer wishes it distinctly understood that he did only a small proportion of this work. While he planned it and in great part directed it, the major portion was done by his assistants; by George H. Ashley, now Director of the Coal Surveys for the U. S. Geological Survey; T. C. Hopkins, now Professor of Geology in Syracuse University, N. Y.; E. M. Kindle, now Paleontologist for the Canadian Geological Survey; Claude E. Siebenthal, now in charge of one of the Divisions of the U. S. Survey; A. E. Taylor, now at the head of one of the Departments of the U. S. Soil Survey, and Chas. W. Shannon, now State Geologist of Oklahoma. They and a score of others served as assistants during the sixteen years that the writer was Director of the State Survey. All were loyal, efficient helpers who did their share and did it well. Each was given full credit for his work, his paper appearing under his name and his alone in the volume in which it was printed. Looking out upon them now where they occupy positions of honor and of trust at the hands of the nation or of other states, I am proud to remember that they did their first work at a meagre salary on the Indiana Geological Survey between the years 1895 and 1910. It was the recognition of the value of that work, by persons competent to judge, that brought them first and lasting renown as geologists and as scientists.

Taking up the more purely scientific or secondary phase of the work as set forth in the second sentence quoted, the writer concluded that since the Department was first christened the "Department of Geology and Natural Science," and later the "Department of Geology and Natural History," that its founders had in mind the study of all forms of living things in addition to the rocks and fossils. Again several of the older members of the Academy of Science had the results of a number of years of observation and study locked up in manuscript form, for which at that time there appeared no avenue of publication. It was decided therefore, that if possible, a part of each annual volume should be devoted to one or more papers on the botany, zoology or paleontology of the State. There appeared, therefore, in the volumes as issued, monographs or other important papers on the crayfish of the State by Hay; the cave fauna by Blatchley; the birds by Butler; the mollusca by Call and Daniels; the dragonflies by Williamson; the flowering plants and ferns by Coulter; the Devonian fauna and stratigraphy by Kindle; the Orthoptera by Blatchley; the stratigraphy and paleontology of the Niagara of Northern Indiana by Kindle; the insect galls by Cook; the fauna of the Salem limestone by Beede and Cumings; the spiders and other Arachnidae by Banks; the stratigraphy and paleontology of the Ordovician rocks by

Cummings; the mushrooms by Reddick; the mammals by Hahn and the beetles by Blatchley. In addition to the papers mentioned a contract had been made by the writer with Dr. O. P. Hay of Washington, D. C., for his paper on the "Pleistocene Period and its Vertebrata," which appeared in Mr. Barrett's first report.

At no time during the writer's service as Director was there an appropriation of more than \$4,120 per annum for all salaries of assistants and of expenses both for the field and office of the Department proper and also the State Museum. This sum did not include the salary of the Director, which was \$2,500 per annum for the first twelve years, and \$3,000 per annum for the last four years.

As showing some of the returns which the State received for this sum, it may be said that in addition to the scientific papers above mentioned as published in the reports and which are now used as reference or text books in the high schools, colleges and universities of the State, the value of the State's mineral resources advanced from \$16,860,674 in 1895 to \$44,971,003* in 1910, an increase of \$28,110,329 or 166 per cent. The value of the coal mined in the State in 1910 was \$20,813,659 or \$3,952,985 more than the total value of all the resources in 1895. If only one-third, or \$9,337,000 of this increase be attributed to the advertising done by the Department of Geology, and the taxes on this be computed at 2.5%, they would amount to \$233,419 per annum, which would be a pretty fair profit on the \$7,120 invested by the State each year in the Department of Geology.

We have now completed our sketch of a century's work on the geology of Indiana. We have seen how the yearly output of its natural resources, other than soils and timber, have increased from a few pelts of raccoons and muskrats to a value of 45 millions of dollars. A century ago the white man received from the red one this fair domain as the God of Nature made it. To-day it is furrowed, creased, scarred, pierced full of bores and shafts and pit holes, its rivers, sewers, its forests devastated, its soils depleted of their fertility. The white man, ruled by the Gods of greed and mammon, has left unscathed only a few spots as nature made them, spots like "Turkey Run," the "Shades" and some of the wilder tracts in the southern counties. He has left these solely because they were too rough to till, or were wholly

*The following table compiled from "Mineral Resources of the United States" for 1895 and 1910, shows the value of the mineral resources of Indiana for the two years mentioned:

	1895.	1910.
Coal.....	\$3,642,623	\$20,813,659
Clays and clay products.....	3,117,520	8,180,839
Portland Cement.....		6,487,508
Limestone.....	1,658,976	4,472,241
Crude petroleum.....	2,807,124	1,568,475
Natural Gas.....	5,203,200	1,473,403
Mineral waters.....	17,531	514,958
Miscellaneous resources.....	413,700	1,459,920
Total.....	\$16,860,674	\$44,971,003

devoid of coal, oil, gas, stone or some other resource which would bring him gold. When a few hundred men and women desire to keep for the "glory of the past," these spots as they are, the men to whom gold is god, step in, seize control and demand \$10,000 ransom for the release to the nature lovers.

The first settlers, the pioneers of a century ago, were content with little. They came, they saw, they conquered a few acres from Mother Nature. Building their cabins wherever a spring purred forth from a hillside to furnish water, they raised their meagre crops, planted orchards for their posterity, hunted, fished, trapped and lived their days in peace and content. But soon westward the wave of civilization found its way, bringing with it desire, greed, discontent, demand for the luxuries as well as for the necessities of life. Then it was that our citizens began to ask "what is there beneath the surface that will bring us wealth?" To answer that question David Dale Owen, Ryland T. Brown, Richard Owen, E. T. Cox, John Collett, Edward Orton and a score of others whom I have mentioned, gave their knowledge and the best years of their lives. All honor, then, to the memory of the geologists of the century that has gone—to the men who were the pioneers that pointed out where the stored resources of a great commonwealth could be found.

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