

## THE NATURAL RESOURCES OF INDIANA.

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### FUELS.

At the present time the relative importance of any State or nation in the world is very largely determined by the amount of available fuel which that State or nation possesses. A fuel is but a form of matter containing within itself a stored supply of potential energy in the form of heat. When that heat is set free by combustion it can be utilized by man to perform work. With heat he at present brings about or produces five-sixths of the mechanical motions of the world.

The heat found in the various kinds of fuel is a stored supply of energy upon which we are constantly drawing—oftentimes lavishly—without being able to add one iota thereto. It is the richest inheritance which has come down to man from the ages past. Millions of years have been necessary for its accumulation. At the present rate of consumption a few thousand will suffice for its total dissemination. Its source, the sun—that wonderful fountain of all terrestrial energy—the heat in any fuel has been caught by the tiny cells of plants in ages past, has been used in promoting their life and growth, has been stored within their tissues or transmitted to some form of animal life, and in time the plant or animal with its stored supply of heat, has, by chemical and physical forces, been changed into what we are now pleased to call coal, petroleum and natural gas.

These fuels are the most valuable resources of our State to-day. We are drawing upon them with a lavish hand. They came to us without great labor, as comes oftentimes the accumulated riches of a toiling and thrifty parent to a spendthrift son, and, as with the latter, “come easy, go easy,” seems to be our motto. Once again would I repeat “that no coal, no natural gas, no oil is being formed beneath the surface of our State to-day. Our present supply of each of these fuels will never increase, but ever diminish. Each constitutes a great reservoir or deposit of reserve energy upon which the people of the present generation are daily drawing without adding thereto. Like a bank account under the same conditions it is only a question of time until it will become exhausted.”

*Coal.*—Indiana contains nearly 7,000 square miles of workable coal-fields. This area occupies a part or all of nineteen counties in the southwestern portion of the State, extending from Warren County southward 150 miles to the Ohio river. At least seven distinct veins of workable thickness occur in the State. These vary from three to eleven feet in thickness and aggregate in a few places from 25 to 28 feet. From this area in ten years—1886 to 1895, inclusive—was mined 33,355,988 tons of coal, valued at \$36,673,059. In 1896 the number of tons mined in the State was 4,068,124, or 243,960 tons less than in 1895. The decrease was due to the extended strike among the bituminous miners which began in May, 1896, and was continued, in some localities, until December.

The coals of Indiana are of three varieties, which in certain localities merge into one another. The most valuable of these from a manufacturing point of view is the "block" coal, or, as it is generally known, the "Brazil" block. It possesses a laminated structure, and is composed of alternate thin layers of vitreous, dull black coal and fibrous mineral charcoal. It can be mined in blocks as large as it is convenient to handle. These blocks split readily in the direction of the bedding plane, but in the opposite direction are broken with difficulty. It is as pure as splint coal, almost free from sulphur or phosphorus, and has the softness and combustibility of wood. In burning it swells so little that its expansion is scarcely perceptible, does not change form, and never cakes or runs together; hence, it is a most valuable fuel for the blast furnace and the cupola of the iron foundry.

For steam and household purposes it likewise has an unrivaled reputation. It burns under boilers with a uniform blaze that spreads evenly over the exposed surface, thus securing a more uniform expansion of the boiler plates. Its lack of sulphur also causes it to have but little detrimental effect upon the boiler, grates, or fireboxes. In household grates it burns with a bright, cheerful blaze, like hickory wood, making a very hot fire, which, for comfort and economy, can not be surpassed by any fuel except an abundant supply of natural gas.

Block coal occurs in three counties—Clay, Owen and Parke. Up to the present the largest supply has been derived from Clay County, where it was first developed. Much of the area in the immediate vicinity of Brazil has been exhausted, but new developments have been made in northern Clay County and in the two southeastern townships of Parke County. A very fine deposit of this coal underlies several square miles in the immediate vicinity of Patrickburgh, Owen County. Owing to a lack of railway facilities, this deposit is as yet undeveloped except for local use.

The bituminous or caking coals found in Indiana vary much in character and purity, but their average will compare favorably with that of

those found in any other State. They comprise by far the greater bulk of our coals, underlying about 6,500 square miles of territory. The thickest bed which has come to my notice is about three miles north of Petersburg, Pike County, where the vein worked is 10 feet 2 inches in thickness and of most excellent quality.

Bituminous coal lands, as yet undeveloped, are found in many parts of the coal area, the best probably occurring in northwestern Greene, northeastern Sullivan, and northern Pike Counties. In a number of localities, notably at Mecca, Parke County, and in the eastern half of Daviess County, a "semi-block" coal, ranking in quality between the true block and ordinary bituminous, occurs. It does not cake when burned and contains a comparatively small percentage of sulphur and other impurities.

Cannel coal, a dull, textureless variety of the bituminous, rich in gaseous constituents, occurs in several of the southern counties, but is mined only at Cannelsburgh, Daviess County. Here the vein varies in thickness from two to four feet and directly overlies a vein of "semi-block" two feet thick, the two being worked together. The cannel coal breaks irregularly, with a conchoidal fracture, and does not smut the skin when handled. It is more valuable for manufacturing illuminating gas than for fuel.

Since 1878 but little concerning Indiana coals has been published in the reports issued by this Department, and that little only in the introduction to those reports. Thousands of bores have been put down to prove the presence of veins of workable thickness and many shafts have been sunk to known deposits close to railways. Much valuable information has thus become available, which, when gathered and properly correlated, will show the exact limits of each of the seven great coal veins of the State.

Realizing that the coal area of Indiana is destined in the future to become a great manufacturing center, a comprehensive survey of that area was planned, and in July, 1896, Dr. Geo. H. Ashley, a graduate of Cornell and Leland Stanford Universities, and a specialist in coal geology, was put in charge. His time for the remainder of the season was spent in field work in Knox, Daviess and Martin Counties. Next season, with able assistants, he will resume this field work, and will continue it until the entire coal area is accurately mapped, when a special report of the field as a whole will be prepared and published as a single volume. This will be the first complete report ever issued on Indiana coals, since in the previous papers thereon, the last of which was issued eighteen years ago, the subject was treated in isolated county areas and scattered through seven successive reports of this Department—now long out of print and almost impossible to obtain.

In the present volume will be found a paper on the "Composition of Indiana Coals," by Prof. W. A. Noyes, professor of chemistry at the Rose Polytechnic, Terre Haute, Indiana. I had this paper prepared at the suggestion of several of the leading glass and steel manufacturers in Indiana, who are now using natural gas for fuel. These gentlemen have come to realize that they will, in a few years, have to remove their factories to other States or use Indiana coal, now distant from their factories. Instructions were given the State Mine Inspector and his assistant to collect fair *average* samples of coal from a number of the leading mines in the State. Nineteen such samples were secured and sent Prof. Noyes, who has made a complete chemical analysis of each and at the same time determined its heat value and steam producing value. Seven samples of Pittsburgh and West Virginia coals were also secured from the Marmet Coal Company, of Cincinnati, Ohio, and the same facts concerning them were determined in order that a comparison could be made of analyses determined under the same conditions.

This comparison shows the quality of the Indiana coals to be much better than expected; the average steam producing value, or evaporative effect, of the nineteen samples being 12.8 pounds, as against 13.7 pounds, the average for the foreign coals. The small value of .9 pound in favor of the Pittsburgh coals is more than offset by their additional cost of transportation.

Full statistics of the coal industry of Indiana, as well as an account of the condition of each mine operating more than ten men, is given in the annual report of the State Mine Inspector in another part of this volume.

It is my opinion that the law should be so changed as to require the examination, at least once each year, of every mine operating in the State, regardless of the number of men employed. Many mines employ from six to eight men, and the aggregate amounts to a large number. The life of any one of these men is as valuable as that of a man working in the larger mines, yet under the present law they receive no protection whatever. The air where they work is often extremely foul—man-shafts are more often lacking than present, and too little attention is given to the condition of the roof. Some of these abuses could at least be ameliorated by the occasional visit of an Inspector invested with power to better the conditions where possible.

*Petroleum.*—The production of petroleum in the Indiana field amounted in 1896 to 4,659,000 barrels. When it is remembered that this field had its beginning only in 1891, its growth will be seen to have been a phenomenal one. Especially was this true of the year 1895, when a gain of nearly 700,000 barrels, or 18.9 per cent., was made over the preceding year. In 1896 the gain was but 272,850 barrels, or 6.2 per cent. The general depression in business, the excitement incident to a national

election, and the much lower average price of oil prevented the sinking of as many wells in 1896, there being but 1,180 new bores put down as against 1,267 in 1895. Of these, 158 were dry. Of the producing wells the aggregate initial output was 25,372 barrels, or an average of 24.8 barrels to the well, as against 33,718 barrels in 1895, or 30.6 barrels per well.

In obedience to a popular demand for a general account of the petroleum industry in Indiana and for an accurate map of the productive territory, the writer spent the greater parts of the months of June, September and October, 1896, in the petroleum field, gathering data for such a report and map. Both are presented in the present volume, and both can be relied upon as being fairly exact up to January 1, 1897.

The map will show that the area producing oil in Indiana is much smaller than has been generally supposed or than has been marked as oil producing territory on the geological maps published in the past by this Department.

It comprises about 400 square miles in the counties of Adams, Jay, Blackford, Wells, Grant and Huntington. A careful study of this field leads me to believe that the production therein will never be much greater than it is at present. The field will, however, doubtless enlarge, especially to the southward, and will in time comprise much of the territory now producing gas. This opening up of new territory will, of course, increase the yield, and may increase the general average production, which, on January 1, 1897, was about four barrels per day for each of the 3,442 wells then producing oil.

A number of the first wells put down are beginning to show signs of failure, and a few have already been abandoned, but this is to be expected where one is daily drawing upon a reservoir to whose contents nothing can be added.

In the paper which follows, I have endeavored to make plain the views of the most noted scientists regarding the origin of petroleum. With few exceptions they conclude, and the facts collected in the Indiana field all tend to verify that conclusion, that petroleum, like coal and natural gas, is a product of past ages. As Prof. Orton has well said, "Every producer of petroleum knows that a field begins to die the moment it begins to live." The age of a productive oil well in the United States does not generally exceed five years, and is often much less, and the longest life of the best American field has never yet attained to a score of years.

Samples of oil and water containing oil are constantly being received at my office from stations outside the present producing field. For the most part they have been gathered near the surface, and the persons collecting them believe that they are "surface indications" of a large supply of the precious liquid. In this they are mistaken, for the sample collected, if traced to its source, will be found to have exuded from a crevice

in some neighboring stratum of rock, or to have come from some large mass of vegetable matter, partially or wholly covered with water or mud. Every shale, sandstone or limestone in the State contains oil in greater or less amounts, and even where the amount is infinitesimally small, enough may collect to exude from a crevice and produce a showing upon some near-by surface of water.

Again, many letters are received, asking: "What are the surface indications of gas or oil?" To all such inquiries I reply that there is absolutely no such thing as a "surface indication" of either of these resources. Where they occur in paying quantities in Indiana, they are found at depths varying from 700 to 1,500 feet below the surface, and no human being can say with certainty that a bore put down, even in the best prospective territory, will yield either in paying quantities.

*Natural Gas.*—The area producing this valuable fuel has not been enlarged by new developments during the past year. It still continues approximately at 2,500 square miles, which is larger than is possessed by any other State in the Union. The wells in the outer zone of this area, which embraces a strip about fifteen miles in width around the entire field, show a much decreased flow, and in many instances have become worthless through the influx of salt water or petroleum. In another year or two much of this outer zone will have ceased to yield, and the natural gas area will have diminished to about two-thirds its present size. The middle zone, probably twenty miles in width, yields much of the gas which is piped to cities outside the field. A majority of the wells in this zone have begun to show signs of water, but up to the present this has not been in sufficient quantity to cause much decrease in the supply of gas. The average pressure of this part of the field has, however, according to careful measurements, made by Mr. Leach, decreased about twenty pounds during 1896.

The third zone, or heart of the field, embraces about 400 square miles in Madison, Delaware and Grant counties. It contains some of the best producing wells in the State and, as yet, shows but few signs of water or other influences tending to diminish the supply of the gas. The rock pressure over this area shows, however, an average decrease of about fifteen pounds over that of 1895.

A careful study of the excellent report on the present condition of the field, furnished by Mr. Leach and printed in another part of this volume, can but lead one to believe that the supply of natural gas is slowly but surely failing and that manufacturing establishments that consume a half million or more feet a day can not be greatly multiplied in any part of the Indiana field without rendering a speedy exhaustion of the supply a certainty. When petroleum or salt water invades a former gas rock it comes to stay—the petroleum until it is pumped out, the water permanently, since the supply of that liquid is too great to attempt to overcome.

As mentioned in my former report, much undeveloped gas territory is still held in reserve in various parts of the Indiana field, and upon it manufacturers can draw for a limited period after the present producing territory is exhausted. That the leading manufacturers realize the coming failure of the gas supply is evinced by the number of letters and inquiries received from them on the subject. They know by experience the value of a gaseous fuel, and it was, if possible, to retain their factories within the State that the investigations were started concerning the composition of Indiana coals and their fitness for conversion into gaseous fuel.

Meanwhile each consumer of natural gas should use every means at his command to husband the supply by stopping at once all unnecessary use or wanton waste. By so doing, the length of time for which the gas can be supplied for household use can be materially lengthened, and another decade may even go by before the last of this valuable and most convenient fuel will be consumed.

*Bituminous Shales.*—The Genesee shales of the Devonian age are rich in bitumens, which, when better means have been perfected, can be extracted and used for fuel and lighting purposes. These shales occupy a large area, extending from New Albany, on the Ohio River, to Delphi, Carroll County, at the former place being 104 feet in thickness. Mr. Hans Duden, an experienced chemist of this city, has recently made a special study of the shale as exposed at New Albany and has determined accurately the percentage of bitumens which it contains. He has given the results of his investigations and experiments in a paper prepared for the present report. In this he shows that 8.5 pounds of the black slate yielded by distillation 45 gallons of gas, which, when burned as an illuminant, showed itself to be 22 candle power in quality.

In Scotland and Germany these shales are utilized on an extensive scale, the former country producing annually from them 60,000,000 gallons of crude oil and 25,000 tons of sulphate of ammonia, the latter a valuable fertilizer. Mr. Duden claims that "taking into consideration its thickness of more than 100 feet, the State of Indiana possesses in this Devonian slate a reservoir of power greater than the coal seams, which can furnish an almost inexhaustible supply of oils for illuminating, heating and other purposes, providing the proper means of utilization are devised." The paper of Mr. Duden merits careful attention from those especially interested in the future problems of a source of light and heat.

## RESOURCES OTHER THAN FUELS.

## BUILDING STONE.

*Oölitic Limestone.*—"Indiana is widely known as the most important State in the Union in its output of limestone for fine building and ornamental purposes." So says that noted authority, Mr. W. C. Day, in "Mineral Resources of the United States" for 1894.\*

Mr. Day refers especially to the Bedford oölitic stone, which has long been noted among architects for its strength and durability. It is of a uniform rich gray color and close texture, and is comparatively soft when first quarried, but hardens on exposure. On account of the ease with which it can be quarried, sawed and dressed for builders' use, it can be put on the market for a less sum per cubic foot than any stone of equal grade in the United States. Within the past fifteen years it has become an exceedingly popular building stone, not only in Indiana and adjoining States, but in the Eastern cities, where many of the private residences of the richer citizens have been constructed from it.

Although the oölitic stone has long been known as one of the leading resources of the State, no detailed account of the area in which it is found has before been published, nor has any map showing its exact distribution ever been prepared. Believing that the quality of the stone and the extent of the industry demanded a more important recognition from the Department of Geology, a special survey of the oölitic region was planned and put in charge of Mr. T. C. Hopkins, the specialist in building stone, who prepared the paper on the "Sandstones of Western Indiana," for my first report, and Mr. C. E. Siebenthal, who had already done much geological work in the oölitic region. These gentlemen have prepared an exhaustive paper on the Bedford oölitic stone, which is presented in the body of the present report.

The text of this paper gives in detail the general geologic features and stratigraphy of the oölitic belt, the structural features and properties of the oölitic stone and descriptions of the principal quarry areas and of areas deserving of development. It also gives an historical account of the development of the oölitic limestone industry and its present status.

Accompanying the paper are maps showing accurately the distribution of the limestone through Owen, Monroe and Lawrence Counties, as well as special maps on a larger scale, showing in detail the distribution and development of the quarry industry in the vicinity of Romona, Owen County; Stinesville, Ellettsville, Bloomington and Sanders, Monroe County, and Bedford, Lawrence County.

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\* P. 498.

Nearly 150 chemical and physical tests of the stone have been made especially for this report. These tests show that the best grades of the stone contain 98.5 per cent. of pure carbonate of lime, which is practically indestructible by atmospheric influences; and that the crushing strength ranges between 4,500 and 7,000 pounds per square inch, for specimens quarried within the year.

Full statistical tables of the production in the past and present are also given. From these we learn that, at a low estimate, \$2,672,000 are invested in the industry, and that the value of the product for 1896 was \$1,264,210, which, owing to business depression and exceeding low price of the product, was \$200,000 less than in 1895.

*Crystalline Limestones.*—These limestones belong mostly to the Niagara formation and contain more or less magnesium carbonate in their composition. They are much harder than the oölitic stone and, as a consequence, can not be sawed. As a rule they are not building stones of a high grade, yet they are used extensively for building purposes in eastern Indiana, where they occur most abundantly. In Decatur County alone there are more than twenty quarries, most of which, however, are operated on a small scale. The stone is also used extensively for bridge purposes. Dr. Aug. F. Foerste, in his paper on the "Geology of the Middle and Upper Silurian Rocks of Southeastern Indiana," published in this report, gives the location and stratigraphy of a number of deposits of this stone which in future will well pay for development.

In some parts of the State true calcium limestones occur, which are highly crystalline in character. These are called "Indiana marbles." They admit of a fine polish and make most handsome mantels and other interior decorations; but in general the deposits are too thin to be quarried, with profit, for building purposes. Large deposits of these "Indiana marbles" occur near Temple and English, Crawford County; at Pipe Creek, Miami County, and in the southwestern corner of Fayette County.

*Sandstones.*—In the last report of this Department was an extensive paper on the "Sandstones of Western Indiana," prepared by Prof. T. C. Hopkins. It was accompanied by maps showing the exact location of quarries now worked, and of deposits worthy of development, and contained the results of numerous physical and chemical tests showing the fitness of the stone for building and bridge purposes.

In that report it was shown that sandstones of excellent quality, and in commercial quantities, occur at a number of localities in western and southwestern Indiana.

These sandstones are of two varieties. First, the *Mansfield Sandstone*, occupying a strip from two to ten miles or more in width, extending from the north part of Warren County 175 miles in an east of south direction to and beyond the Ohio River. While the Mansfield sandstone is soft, friable and easily worked, it hardens by exposure and

becomes in time one of the most durable rocks in the State. Two color varieties occur: (a) A handsome dark brown, especially suited for business blocks, and for lintels and cornices of buildings whose fronts are constructed of pressed brick, since the rain never discolors small portions of such stone, and the brick walls are therefore permanently free from those unsightly, mouldy-looking streaks which soon appear where limestone is used for finishings; (b) buff and gray, well fitted for building and bridge foundations, or, where of the best quality, for business fronts. The brown stone is quarried extensively at St. Anthony, Dubois County, and large and valuable deposits of it, as yet undeveloped, occur near Bloomfield, Greene County, and Portland Mills and Mansfield, Parke County. The gray and buff varieties are quarried on a large scale at Attica, Williamsport and Fountain, in Fountain and Warren counties.

Second, the *Coal Measure Sandstones*, which occur at horizons above the Mansfield sandstone at a number of localities in the coal bearing counties of the State. These stones are usually light blue or light gray in color, easily worked, very durable, and are rapidly coming to the front for building purposes. Extensive quarries are in operation at Worthy, Vermillion County; Riverside, Fountain County, and Cannelton, Perry County.

The capital invested in the sandstone industry in Indiana in 1895 was \$610,000, and the output for the year was valued at \$118,000. The undeveloped deposits of sandstone in the State are sufficient in quantity and in quality suitable to merit the careful attention of capitalists in search of good investments.

#### STONE FOR OTHER USES.

*Flagging and Curbing.*—Extensive deposits of thin bedded Niagara limestone, especially fitted for flagging and curbing, occur in several portions of the State, notably near Laurel, Franklin County, and Wabash, Wabash County. At the former locality the deposits are especially large, sections 17, 18, 19 and 20 of Laurel Township being for the most part underlaid with it. It can be quarried more easily and with less expense than any other stone of a similar nature in the State, the natural seams and even bedding doing away largely with the necessity for drilling and blasting. The stone is of an excellent color, and is harder and more durable and therefore cheaper in the long run for curbing than either the oölitic limestone or the Berea, Ohio, sandstone. Numerous small quarries have been opened, but as yet the railway facilities are insufficient. With a switch from the Whitewater railway constructed to two or three of the best deposits, this stone could be put on the market

in quantity for a lower price and yet with a greater profit than is now secured; and its superior quality would soon lead to its extensive adoption for those purposes for which it is so well fitted.

*Lime.*—In the vicinity of Huntington, Huntington County; Delphi, Carroll County, and Logansport, Cass County, deposits of Niagara limestone are found which are especially suited for the production of lime for building purposes. At Huntington and Delphi the manufacture of lime is carried on on an extensive scale, the value of the yearly output at the two points approximating \$250,000. The product is noted throughout the eastern United States for the excellence of its quality, and is much sought after by builders and contractors.

The oölitic limestone of southern Indiana has not proved itself fitted for the production of lime, but a formation immediately overlying the oölitic has been extensively used, and large kilns are now producing from it a good quality of lime at Mitchell, Lawrence County, and Romona, Owen County.

*Cement Rock.*—Hydraulic limestone suitable for the manufacture of cement occurs in a number of localities in southern Indiana. The largest deposits are found in Clark County, extending up the valley of Silver Creek for about fifteen miles above Clarksville. From these the Louisville Cement Co., in 1895, manufactured 865,000 barrels of rock cement, valued at \$413,200. This cement is used in mortar for building, in the foundation of asphalt and brick pavements, in the construction of tunnels, bridges, dams and aqueducts; in the lining of cisterns and cellars, and for many other purposes. Cement rock of good quality occurs also in Scott and Jennings Counties, and recently a large deposit has been discovered at Derbyshire Falls, near Laurel, Franklin County. In the northern part of the State a large deposit also occurs near Wabash, Wabash County, which has been much used locally. The rock belongs to the Corniferous epoch of the Devonian age. The industry is a growing one, and Indiana already ranks second in the Union in the manufacture of the product.

*Whetstone and Grindstone Rocks.*—The fine-grained silicious rocks in Orange and Martin Counties have long been used for the manufacture of abrasive materials. In the last volume issued by this Department was a full report on the whetstone and grindstone industry of the State, prepared by Mr. E. M. Kindle. This was accompanied by an accurate geological map of the area mentioned. Indiana ranks second among the States of the Union in the production of whetstones and grindstones, being excelled only by Arkansas. The output in this State is not large, being in 1895 but 300,000 pounds, valued at \$15,000. The demand, however, is constantly increasing, and if better railway facilities were provided the industry would soon become a prominent one in the area which contains the raw material.

*Marls.*—Many inquiries were received at this office during 1896 relative to marl deposits in Indiana. Marl is a very nearly pure carbonate of lime. The larger deposits in the State are found in the vicinity of the lakes of northern Indiana, especially near Silver Lake, Dekalb County; Lime Lake, Steuben County;\* Rome City, Noble County; Rochester, Fulton County, and North Liberty, St. Joseph County. These "shell marls" are pure white in color, and are generally supposed to be the remains of fresh water shells. They probably owe their origin, however, to deposits from calcareous springs, the waters of which contain much lime in solution. These marls are coming into extensive demand for the making of Portland cement, which is made from carbonate of lime and clay, and also for making disinfectants and deodorizers.

The Bedford oölitic stone, composed, as it is, of 98 per cent. pure calcium carbonate, would seem to be suitable, after grinding, for the making of Portland cement. Experiments looking to this end have been recently carried on, which I understand have proven successful, and a company known as the Bedford Portland Cement Company has been organized, and will soon erect a large factory for making the cement near Bedford, Lawrence County.

#### CLAYS.

During the past decade an enormous expansion of the clay industries has taken place in the United States. The utilization of vitrified brick for roadways has created a new and distinct industry, thousands of miles of streets throughout the West having, since 1890, been paved with this material. The disappearance of our forests, and the consequent rapid advancement in the price of all kinds of lumber, has led architects and builders to investigate more carefully the value of clay products for structural purposes. These investigations have resulted in valuable discoveries concerning the chemical constituents and properties of clays; have suggested the invention of new, or the improvement of old forms of machinery and kilns, for their manipulation and burning, and have proven their unexcelled fitness for many purposes to which stone, wood or other materials were previously put.

As a proof that the general public is beginning to appreciate this fitness, one has but to note the rapidly increasing use of terra cotta and pressed brick for the fronts of business blocks and the more fashionable and costly private residences; of clay shingles for their roofs, and of encaustic tiles for their floors and mantels. Indeed, all present signs point to clay—that most widely distributed and cheapest resource known on earth—as the leading factor in the future structures built by man.

\*A large deposit also occurs on the shores of a small lake in sec. 3, tp. 37 n., r. 13 e., Steuben County. For analysis see Ind. Geol. Surv., 1872, 41.

That Indiana has not kept pace with her sister States in this rapid development of clay industries is known to all who have given the matter any attention. Recent and accurate statistics, compiled by the United States Bureau of Mineral Resources, show that of the total value of clay products manufactured in the United States in 1895, Ohio made 16 per cent.; Pennsylvania, 13 per cent.; Illinois, 11 per cent.; New York, 9 per cent.; New Jersey, 7 per cent.; while Indiana made but 5 per cent., and they largely of the cruder kinds. The reason that this State ranks as low as it does, lies not in the lack of quantity or variety of raw materials, nor in the lack of enterprise and capital among her citizens, but almost wholly because of the ignorance prevailing concerning the location and quality of its clay deposits and the uses to which they are capable of being put.

In order to overcome this ignorance, and to make plain to the people of the State, and the nation, something of the true value of Indiana clays, a careful study of the "Clay Deposits of the Coal-bearing Counties of Indiana" was made in 1895, and a detailed paper thereon was published in the last report issued by this Department. This paper proved conclusively that with the exception of some of the clays used in the making of the better grades of terra cotta, encaustic tile and china ware, Indiana possesses in great abundance the raw material for making every kind of clay product used within her bounds.

The kaolin of Lawrence, Martin and Owen Counties can not be excelled in quality, numerous chemical analyses showing it to be composed of more than 98½ per cent. pure silicate of alumina. It has been proven by practical use to be well suited for the making of porcelain ware, and also for sizing for the finer grades of wall and letter paper. Experiments have within the last year shown it of excellent quality for being converted into the better grades of ultramarine, a pigment, of which 25,000 pounds or more are imported weekly at a cost of 10 to 25 cents per pound. It can also be used for making the finest grades of refractory ware, such as retorts, glass pots, glass tanks, etc. At the largest known deposit, near Huron, Lawrence County, thousands of tons of this purest of clays can be seen, comprising a stratum five to eleven feet in thickness; yet, since 1891 not a pound has been put to use. A great mineral resource of untold value—there it lies, unworked, unutilized, awaiting only the coming of energy and capital to make it up into many kinds of products which are now brought into our State from distant lands.

Millions of tons of shales and underclays, well fitted for making the best grades of paving brick, exist in the coal-bearing counties of Indiana. These clays lie in the closest proximity to the fuel necessary to burn them; yet, previous to 1896, of the \$884,667 expended by twenty-seven towns and cities (not including Indianapolis) of the State for paving

brick, no less than \$647,022 were sent to Ohio and West Virginia for that product.

These underclays and shales can also be made into the best of sewer pipe, roofing tile, terra cotta, hollow brick, "stone" pumps, pressed front brick, etc. A number of large factories have been recently erected at Brazil, Terre Haute, Clinton, Veedersburg, Cayuga and other towns for utilizing these clays. These factories have, for the most part, been kept very busy, even during the dull seasons of 1895 and 1896, the demand for their products being in many instances greater than the possible supply. They have proven by practical experience that the shales and underclays of the coal measures are in every way fitted for manufacturing each of the products above mentioned. These factories are but the forerunners of others yet to come, for the raw material is there, the fuel necessary to burn it is there, railway facilities for bearing away the finished product are plentiful, and where these three necessary elements are present, capital in time is sure to come, to be invested and to make this section of our State a great clay industrial center.

Potter's clay of excellent quality abounds near Bloomingdale and Annapolis, Parke County; Brazil and Clay City, Clay County; Huntingburg, Dubois County; Cannelton, Perry County; Logoootee and Shoals, Martin County, and at numerous other points in the coal-bearing area of our State. Many of these deposits have been and are being put to practical use, but as yet no large potteries, similar to those at Zanesville and Akron, Ohio, have been erected in Indiana, though the facilities for raw material and fuel at some of the points above mentioned can not be excelled elsewhere in the United States.

Fire clays, suitable for making fire brick, saggars, bessemer converters, furnace linings, and many other refractory products, occur in quantity in the coal-bearing counties. One of the largest and purest deposits occurs near Montezuma, in Parke and Vermillion counties. Chemical analysis of this clay proved it to contain 98.24 per cent. of clay base and silica, and but 1.76 per cent. of fluxes. It has been in use for over twenty years in making refractory products.

Clays suitable for pressed front brick occur in many portions of the State. Different colors of these brick can be made by mixing the underclays of the coal seams with surface clays, shales, etc. One of the best clay deposits, not only for making pressed brick of different colors, but for making many other kinds of clay products, occurs at Mecca, Parke County, Indiana.\* Another large deposit suitable for making the finest of red front brick is found in the outskirts of the town of Martinsville, Morgan County. Both of these deposits have railway facilities already in place, and at Mecca valuable coal mines are being operated on the land.

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\*See twentieth report of this Department, page 53.

## SANDS.

Sand suitable for glass making occurs in quantity near Pendleton, Madison County; Montpelier, Blackford County, and Lapel, Hamilton County. A large deposit has also been recently discovered near Coxville, Parke County, which is being rapidly developed. A fine grade of moulder's sand, suitable for foundry use, occurs near Centreton, Morgan County; Rockport, Spencer County, and Salem, Washington County, and the Hon L. U. Downey, of Gosport, has recently discovered a similar deposit of large extent near that town.

Sand suitable for builders' purposes and similar uses occurs in all parts of the State, one of the largest available deposits which has come to my notice being located one mile north of Mecca, Parke County. The deposit at this point is thirty-five feet thick and one-half mile long, and lies alongside a switch of the C. & I. C. Railway.

## SOILS.

Among the most valuable natural resources of Indiana are her soils. More people are dependent upon them than upon all the rest of her resources and manufacturing establishments combined. The study of the origin, distribution and constituents of soils falls naturally to the Department of Geology, though many essays and valuable papers relating to their culture and fertilization appear in the Reports of the State Board of Agriculture.

The soils of Indiana may be roughly classified into three great groups, viz.: drift soils, residual soils and alluvial soils. The drift soils are found in the northern three-fourths of the State, are extremely varied in depth and character, and are formed of a mass of heterogeneous material which was brought to its present resting place by a great glacier or slowly moving sheet of ice which, thousands of years ago, covered the area mentioned.

The residual soils are found in the counties south of the southern limit of the glacier. They were formed for the most part in the place where they are now found by the decay of the underlying limestone or sandstone rocks. The variety of materials entering into their composition is therefore limited, and they are for that reason among the poorer soils of the State.

The alluvial soils are those of the river and creek bottoms throughout the State. Gentle rains and earth-born torrents, little trickling rills and strong streams are ever at work tearing down the soils and underlying clays from every slope and bearing them away to lower levels. The small water-formed trench of to-day next year becomes a chasm and

ages hence a hollow, and the transported material is gradually deposited as alluvial soil over the so-called "bottom lands" which are annually overflowed.

In the production of any cereal nothing new is created, but forms of matter, already existing in the earth, air and water are utilized by the growing plant. Taking wheat for example, besides the carbon, hydrogen and oxygen, which make up the greater bulk of the straw and grain, and which are abundant enough in the air and water, potash, nitrogen, phosphoric acid, magnesia, lime, sulphur, chlorine and silicon are absolutely essential constituents. If any *one* of these is lacking in the soil, or is present in a form not available by the wheat roots, the plants will not flourish and the soil will be worthless for wheat production. Such a soil may, in most cases, be made to produce a crop of grain by adding to it the constituent which is lacking, but if this can not be done except at a prohibitory cost, or one at which more fertile ground can be procured, the soil may be regarded as "worn out" or barren.

The drift soils, which cover the northern and central portions of Indiana, derived, as they were, from various primary and igneous rocks in the far north—ground fine and thoroughly mixed, as they were, by the onward moving force of a mighty glacier—are usually rich in all the above named necessary constituents of plant food. Neither they nor the alluvial soils require a large annual outlay for artificial fertilizers as do the residual soils of southern Indiana, over which the drift of the glacial period did not extend.

Analyses of soils from every county, showing the proportions of phosphates, nitrates and other necessary elements of vegetation, should be made. From them the farmer could determine what constituent of his soil, if any, is deficient, and could supply the same in suitable quantities and in an available form. From them, also, it would be possible to specify the localities where the different staple crops could be most advantageously grown, instead of compelling the farmers to learn the peculiarities of their lands by experiments which necessarily consume time and exhaust the soil. Such a series of analyses, and an exhaustive report dealing with the origin, distribution and fertilization of our soils, can only be undertaken and carried to successful completion when the Legislature of our State becomes more generous in the sum allotted for the maintenance of the Department of Geology.

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The above is a brief résumé of the more important resources of Indiana. As already noted, these resources are being developed at the rate of nearly twenty millions of dollars yearly, yet much of the capital which is bringing about this development is owned by parties outside the State. They reap the benefits; they pocket the profits. The people of

Indiana, with hundreds of thousands of dollars of capital lying idle, are for the most part reluctant to invest in the resources of their State. They stand by and see our thickest coal veins, our greatest clay factories, our largest stone quarries, the majority of our oil wells, and the greater part of our natural gas property owned and operated by foreign capital.

A few millions of dollars are invested in developing these resources and pay taxes into our treasuries, but the profits, aggregating far greater sums, go into the coffers of non-resident owners. Were Indiana capital invested, both capital and profits would remain in the State, and the wealth upon which taxes are based would increase in much greater proportion.

In the clay industry, especially, should Indiana capital be invested, and the several millions of dollars now annually sent outside the State for clay products be kept within her bounds. With raw material and fuel both plentiful, home factories should be erected, should be protected, should be patronized, for in such a way only can the future wealth and welfare of the State be increased and plentiful labor be provided for her workingmen.

#### OTHER FEATURES OF THE REPORT.

Besides the features already mentioned, the present report contains a paper on "The Geology of Vigo County," by Dr. J. T. Scovell, of Terre Haute.

In this paper Dr. Scovell has given especial attention not only to the general geology of the county, but has treated fully its economic resources and archaeology. The paper is accompanied by an excellent map of the county, showing the location of all the more important features mentioned in the text. Both paper and map are based on careful observations made during a residence of more than twenty years, so that the report is much more valuable and can be relied upon much more fully than if written by a non-resident assistant detailed for that purpose.

A paper upon "The Flora of Vigo County," based upon notes accumulated during a seven years' study of the plants of the county, was prepared by the writer, and is published in connection with Dr. Scovell's paper.

But little has heretofore been written concerning the caves of southern Indiana. These caves are numerous in the thick limestone formations of that section of the State, and form one of its natural features well worthy of special investigation by all who enjoy the study of Nature. A five weeks' trip, devoted to the exploration of a number of these caves, was made by the writer and a party of assistants in the summer of 1896, the main object in view being the collecting of underground specimens for the State Museum. Full notes relative to the origin, size, shape and

fauna of each cave visited were taken and from these notes a paper entitled "Indiana Caves and Their Fauna" has been prepared, and forms a part of this report.

#### THE STATE MUSEUM.

To the State Museum connected with the Department of Geology many additions have been made during the past two years. Among these may be mentioned more than two hundred mounted birds and mammals, a large collection of birds' eggs, a case of clays and clay products, a case of cave specimens and a case of native woods, most of which are from Indiana.

The greater portion of the contents of the Museum have been rearranged on an accurate scientific basis and typewritten labels prepared therefor. This work has been done by myself and assistants during the winter months, after the completion of the annual report and before the beginning of the next season's field-work. A catalogue of the contents of the Museum has also been partially prepared and will be published as soon as the work is completed. It is my ambition to make the Museum a representative collection of Indiana geological and natural history specimens, where much may be learned of the forms of life inhabiting our State in the past, as well as those found therein at present. The Museum has already become a center of attraction to many people of the State who visit Indianapolis, and its educating effect can hardly be over-estimated. Many teachers bring their pupils in a body and spend a day or two in looking over its contents. All visitors are welcome—the open hours being from 9 A. M. to 4 P. M., except on Sundays and legal holidays.

#### OFFICE WORK.

More than two thousand letters relative to the resources of Indiana, were answered from the office of the Department in 1896. They came not only from citizens of Indiana, but from almost every State in the Union, and proved conclusively the need of a central bureau where such information can be obtained. Taking into consideration the vastness of the undeveloped resources of the State, and the fact that the Department of Geology is the only official source of information concerning them, it would seem that Indiana should not only maintain, but maintain liberally, that Department which has for its purpose the advertising of these resources to the other States and nations of the world. Omitting the soils and taking the estimate of \$20,000,000, which is an extremely low one, as the annual value of the resources at present produced, the sum allotted to the Department for the years 1896-'97 was but thirty-five

one-thousandths of one per cent. of that productive value. What business man would, for a moment, think of carrying on a successful business with so small a percentage spent for advertising? Yet the advertising at present done through its reports can but result in bringing into the State a vast amount of capital, the taxes on which will soon amount to a hundredfold more than the few thousand dollars now set apart for the annual maintenance of the Department of Geology and Natural Resources.