THE CLAYS AND CLAY INDUSTRIES OF NORTHWESTERN INDIANA.

BY W. S. BLATCHLEY.

During the past five years the clay industries of Indiana have had a steady growth. The ever increasing demand for clay products for structural and road uses has been the chief incentive to this growth. The rapid advancement in the price of lumber, due to the disappearance of the forests of the State, has led architects and builders to investigate more carefully than ever before the advantages of clay products for structural purposes. These investigations have, for the most part, proven satisfactory, and have shown the unexcelled fitness of such products for many uses 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 hollow brick for their partition walls; of flue linings for their chimneys; 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.

Nor has the increased demand for clay products been confined to those used for building purposes. The use of vitrified products, such as sewer pipe and paving brick, and refractory clay wares such as fire brick and furnace linings, has also been constantly growing. To supply these increased demands new industries have sprung up in many portions of Indiana, and new discoveries have been made concerning the practical uses of many deposits of clay before considered worthless. Meanwhile, constant inquiries for literature relative to the clays of the State have been received at the office of the Department of Geology. To meet this demand for literature, the writer, in 1895, made a careful study of the clay deposits of the coal-bearing

counties in southwestern Indiana, and a detailed paper concerning them was published in the Annual Report of the Department for 1895.

In that paper it was shown that with the exception of some of the clays used in making the better grades of terra cotta, encaustic tile and china ware, Indiana has within her coal-bearing counties the raw material in abundance for making every kind of clay product used within her borders. Some of the best clay deposits and the largest clay factories of the State are, however, located in the northwestern counties, and a portion of the time of the writer during the field season of 1897 was spent in the study of the clays of that region. The results of that study are incorporated in the present paper.

Definition of Clay.

It is difficult to give an accurate definition of the term "clay," as commonly used. In general, the name is applied to any soft, earthy substance which, when wet, can be readily fashioned into any desired shape, which shape it will retain while being dried or burned. All clays are, however, not soft. Many of the best clay deposits of the State are hard, rock-like substances, which must be blasted and ground into powder, before being used. Such clays are either shales or fire-clays. The shales are only clays which, many centuries ago, were deposited in deep water. By pressure they have since become consolidated and separated into rather thin layers or laminæ. A shale is therefore only a hardened, laminated clay. The fire clays are the under-clays of the coal veins. At one time they formed the soil from which sprung the luxuriant plant growth which was afterwards changed into coal. Those plants removed from that soil many of the elements now found in shales and clays, and as a result articles made from fire-clays are more refractory; i. e., will withstand far greater heat without melting, than will those made from shales or ordinary soft clays.

According to the chemist, pure clay is a "hydrated silicate of alumina," the formula of which is $Al_2O_6 2SiO_2 + 2H_2O$. This simply means that two atoms of the element aluminum, two of silicon and seven of oxygen are united into a molecule of the compound, silicate of alumina, and that that molecule is combined with two molecules of water, to form the clay. Pure clay, with the above composition, is called *kaolin*. Most clays are, however, impure and contain numerous other compounds mixed with their kaolin. The kaolin, called the "clay base," is present in all material to which the term clay rightfully belongs. The purer the clay the greater the amount of kaolin which it contains.

Many inquiries are made concerning "aluminum clay." From the above it will be seen that all clays contain aluminum in greater or less

quantities. All clays are, therefore, aluminum clays. The metal aluminum is not, however, separated from a clay, but from a compound called bauxite, which differs from a pure clay in that its aluminum is combined with oxygen to form a soluble oxide instead of with silicon and oxygen to form an insoluble silicate. Bauxite occurs in Alabama, Arkansas, and other Southern States, but not in Indiana.

Origin of Clays.

The clay base or kaolin in all clays had its origin in the decomposition of granite or other primitive rocks which contained feldspar. Granite is composed of three minerals: quartz, mica and feldspar. Quartz or silica is wholly insoluble in rainwater or ordinary acids. Mica is also as insoluble as quartz. The feldspar of granite is composed of a silicate of potash which is soluble combined with a silicate of alumina which is insoluble, and this combination acts as a cement. Granite, then, may be regarded as composed of particles of insoluble quartz, united to particles of insoluble mica by a cement called feldspar which is partially soluble and partially insoluble.

When the granite of the first crust of the earth was exposed for centuries to the air and water, the oxygen of the former and the carbonic and other acids in the latter, acted in time upon the feldspar or cement. As the water percolated through the granite which had been softened by long exposure to the air, the carbonic acid united with the potash of the feldspar to form a carbonate of potash very soluble in water. The feldspar or cement was thus destroyed and the granite crumbled. From it resulted a mass of kaolin (the insoluble silicate of alumina of the feldspar) mixed with quartz particles or sand and numerous scales of mica. This resulting kaolin now forms the clay-base, or essential part of all clays. Besides granite, syenite, gneiss and other primitive rocks contained much feldspar, and by a similar decomposition as that noted have yielded their proportion of kaolin. The latter is, therefore, simply one of the kinds of matter resulting from the decay of feldspathic rocks.

VARIETIES OF CLAYS.

When the clay remains in the place where it has been formed it is called a *residual clay*. When it has been carried by water, ice or other agency to a new location and redeposited in water it is called a *sedimentary clay*. Ninety per cent. of the clays of Indiana belong to the latter group. Among the sedimentary clays are the shales, above mentioned, which were deposited in deep water, and the fire-clays, deposited in the more shallow lagoons and swamps in which the coal plants grew. In the area considered in the present paper, all the clays

are sedimentary and most of them are soft clays, belonging to one of three subdivisions: namely, drift clays or "hard pans;" alluvial clays, and silty or marly clays.

Drift Clays or Hard Pans.

The drift clays or hard pans are by far the more common clays in northwestern Indiana. They form a very large percentage of the unstratified morainic material or till which was dropped where it now lies by the melting of one or more of the great ice sheets or glaciers which many centuries ago invaded Indiana.* Transported and deposited as they were, these drift clays are, in general, too impure for any use but the making of ordinary brick and drain tile, and oftentimes they contain too much lime even for this purpose, numerous analyses showing the presence of as high as 40 per cent. of calcareous material. This is due to the grinding up and mixing with the clays much of the surface limestones over which the glacier passed, as the erosion of that epoch not only removed and commingled the previously formed residual deposits, but planed away the country over a vast area to a greater depth than had been reached by any previous decay. These eroded limestones and the clays with which they were mixed were many of them ground into impalpable powder and deposited before a subsequent decay could take place, so that, as has been well said, "the drift clays are, many of them, rock flour, and not, as are the residual clays, the products of rock rot."†

Alluvial Clays.

Along the lowlands and second bottoms of the larger streams of northwestern Indiana are found, at intervals, very large deposits of alluvial clays. These are sedimentary clays of the present age. They owe their origin either to the deposition of fine particles of clay in the eddies of the streams, or to the slow accumulation of the clayey sediment during the annual overflows of the areas which they now occupy. In some places they are 30 to 90 feet in thickness and remarkably free from pebbles or coarse impurities of any kind. They are usually very plastic owing to the presence of salts of lime and iron oxides which are intimately diffused through them.

Silty or Marly Clays.

Silty or marly clays resemble very closely alluvial clays. They differ in that they were deposited in bays, lakes or harbors, by still instead of by flowing water. Much "rock flour" containing a large percentage of kaolin was produced by the passing of the glaciers over beds of shale. This was held in suspension by the glacial streams and finally deposited

* For a more extended account of one of these ice sheets see p. 30 of this volume.
† Chamberlain, T. C.—Sixth Ann. Rept. U. S. Geol. Surv., p. 249.

in the bays and lakes of that epoch. These marly clays are, in general, composed of finer grains, and are more usually in thin layers, separated by a coating of sand, than are the alluvial clays. They contain a greater percentage of finely disseminated lime and magnesium carbonates, and for that reason products burned from them are usually cream colored or whitish.

The beds of sedimentary clay now found upon the surface of Indiana are very few of them identical with those first formed after the decay of the primitive crystalline rocks. That igneous force which somewhere is ever pushing the bottom of the sea upward, long ago raised the first shale beds into dry land. Rain and frost again caused their decay, and again did the agency of flowing water mix and grind and bear their particles to the bottoms of new seas and lakes. No one knows, or can ever know, how often these successive changes of elevation, disintegration, erosion and deposition have taken place in the ages past; but the clay-base in the materials of our buildings and roadways of to-day, would, if traced backwards, lead us through many a geologic change to the granites and gneisses of the old archæan times.

PROPERTIES OF CLAYS.

All clays suitable for manufacturing purposes possess certain essential and characteristic properties which will now be briefly considered. The most important of these is plasticity. It is this property which causes clay, when mixed with water, to become a tough, pasty mass readily capable of being fashioned into any form by the hands or molds. This plasticity is due to several causes, chief among which is the presence of the water combined with the silicate of alumina in the formation of the clay. When the clays are once burned and this combined water driven off by heat, they lose their plasticity. Brick dust or burned clay may be ground fine and moistened, but unless mixed with some unburned plastic material the particles will not cohere. The absence of crystals in the clay-base or kaolin also adds greatly to the plasticity of the clay, as does also the fineness to which the grains of kaolin have been reduced. Clays which are mixed in autumn and "weathered"—i. e., exposed to rain and frost throughout the winter, have the crystalline structure of their kaolin more or less broken up by alternate freezing and thawing. Their degree of fineness is at the same time increased, rendering them more highly plastic and therefore more readily molded into any desired shape.

Plasticity.

A second important property of clay is infusibility or refractoriness. Kaolin and the best grades of fire clay cannot be melted in the highest heat produced by man. This property is very valuable, in that it enables clay to be formed into many products used in the structure of fire proof buildings, and in furnaces for the reduction of ores. Most sedimentary clays contain lime, potash, iron and other impurities which weaken the property of infusibility, and cause them to melt or fuse at a comparatively low temperature. Such impurities are called "*fluxes.*" Good grades of fire-clays cannot contain more than three to four per cent. of these fluxes. All sedimentary clays contain a much higher per cent. and for this reason fire bricks, furnace linings, crucibles, retorts, etc., cannot be made from them. Great care must be taken in the burning of wares from such clays, in order to prevent the heat from rising to or above that point where fusion takes place.

Infusibility.

A third property of clay is insolubility. The better grades of clay are not affected by any acid or other chemical. On impure clays, however, especially those containing much lime, carbonate of iron or allied chemical, muriatic or sulphuric acid will cause an effervescence or bubbling, and the clay will be in part destroyed. This property of insolubility possessed by the raw clay is not lost in the burning and the finished clay product can be brought in contact with acids or chemicals without being impaired.

Insolubility.

The fourth and last property of clay to be here mentioned is that of induration. By this is meant the power which it possesses of hardening when subjected to heat. The importance of this property can scarcely be over-estimated. Without it an article fashioned from clay would be only so much stiff mud which on exposure to rain or frost would soon crumble to dust on account of its porosity and attraction for moisture. Almost any clay which possesses plasticity enough to be molded into shape can be baked and thereby made to become hard, solid, and stone-like in appearance.

Induration.

IMPURITIES OF CLAY.

The uses to which any clay can be put are determined very largely by the impurities which it contains. Anything other than the clay-base or kaolin may be considered an impurity. The impurities most commonly found in clays are silica or sand, compounds of iron, lime, magnesia, potash, soda, and sometimes organic matter.

Of these the most common is silica or sand in a free or uncombined state. It is found in all clays, and though classed as an impurity, it is in most instances a necessary constituent, since its presence prevents that warping, shrinking and cracking while drying which is sure to take place in the made-up ware when too great a percentage of pure kaolin is present. Clays which are tough and exceedingly plastic are termed "fat clays," and to them sand is often added artificially to lessen the plasticity and render their products more easily dried. Uncombined silica in moderate quantities is thus beneficial, since it preserves the form at high temperatures. When in excess it destroys cohesion and renders the ware brittle and weak.

Sand.

Next to sand, compounds of iron are the most common and the most important impurities of clays. The two oxides, ferrous and ferric, the carbonate, and the sulphide are the forms of iron compounds usually occurring, though others may be present.

The oxides of iron have much to do with the colors of clays, both in the raw and burned state. Ferrous oxide—the more common of the two—is found in all drift and alluvial clays, especially those of a bluish or greenish-blue color. When such clays are burned the ferrous oxide is changed to a ferric oxide, which is brownish red, and the wares become the same color.

Compounds of Iron.

Besides imparting a color to clay products, the oxides of iron act as fluxes. Especially is this true where from 5 to 15 per cent. of these oxides are present, as in many of the shales and drift clays. Such clays fuse at much lower temperatures than others which are similar in every respect, except in the percentage of iron oxides. The carbonate, sulphide and sulphate of iron, when present, also act as fluxes and are liable to produce a distortion of the brick or other product.

Among the sedimentary surface clays, especially those treated in the present paper, lime and magnesia are always present. If in fine particles, thoroughly disseminated through the clay, they only act as fluxes, and so limit the use of the clay to the making of certain products. Lime, however, more commonly occurs in the drift clays or till, in the form of small grains or pebbles of the carbonate. Unless these can be removed or ground to powder by a crusher, the clays containing them are practically worthless. If burned with the clay each lime pebble loses carbon dioxide and is changed from a carbonate to an oxide or quick-lime. This has great attraction for water, and when exposed each pebble absorbs moisture, swells and bursts off a piece of the ware, causing a defect or shallow pit in its surface.

Lime and Magnesia.

When lime and magnesia are present in quantity in a finely divided state they combine with the oxides of iron and with some of the sand to form a light colored double silicate of iron and lime. For this reason many of the alluvial and marly clays in northwestern Indiana—especially those near Hobart, Michigan City and South Bend—although rich in iron oxide, produce whitish or cream colored instead of red products.

Potash and Soda.

Potash and soda are two of the most powerful fluxes found in clays. They melt at a lower temperature and unite more readily with the clay-base than do iron, lime or magnesia. Their amount is not large, being, on an average, but 2 to 4 per cent., but in fusing power this is equal to more than double that percentage of the fluxes above mentioned. If vitrified products, such as paving brick and sewer pipe are desired, a total of from 10 to 14 per cent. of all the fluxes named are necessary in the clay. When the ware is raised to a temperature sufficient to melt the potash, iron, lime, etc., these fluxes fuse with the silica and give to the ware that dense, tough, non-porous condition characteristic of all so-called "vitrified" products.

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On account of office work connected with the issuing and distributing of the 21st Annual Report, I was unable to begin field investigations in 1897 until July 10th. The most of the time thereafter was spent in gathering data for the detailed report on Lake and Porter counties which appears in the present volume. The time left at my disposal for studying the clays of northwestern Indiana was very limited, and the present paper, therefore, deals only with the more important clay deposits of Benton, Newton, Jasper, Starke, Lake, Porter, Laporte and St. Joseph counties.

THE CLAYS AND CLAY INDUSTRIES OF BENTON COUNTY.

Benton County comprises an area of 414 square miles of the most fertile portion of northwestern Indiana. It lies on the western border of the State and is the third county south from Lake Michigan. Its entire surface is a gently rolling prairie broken only by three prominent morainic ridges which run in an easterly and westerly direction across its area. Standing upon one of these ridges near the center of the county one can behold the undulating prairie spreading away in all directions like the billows of the ocean. Timbered groves—island-like—dot here and there its surface, and well built farm houses with

surrounding orchards are seen on every side. No finer body of farming land exists in the Mississippi Valley than these rolling plains of Benton County.

The soil is everywhere a rich, black loam, composed of the remains of plants which have decayed under water, and of silt which has been mixed with them by slow deposition. For, after the recession of the great ice sheet which covered the underlying rocks with a thick deposit of bowlder clay, all these prairies were covered with shallow lakes, which by natural causes were gradually drained. In the first settlement of the county many of the prairies were too wet for cultivation, and a number of marshes which had not yet reached the stage of "wet prairies" were scattered at intervals within its bounds. To properly drain these wet regions has been the chief problem of the land owners. This has been accomplished by the construction of a great system of surface ditches which ramify throughout every portion of the county. These have necessitated the using of an immense quantity of drain tile. The manufacture of this tile has been the chief, and up to 1896, practically the only clay industry in the county.

The clays of Benton County are all of them of glacial origin. They lie immediately beneath the black prairie loam, and vary in known thickness from 5 to 130 feet. When first deposited by the melting ice these clays were a uniform blue in color. In the course of time, however, the upper portions of the clay beds have been percolated by waters containing humic acids and other substances from the decaying vegetation above. These have changed the ferrous or lower oxide of iron to the ferric or higher oxide. As a result the upper 5 to 20 feet or more of the clay, is now a brownish yellow. There is often a sharp line of division between the yellow, weathered portion and the blue or unweathered part of the clay. The latter is usually the more plastic and the better in quality.

The best deposit of clay in Benton County, so far as known, is the one at Earl Park, on the Chicago Division of the Big Four Railway. It has been worked since 1891 by the Earl Park Elevator and Tile Co., whose works are located about 150 yards from the pit in the south part of the town. A section obtained at the pit showed as follows:

1. Soil—stripped for working..... 8 inches.
2. Coarse-grained yellow clay, with many small pebbles ..... 4 feet.
3. Fine-grained drab clay..... 8 feet.
4. Blue clay—marly—fine-grained .....38 feet.
5. Limestone ..... ? ?

No. 2 of this section contains little lime, except what is in the pebbles. It is more refractory than the clays of the lower strata, but the lime and other pebbles must be removed or crushed, else they will spoil all wares produced from it.

The clay of stratum No. 3 is very similar to that of No. 4, except in color. Its lighter hue is due to leaching waters. The sediment of which the two strata are composed was probably deposited in still water by a stream from the retreating ice sheet. They contain an occasional drift pebble, but no large number of small limestone pebbles as does the upper stratum. Both are very fine grained, effervesce freely with acids and are to be classed as marly clays. They probably contain about 8 per cent. of carbonate of lime and magnesia in addition to the other fluxes. For this reason vitrified products of high quality cannot be made from them. Mixed with the upper clay, No. 2, they will withstand more heat. From them alone can be made, however, good pressed front brick, terra cotta lumber, drain tile and ordinary building brick.

The company operating this deposit has been recently reorganized and have put in some good machinery. Before 1896 only drain tile and ordinary brick had been made; the former from a mixture of all the clays, the latter from the two upper strata. They had used only a Pott's disintegrator to separate the pebbles, and a "Little Wonder" stiff-mud brick and tile machine. In that year they put in a 9-foot dry pan for crushing the clays; a Boyd dry press for pressed front brick, and a Boyd steamer to moisten the clay dust, after the latter has passed through two inclined screens. For drying the stiff mud brick and tile they have four floors, each 60x90 feet, heated by steam pipes, and for burning all their wares, four down-draft kilns, each of which hold 40,000 brick.* Hereafter the making of pressed front brick will be carried on to quite an extent. The color of these will depend upon the mixture of the clay, those from the blue clay alone being whitish yellow, and from the other clays different shades of red. At the time of my visit the making of such brick was yet in the experimental stage. Too many different shades were being made and too large a percentage were warped. Experience will doubtless remedy these defects, and with a man who has a practical knowledge of clay manufacturing in charge of the plant, there is no doubt but that its future will be a success.

At Lochiel, on the C. I. & C. Railway, drain tile have been made for a number of years by the Lochiel Tile Company. The material

*For further statistical information concerning this and other factories see table near close of this paper.

used is a stiff, dark colored drift clay which contains numerous small pebbles of lime. It is rather coarse grained and resembles the upper stratum at Earl Park in containing too small an amount of disseminated lime to effervesce with acids. Six inches of soil are stripped and the clay used only to a depth of four feet. It is hauled in carts to the plant and passed through a crusher and then through an Adrian brick and tile machine. Experiments in making pressed brick have been tried, but the brick were too brittle and the clay in general too coarse. Some hollow brick, of good quality for foundation work, have been made at this place. This company formerly produced the second largest output of tile of any in the county. Of late years the demand has fallen off and the production is much less. They have ample dry sheds and three round down-draft kilns of standard size. If the clay be properly crushed a good grade of tile can be made at Lochiel, but the qualities of the clay are not of the best for making other wares.

Drain tile have been made at Fowler, the county seat, by the Fowler Tile Works, since 1883. The material used is a rather coarse grained "hard pan" or "drift clay" very similar to that at Lochiel, but contains a much smaller number of lime pebbles. Five feet of clay are utilized after six inches of soil have been stripped. This clay is passed through a Potts disintegrator and pug mill, then made into tile on a Frees brick and tile machine. The tile are dried in sheds heated with exhaust steam for about one week. They are then water-smoked for 24 hours and burned from 24 to 30 hours. The burning is done in three round down-draft kilns, each capable of holding 15,000 4-inch tiles. The fuel used here, as elsewhere in the county, is slack coal. The clay burns red, but in time there appears on many of the tile a whitish efflorescence. This does not injure the quality of the tile.

The following is the daily capacity of the different sizes of tile made on a Frees brick and tile machine at the Fowler Works, and the price of tile at that place in 1897. Fifteen tile of any size equal one rod in length.

Size.	*Daily Capacity.*	*Price.*
3½ inch	12,000	$18.00 per thousand.
4 inch	10,000	12.00 per thousand.
5 inch	7,000	18.00 per thousand.
6 inch	5,000	23.00 per thousand.
7 inch	3,500	32.00 per thousand.
8 inch	3,000	40.00 per thousand.
10 inch	2,500	60.00 per thousand.
12 inch	2,000	80.00 per thousand.
14 inch	1,200	110.00 per thousand.
15 inch	1,000	125.00 per thousand.

The deeper the clay the better the quality for tile-making at the Fowler plant. The upper portion contains less sand and shrinks more in drying than the lower. A mixture of clays from top to bottom of the pit is aimed to be used, and the more thorough the mixture the better the product. By going deeper it is more than probable that a finer-grained blue clay will be found which can be made into terra cotta lumber, hollow brick and other products.

Ordinary building brick in small numbers are also produced at Fowler. It is claimed, however, that, on account of being made on a tile machine, they are compressed too firmly, and are left with too smooth a surface. As a consequence, they crack too easily in drying. There is at Fowler, however, room and plenty of raw material for a good, ordinary brick factory.

At Oxford, John Lawson has been making drain tile on a small scale for 15 years. On his tile yard is a flowing well 50 feet deep, which pierces the gravel beneath the blue clay. The clay for tile is gotten from low ground. Eight inches of soil are stripped, and 16 inches of a blackish sedimentary clay wholly free from lime pebbles are first taken out. This is mixed with three feet of underlying yellowish clay, then passed through a crusher and made into tile on a Hoosier tile machine. The tile are air-dried in sheds and when burned are smooth, a bright-red in color and of excellent quality. About $5,000 are invested in the enterprise and the annual output is valued at $3,500.

At Otterbein tile have been made by Wm. Lawson since 1891, and a factory is also in operation on Pine Creek, in the eastern part of the county. I was unable to examine the clays at these factories, but it is said that they are "drift clays" of good quality for tile-making.

Other tile factories have been in operation at Templeton, Wadena and Boswell, but have been abandoned in recent years. The reason for this abandonment as well as that of the decreased output at all other factories are several; chief among which was the business depression of 1893-5, causing farmers to stop drainage on account of a lack of money; the gradually decreasing amount of lands needing drainage, and the selling in Benton County of tile from Summitville and other points in the natural gas field, cheaper than they could be there manufactured at a living profit.

On the whole, it may be said that the clay resources of Benton County are inferior in value to those of the counties in the coal-bearing area of Indiana, or of some of the counties adjacent to Lake Michigan. But what the county lacks in clays it far more than offsets in the richness and productiveness of its prairie soils.

THE CLAYS AND CLAY INDUSTRIES OF NEWTON COUNTY.

Newton County comprises 400 square miles of northwestern Indiana, lying adjacent to the Illinois line, north of Benton and west of Jasper counties. The Kankakee River forms its northern boundary and drains the northern half of its area. The Iroquois River flows across the southern half of the county from east to west. It forms the northern boundary of that magnificent prairie region which embraces the southern third of Newton and all of Benton counties. North of the Iroquois are also some fine prairies which extend to the southern border of McClellan and Colfax townships.

With the exception of about 25,000 acres, formerly comprising Beaver Lake, the surface of the four northern townships of Newton County is covered with loose sand. Up to the present this sandy area has been deemed comparatively worthless for agricultural purposes, but the time will soon come when, by proper cultivation, it will be made to yield handsome returns in small fruits and certain vegetables. The area covered by Beaver Lake was long since drained into the Kankakee and now comprises one of the most productive regions of the county.

The clays of Newton County are, all of them, drift clays or marly clays. They were deposited either by melting ice or by the still water of the numerous shallow lakes which for centuries immediately following the glacial period covered the greater portion of the county. In many places they cover the uppermost rocks to a depth of 120 to 140 feet, and in but a few known places are they less than 10 feet in thickness. The northern third of the county was not visited since it is so covered with sand and lacking in railway facilities for transporting clay products. The fine-grained blue clay common to the region will doubtless be found to underlie all of this sandy area to a great depth.

In the vicinity of Kentland there are no clay factories, and no openings where the strata of underlying clay are exposed. The record of the well in the public square shows the blue glacial clay to be 146 feet in thickness. At Kent's warehouse it was 80 feet, and on Kent's farm, two miles southwest of Kentland, section 29 (27 north, 9 west), 50 feet in thickness.

A brick yard was for some time located on the north side of the Iroquois River, where the road running north from Kentland crosses that stream, southwest quarter of section 34 (28 north, 9 west). The clay is yet exposed in a cut by the roadside to a depth of five feet. It

is a fine-grained, reddish, loamy clay, free from pebbles and lime, and will withstand much heat when burned. It should make excellent ordinary brick, but is not suited for drain tile on account of the large amount of free silica which it contains.

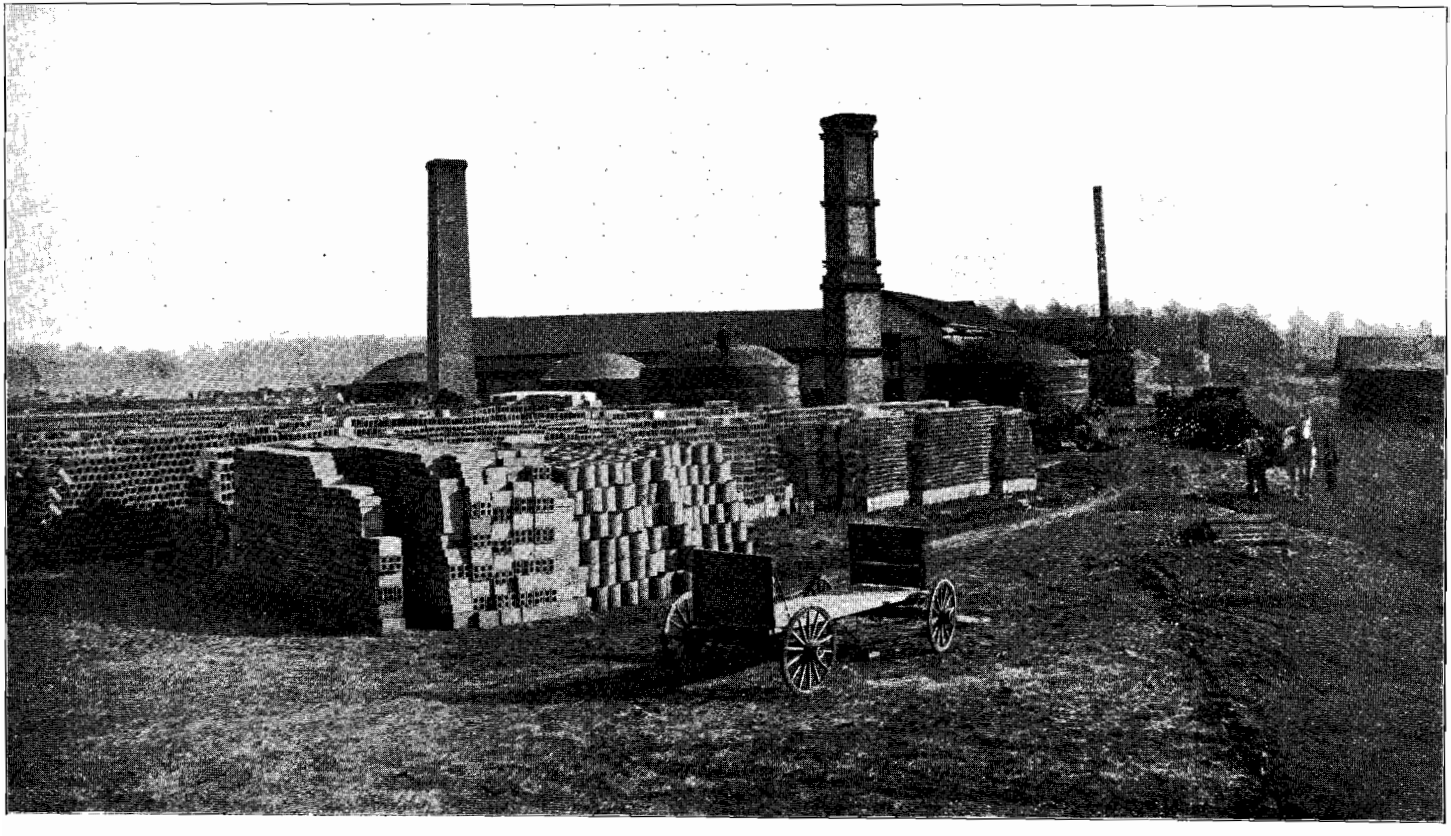
At Morocco, in the south half of section 21 (29 north, 9 west), Darroch Bros. have been operating a brick and tile yard for four years. The firm have their plant very well fitted with machinery, but are unfortunate in the selection of their clay. Seven inches of soil is stripped and three feet of brownish drift clay is utilized. It is very full of lime pebbles, and for that reason the tile and brick are of poor quality. One hundred yards north of their plant the blue clay comes within five feet of the surface and will make much better tile, but they will be yellowish-white in color. Two well sections at Morocco show this blue clay to be 113 and 120 feet in thickness, very fine-grained and very plastic.

A much better clay for tile and brick-making occurs at Beaver City, and has been worked by M. E. Handley since 1893. The section at the pit is as follows:

1. Soil—stripped ..... ½ foot.
2. Yellowish sandy clay.....3½ feet.
3. Tough, bluish clay.....4½ feet.

Wares made from the above yellowish clay air crack in drying, especially if exposed to the wind. When the yellow clay is mixed with the blue this is prevented. The blue clay has been proven by a bore to be 140 feet in thickness. But little trouble is had with lime pebbles, as comparatively few are present. The clay is thoroughly moistened, pugged and crushed before entering the machine. The mixture burns red, and the owner claims that red tile sell much better than white, as they stand freezing better. Tile from 3½ to 12 inches in size are made and more were sold in 1897 than any year since the factory was started. The brick made are of fair quality and bring $8.00 per thousand at the yard, but the local demand is small.

At Mt. Ayr, on the La Crosse Branch of the C. & E. I. Railway, a grayish-blue clay comes close to the surface in a marshy field in the eastern outskirts of the town, and is worked into brick and clay by Stucker & Coovert. It is fine-grained and tough, but contains occasional botryoidal masses of pure amorphous carbonate of lime the size of a marble or smaller. No true pebbles of lime are found in the clay and a similar occurrence of amorphous lime was noted nowhere else in northwestern Indiana. The clay itself possesses scarcely enough lime in its composition to cause an effervescence with acids, and burns a bright red. Four to six feet of it are used, the deeper portions burn-



YARD AND WORKS OF THE J. H HAYNES CO., BROOK, NEWTON COUNTY, IND.

ing to wares of a lighter color. About 25 kilns of a good quality of tile are made at this factory besides enough brick to supply the local demand. If the lime above mentioned was absent, the clay would be of most excellent quality for drain tile, flue linings and fire-proofing.

The J. H. Haynes Company, of Brook, have the largest and best-equipped clay factory in Newton County. Their clays are also excellently suited for the wares which they are making. A section at their pit, northwest quarter of section 20 (28 north, 8 west), showed as follows:

1. Black soil .....1 foot.
2. Yellowish loamy clay.....2 feet.
3. Grayish or drab, marly clay.....3 to 6 feet.
4. Tough blue marly clay.....2 to 5 feet.
5. Gravel and sand.....? ?

The entire deposit was evidently laid down in still water instead of being dropped by melting ice. As a consequence but little trouble is experienced with lime pebbles. From a portion of the soil and the loamy clay—No. 2—ordinary red brick and drain tile were made for a number of years. In 1895 the company begun to utilize the upper marly clay—No. 3—in making terra cotta lumber for the Chicago market. This clay is a silt, the lower part of the stratum being in thin layers with a coating of sand between them. An incomplete analysis shows that it contains about 10 per cent. of magnesium and lime carbonates. In the making of terra cotta lumber three parts of clay are mixed with one part of sawdust. The mixture is passed through a pugmill and crushed, and then through an Adrian tile machine fitted with dies of the proper pattern for the product desired. The so-called lumber is in reality a hollow brick, 12x12 inches square and 3, 4 or 6 inches thick. The walls are three-fourths of an inch thick and the hollow portion has two partitions to give the structure additional strength. At the present time the brick are dried in sheds for six to eight days, but a tunnel dryer will soon be constructed. After drying they are burned for 36 hours, and, the sawdust being consumed, leaves the product very light and porous, but at the same time strong enough for all purposes for which it is used.

On account of the porosity, this "clay lumber" can be readily sawed to any desired shape, and a nail can be driven into it with as much ease as into a pine board. It is used mainly for partition walls in fire-proof buildings, and is rapidly taking the place of ordinary brick and solid fire-proofing for that purpose. Its advantages over the latter are obvious. On account of a grooved outer surface, plaster is spread over

it without the use of intervening laths. Any wood finish can be nailed directly to it; while with a saw or trowel it can be quickly cut into any desired shape. Its weight is as follows:

3 inch.....13,500 lbs. per 1,000 square feet.
4 inch.....15,000 lbs. per 1,000 square feet.
6 inch.....20,000 lbs. per 1,000 square feet.

The prices at which it was sold in 1896 were $27.50, $30.00 and $35.00, respectively for the sizes made, delivered in Chicago.

From the blue clay, No. 4 of the section, flue linings, solid fireproofing, furring brick and foundation brick are made. This clay, as well as No. 3, burn to a cream color on account of the large percentage of lime which they contain. With a better system of drying their wares, and with a few additional kilns, this company will have their plant in excellent condition to meet almost any demand. Their trade is constantly increasing, as they aim to make all their products of the best possible quality and sell them at reasonable prices.

The Goodland Tile Company has been making brick and tile at Goodland, in the southeast corner of Newton County, for 12 years. The clay which is mostly used is peculiar for this region of the State, in that it is a pinkish-red in color. It resembles closely the clay of the same color found near Freedom, Owen County,* which is quite largely used in the making of encaustic tile and terra cotta. Both are very fine-grained, free from grit and pebbles, and exceedingly tough and plastic. The clay at Goodland effervesces rather freely with muriatic acid, showing that it contains several per cent. of lime carbonate, while on that from Owen County acid has no effect. The latter is, therefore, much the more refractory.

The section at the clay pit at Goodland was as follows:

1. Soil .....1 foot.
2. Grayish pebbly hard pan or drift clay.....2 to 3½ feet.
3. Pink clay .....4 to 10 feet.
4. Blue clay merging into shale.....5 to 8 feet.

The pink clay covers a large area southeast of Goodland, southwest quarter of section 25 (27 north, 8 west), on the land of W. J. Stewart. Burned by itself, it produces ware of a dark-red color. Mixed with the overlying grayish clay, it burns brown. Drain tile made from it are very hard and ring when struck, as though composed of iron. On account of its tough, plastic condition it is apt to twist and shrink under the influence of great heat. It must be thoroughly moistened

*See 20th Ann. Rep. Ind. Dep. Geol., 1895, 85.

in a pug mill, as it is too tough to work dry. When properly tempered or weathered it does not air-crack in drying. It possesses all the properties of an excellent modeling clay, and is of too high a grade to be used only for brick and drain tile, as it is at present.

The Goodland Company have a very well equipped plant, but in the past have made many poor tile from the upper pebbly clay, and have thousands of them on their yard. Besides drain tile and ordinary brick, they make solid fire-proofing, hollow brick and foundation brick. Of ordinary brick their output is only about 100,000 per year, which they sell for $8.00 per thousand at the yard. In 1896 they made 55 kilns of drain tile, but in 1897 the long strike among the coal miners shortened their season and they produced less than half as many.

From what has been stated it will be seen that the clays of Newton County are more varied in character and of better average grade than those of Benton. Good deposits of marly clay, suitable for terra cotta lumber, doubtless occur along the Iroquois River, east and west of Brook. Three railways pass through the county and its proximity to the coal fields of both Indiana and Illinois renders cheap fuel a certainty. There is no reason why larger clay industries should not start up and flourish, especially at Goodland and Brook.

THE CLAYS AND CLAY INDUSTRIES OF JASPER COUNTY.

Jasper County lies east of Newton and south of the Kankakee River, which forms its northern boundary. The Iroquois River, with its tributaries, Pickamink River and Carpenter's Creek, drains about three-fourths of its area. The county contains 550 square miles of surface, which is very diversified in character. The northern half is, for the most part, sandy, with intervening low prairies, marshes, and ridges and knolls covered with scrub oak timber.

The marshes and wet prairies, when drained, produce excellent crops, and comprise the best land in this section of the county. In Barkley, Gillam and Walker townships is one tract of 33,000 acres, owned by Benjamin J. Gifford, of Kankakee, Illinois, a large portion of which has been drained since 1893. On it are now more than one hundred dwellings, with good outbuildings and young orchards. Immense crops of oats and corn are produced and a thriving farming community now exists where, but a few years ago, only the wild duck and the muskrat flourished. The southwestern part of the county is a gently rolling prairie of black loamy soil.

The clays of Jasper County are the characteristic drift and marly clays of northwestern Indiana. The best grade of clay noted is located

one and one-half miles north of Rensselaer, in section 7 (29 north, 6 west), and is utilized for drain tile by A. E. & H. A. Alter. A prominent ridge rises 30 or more feet above the plain on which Rensselaer stands, passes east and west through this and adjoining sections and contains the deposit of clay. At the pit near the summit of this ridge, the section exposed was as follows:

1. Soil ..... 8 inches.
2. Yellow clay with occasional pebbles..... 3½ feet.
3. Grayish blue clay.....10 feet.

A well close to the pit pierced the blue clay to a depth of 126 feet before striking a water supply in gravel. In the making of tile but a few inches containing the roots of grass are stripped, and the clay from top to bottom of the pit is mixed, in the proportion in which it occurs. This mixture is soaked for a day or two and then passed through a Potts disintegrator and made into tile on a New Departure machine. The mixture burns pinkish on account of the presence of the top stratum. By itself the lower stratum burns to a cream color.

The grayish blue clay is very hard and has to be dug with a pick, as a spade will not penetrate it. It is fine-grained and very stiff and tenacious. It makes a firm, smooth tile of excellent quality, for which the demand has lately been greater than the supply. With proper weathering and tempering it could be made into hollow brick, flue linings, fire-proofing and many similar products, but contains too high a percentage of fluxes for paving brick, sewer pipe or other vitrified wares. The deposit of this clay comes close to the surface over several sections, both east and west of the point where it is worked and its quality is such as to merit a more extended use.

On the land of John T. Randall, near the postoffice of Pleasant Grove, 10 miles northeast of Rensselaer, drain tile has been made for 11 years. The material used is the ordinary fine-grained blue clay, mixed with about one foot of black soil and two feet of red clay. The blue clay at this point is 50 feet in thickness. Wares made of it alone air-crack in drying. Many unburned tile which had been exposed to a strong wind and had cracked were scattered about the yard. Some trouble is also experienced with lime pebbles in the red clay. About 50 kilns are burned each year. The tile are not nested when set in the kiln, and for that reason the average value of the kiln is but about $90.00. Wood is used for fuel at a cost of about $2.00 per cord. The owner claimed that below the depth exposed the blue clay became of the same character as that north of Rensselaer.

Good clay for drain tile, fire-proofing, etc., also occurs on the land of John English, northeast quarter of section 9 (29 north, 6 west), and on that of Murray Bros., northeast quarter of section 10 (29 north, 6 west).

Just west of Rensselaer, on the north half of section 25 (29 north, 7 west), John Kohler & Son have been making brick and tile for 11 years. The section exposed at their clay pit is as follows:

1. Soil and surface clay	1½	feet.
2. Tough, plastic bluish clay	4	feet.
3. Bluish pebbly clay	1½	feet.
4. Bluish clay free from pebbles	8 to 10	feet.

Stratum No. 1 is used for making brick and No. 2 for tile. Several kilns of brick were at one time made from the pebbly clay. No. 3. The lime in these caused them to crumble badly and gave the brick from this yard a poor reputation, causing the local trade to go elsewhere for its supply. More care is now taken to avoid the use of this stratum, and the brick on the yard were of good quality, but were bringing but $4.75 per thousand, delivered in Rensselaer.

Were it not for the heavy stripping the lower stratum, No. 4, would be used for brick. It has been tested and forms a very hard, whitish product. Clays of the same quality as those of this yard occur close to the surface over an area of one and one-fourth miles long and one-half mile wide west of Rensselaer.

On the land of Dr. W. W. Hartsell, two miles west and one mile south of Rensselaer, a well section showed 4 feet of soil and loam and 30 feet of clay; the latter being very sticky, fine-grained and free from grit or pebble. Just as it comes from the bed it can be formed by the hands into shallow vessels which will hold water until it evaporates. It can be burned into solid fire-proofing, flue linings, foundation brick, etc.; but will probably need some tempering with sand on account of its great tenaciousness.

A similar clay to that on the Hartsell farm is exposed in a large dredged ditch in Milroy Township. This ditch is a mile in length, extending from the center of section 10 to the center of section 15 (28 north, 6 west). The upper portion of the clay lies from two to four feet below the surface, but its thickness has never been ascertained. When damp it can be cut into ribbon as thin as a knife blade and a yard long. When dry it is very hard and tough. It is probably too far distant from a railway for utilization.

At Remington, on the P., C. & St. L. Railway, near the southern edge of the county, a tough blue clay is made into tile by Samuel Bowman. It lies immediately below eight inches of soil, part of which is

mixed with it when used. It contains numerous pebbles which must be crushed, or thrown out by a disintegrator, but otherwise is well suited for tile-making. Enough ordinary brick are made to supply the local demand.

This comprises all the exposures of clay which I was enabled to visit in Jasper County. The blue clay which is the more common probably underlies the entire county, but only in the vicinity of Rensselaer was it found of a quality suitable for making other wares than drain tile.

THE CLAYS OF STARKE COUNTY.

Starke County lies east of Jasper, in the second tier of counties south of Michigan, and in the third east of Illinois. Its eastern border is 18 miles and its southern border 24 miles in length. Nine miles west of its northeastern corner the Kankakee River intervenes between it and Laporte County, and, flowing southwesterly, forms the remainder of the northern and all but five miles of the western boundary. Yellow River, flowing west through the center of the county, and Bogus River and Pine Creek, north through the southwestern fourth, empty into the Kankakee. Bass Lake, formerly known as Cedar Lake, lies in the southeastern part and is 3x1½ miles in area, with an average depth of about 20 feet.

The county has an area of 306 square miles, the surface of which is diversified by marsh, wet prairie, dry prairie and sand ridge, the latter predominating. More than half of the area is covered to a depth of 2 to 15 feet by the fine-grained buff sand so characteristic of all the region adjacent to the Kankakee on the south. Experience has proven that this sandy soil, if properly cultivated, will produce excellent melons, sugar beets, berries, grapes, etc. Where ploughed deep and fertilized it also yields good crops of corn, oats and potatoes. Within the past ten years colonies of frugal, industrious Germans and Swedes have bought at a low price large areas of this once despised land and are making a good living from it. They utilize all fertilizers produced on the farm; they haul muck from the lowlands and mix it with the sand; they plough deeply each season; and by these means and others are proving the land of far greater productive power than it was ever believed to be.

Many thousand acres of the marsh land in the northern half of the county have been recently drained, and where a few years ago the waters were waist-deep the year round bountiful crops of corn are now produced. That the county is rapidly coming to the front agricultu-

rally is proven by the growth of Knox, the county seat, where several fine business blocks were erected in 1897, and where a $90,000 court house will be finished next year.

Beneath the sand, the prairie sod and the marsh bottoms of Starke County there is everywhere the fine-grained, ash-blue bowlder clay which covers the entire area of northwestern Indiana. In many places this comes close to the surface, yet there is not at the present time a brick yard, tile factory or clay industry of any kind within the bounds of the county. Several brick factories have been started in the past, but always by some one inexperienced in clay-working and usually without capital. As a result, they were failures, and, after a few kilns were burned, they were abandoned.

One of these factories was located in section 5 (32 north, 2 west), one and three-fourths miles east of Toto, a station on the "Three I" Railway. A record of the well on the former yard is as follows:

1.	Sand	2 feet.
2.	Yellow clay	4 feet.
3.	Blue clay	38 feet.
4.	Sand	8 feet.
5.	Blue clay	23 feet.
6.	Sand	5 feet.

A plentiful supply of water was obtained in the third stratum of sand.

The clay used was that from stratum No. 2, mixed with a foot or two of that from No. 3. It contains quite a percentage of disseminated carbonate of lime, but no lime pebbles. The mixture burns red, and, from samples of brick and tile left on the yard, produced wares of good quality. Wood, costing but $1.25 per cord, was used for fuel, and the brick were sold at the yard for $6.00 per thousand. They were made on a Penfield brick and tile machine, which is still in the abandoned shed, and dried in an open yard. The parties claimed that the location was too distant from Knox, about five miles to the northeast, where the brick were mostly sold, and that the demand was too limited to continue the business.

On the land of Isaac R. Bascom, northeast quarter of section 1 (32 north, 3 west), one-third of a mile west of Toto, a reddish yellow clay comes to the surface near the right of way of the "Three I" railway. This clay has been proven by tests in three factories to be well fitted for the making of brick and tile. It contains some pebbles, and a disintegrator and crusher would have to be used. This location is probably the best in the county for a clay factory for brick and tile, as a switch could be put into the plant with but little expense. Water

in abundance can be obtained at all seasons from the Bass Lake outlet, which passes through the deposit. A factory started at this place could supply at a low rate all the brick needed in the towns of Starke County along the "Three I" railway, and at the same time the constantly increasing local demand for tile among the farmers. At present these clay products are shipped into both Knox and North Judson from other counties.

Three miles south of Knox, on the land of John Lindstrand, northwest quarter of section 3 (32 north, 2 west), is also a deposit of clay suitable for brick and tile. It covers 40 or more acres and comes to within less than a foot of the surface.

On the line between Marshall and Starke counties, section 36 (33 north, 1 west), a brick and tile factory was in operation for a number of years, but has been recently abandoned on account of its distance from a town of any size. I did not visit this point, but was informed that the wares made gave good satisfaction wherever used.

Nine miles west of Knox, on the land of Fred. Surma, northeast quarter of section 33 (33 north, 3 west), a number of kilns of brick have been burned to supply a local demand, but no permanent factory has been started. Just across Yellow River, one-third of a mile north of the Court House at Knox, several kilns were also made a number of years ago, but the clay is of poor quality and in no place more than two feet in thickness, and overlies a bed of sand. It was used only because no better deposit was thought to occur in the county.

These constitute all the points, as far as could be ascertained, at which clay suitable for brick or tile comes close to the surface in Starke County. By stripping the sand the blue clay will be everywhere found, but ordinary brick have not as yet been made from it. Custom has established the idea that brick and tile should be of a red color, and since the blue clay burns yellow, it is wrongly considered to be useless for such wares. At any one of two or three of the points mentioned a man with a practical knowledge of clay working and possessed of energy could establish a combined brick and tile factory on a paying basis, since a county which is advancing as rapidly as Starke should by all means support at least one such factory within her bounds.

THE CLAYS AND CLAY INDUSTRIES OF LAKE COUNTY.

The location and leading surface features of Lake and Porter counties are given in another paper in the present volume, hence they are not treated in this connection. The clays of the county which come close enough to the surface for utilization are of two kinds,

drift clays and silty or marly clays. The drift clays are utilized at Lowell and Crown Point in the making of brick and drain tile, and the silty clays, at Hobart, on an extensive scale, in the making of terra cotta lumber, flue lining, fire-proofing and ordinary and pressed front brick.

At Lowell the clay factory has been operated by P. D. Clark for 13 years. The amount invested is but $5,000 and the value of the annual output is about the same, equally divided between the two products. The clay used is gotten from a hillside northwest of the town, northwest quarter of section 23 (33 north, 9 west). It is a tough yellowish drift clay about 12 feet in thickness, with many small pebbles of lime carbonate and other material scattered through the basal portion. For this reason only the upper four or five feet are used and this has to be passed through a crusher. Underlying the clay stratum is a thick deposit of coarse sand.

The plant is located at the base of the hill, and the clay is hauled to it in carts. After being crushed it is passed through a perpendicular pug mill and then through a "Little Wonder" brick and tile machine. The products are dried by air in sheds and burned in round down-draft kilns. Aside from an occasional pebble, which escapes the crusher, and causes a flaking of the surface, the brick and tile are of good quality. The clay, however, is not suited for higher grade products.

Drift clay similar to that used at Lowell lies near the surface over an area about three miles wide between Lowell and Crown Point. At the latter place H. W. Wise has been making brick from it for 24 years and has lately begun the making of tile. Only about three feet of the clay can be used on account of the pebbles in the lower portion of the bed. A Penfield brick and tile machine is used and the value of the annual output is about $2,500.

By the side of the Pittsburg, Fort Wayne & Chicago Railway, just north of Hobart, in the southwest quarter of section 29, and the southeast quarter of section 30, (36 north, 7 west), is one of the largest, best known and most valuable deposits of silty clay in northwestern Indiana. For a long period ordinary soft mud brick were made in large numbers from the surface portion of this deposit, but in April, 1887, W. B. Owen began the making of terra cotta lumber and fire-proof products from the deeper portions of the clay bed, and this business, now carried on under the name of "The Hobart Terra Cotta Lumber Company," has become one of the most important clay industries in the State. The pit at the Owen yard covers an area of about four acres and is 25 feet deep. A section of it showed as follows:

1. Soil ..... 6 inches.
2. Fine grained yellowish marly clay..... 2½ to 3 feet.
3. Grayish-blue clay, exceedingly fine grained.21 feet.

The two clays, Nos. 2 and 3, were, when deposited, doubtless of the same color, and the difference in hue now existing has been caused by leaching waters. No. 3 has been pierced by a bore to a depth of 132 feet without reaching its base. The deposit is a well-defined silt, the upper six to ten feet of blue clay being in layers two to six inches thick, with each layer separated from the one above and below by a thin coating of sand. Towards the bottom of the exposure the layers become thicker, eight to fourteen inches, and the clay is more condensed and contains less free silica. Not a pebble or solid body of any size occurs in the entire deposit, and it was most probably laid down by slow deposition in the waters of a shallow bay which formed an adjunct to the highest stage of the old glacial Lake Chicago.*

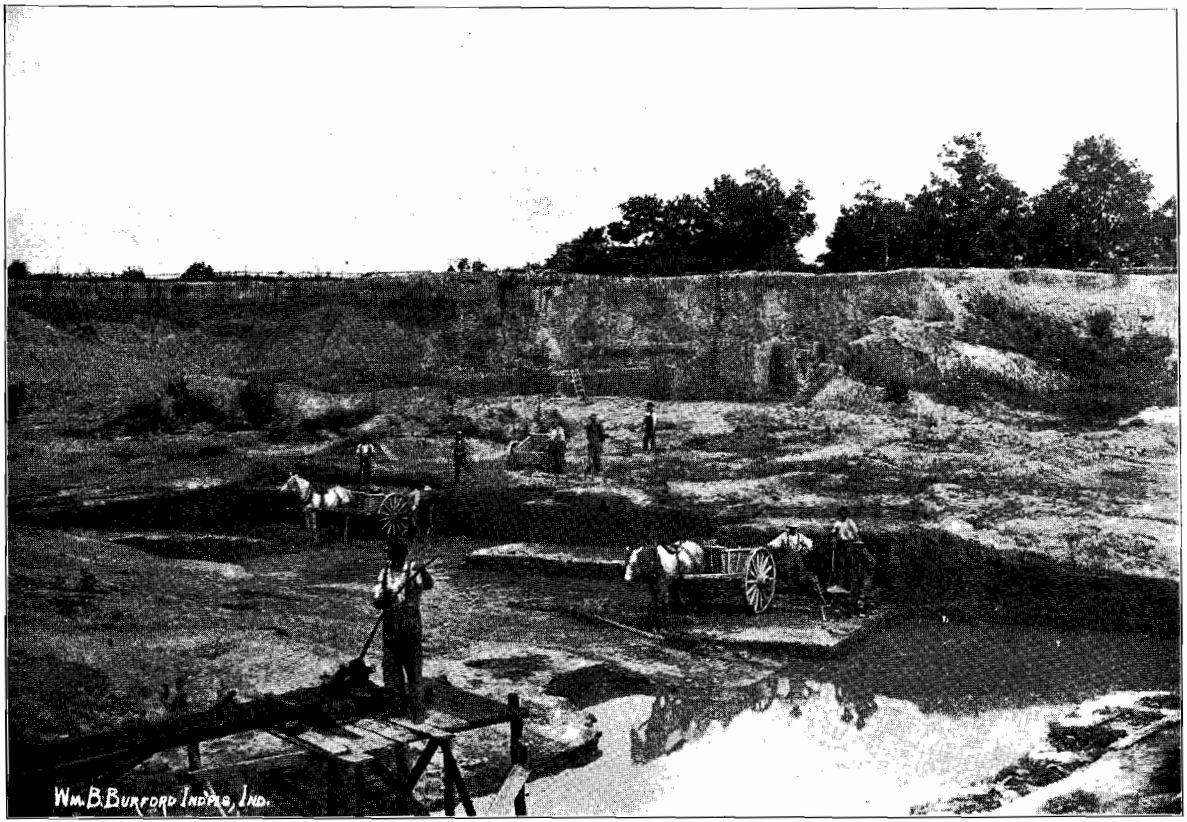
When dry the clay becomes much lighter in color. By itself it burns to a dark cream, and, when mixed with the surface stratum, to a light pinkish hue. On account of the presence of about 20 per cent. of calcium and magnesium carbonates, the clay effervesces freely with acids. Its chemical composition, as determined by Noyes, is as follows:

ANALYSIS OF MARLY CLAY FROM HOBART, IND.

	Per Cent.	
Silica	50.56	
Titanium oxide	1.00	
Alumina	13.11	
Combined water	2.76	
Clay base and sand		67.43
Ferric oxide	2.98	
Ferrous oxide	2.32	
Lime	7.87	
Magnesia	5.06	
Potash	3.74	
Soda	.70	
Fluxes		22.67
Carbon dioxide	9.62	
		9.62
Total		99.72

The large percentage of the fluxes present shows that wares from this clay can not be subjected to great heat on account of the danger

*See p. 33 of the present volume.



CLAY PIT OF HOBART TERRA COTTA LUMBER COMPANY, HOBART, INDIANA.

of their melting down. The clay is peculiarly fitted for a light, porous product, which does not require the properties of hardness or toughness.

In the making of the terra cotta lumber and other fire-proof products, the clay is excavated with spades and elevated in tram-cars as fast as needed to the upper floor of the plant, where it is dumped by the side of an opening leading to a perpendicular pug mill. From the opposite side of the building a belt carrier elevates screened sawdust and drops it near the same point. The clay is moistened by sprinkling water over it with a hose, and two men scoop alternate shovelfuls of clay and sawdust into the pug mill. In it the two are thoroughly mixed and then passed into a horizontal brick machine, from which the mixture emerges as a cylindrical roll eight inches in diameter. This is cut into blocks 14 inches long, which are elevated to the top of a Vaughn & Taylor sewer-pipe press fitted with dies of the proper size and pattern for the product desired. As fast as taken from the press the wares are placed on double-deck iron cars, 280 of which are in use, and dried by steam in tunnel dryers. The kilns in which it is burned are ten in number, rectangular down-draft, each one holding 10,000 feet of six-inch partition. The output of the plant averages 60 tons a day of the finished product, and the drying and burning capacity is sufficient to take care of this amount. About nine days are required from the time the clay is taken from the pit until the finished material is ready to load on the cars. Sixty carloads a month are shipped to all parts of the United States; the value of the annual output being from $60,000 to $75,000. The products of this plant consist of wall partition or fire-proofing, from seven-eighths to twelve inches in thickness; floor arching, wall furring, column and girder covering, under-roofing to which slate or roofing tile can be nailed, and everything in the clay line that goes inside the walls of a fire-proof building. For the porous wall partition the following points of advantage are claimed:

1. It is a non-conductor of heat, cold and sound.
2. One coat of plaster, without studding or lath, finishes the partition.
3. It can be shaped with edge tools and holds nails and screws.
4. It can be put in place more rapidly and at less cost than brick.
5. Its cost to the consumer is only slightly greater than wood.

But three factories are at present making this porous partition in the States of Illinois and Indiana; one located at Pullman, Illinois,

one (described in the present paper) at Brook, Indiana, and the one at Hobart. The demand is constantly increasing and the factory at Hobart made no stop during the panic of 1893-'95.

Just across the railway from the Owen factory is the Kulage Brick and Tile Works, where, for a number of years, large quantities of ordinary brick and drain tile have been made. In 1897 the owners began the erection of a large plant for the making of dry pressed brick.

From numerous experiments which have been made it has been found that by proper mixture high-grade dry-pressed brick of a number of different shades between a deep red and a handsome cream color can be made from the clays of the vicinity. A mixture of equal parts of the upper and the lower clays burns to a beautiful shade of pink.

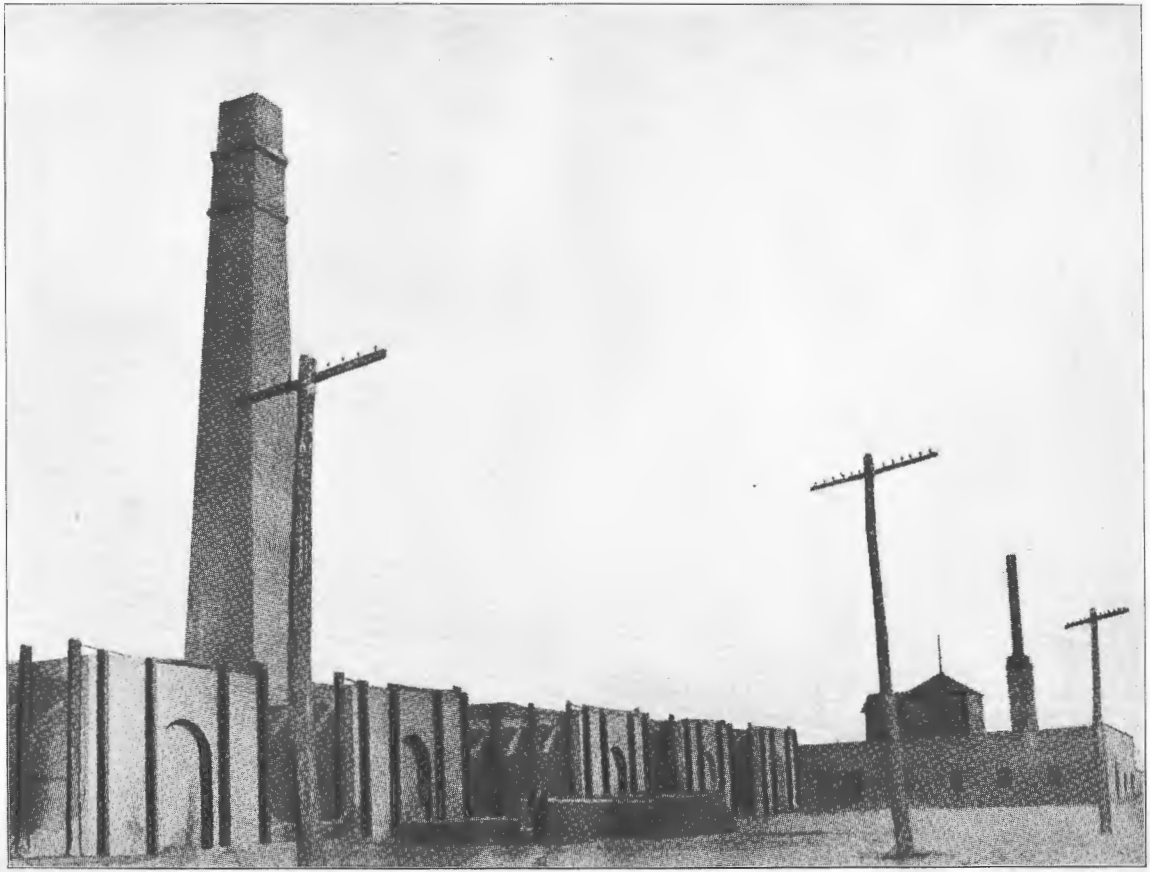
Five large, rectangular down-draft kilns, each 100 feet long by 20 wide, and holding 260,000 brick, were erected in 1897. These kilns were constructed of ordinary brick burned from the clays at hand, and were lined with Ottawa fire block. They were built according to the designs and inventions of the Kulage Company, and are probably the largest kilns of the down-draft type in existence, their combined capacity being nearly as great as that of a dozen down-draft kilns of the usual size. Each kiln is so constructed as to be operated separately and independently, or the entire set may be connected and used as a continuous system, thereby reducing materially the cost of burning. These kilns also admit the setting and burning of shaped, ornamental, glazed and enameled brick with the plain brick without interfering with the latter.

When in operation the clays will be ground in a nine-foot dry pan, passed over rotary screens and made into brick on presses designed and manufactured by the Kulage Company, of St. Louis, who are erecting the plant. Their presses are the "Challenge," of 25,000, and the "Triumph," of 35,000 daily capacity. The latter is a quadruple pressure machine, weighing 40,000 pounds, and it is claimed, gives a pressure three times as great as any secured on the ordinary pressed brick machine in use.

The section exposed in the Kulage Company's pit in July, 1897, was as follows:

Soil	4 to 6 inches.
Yellow marly clay	6 to 7.5 feet.
Bluish-gray marly clay	4 to 7 feet.

The blue clay has been proven by bores put down in a number of places on the land of the Kulage Company to be more than 90 feet in



KULAGE BRICK AND TILE WORKS, HOBART, IND.
(Kilns in course of construction.)

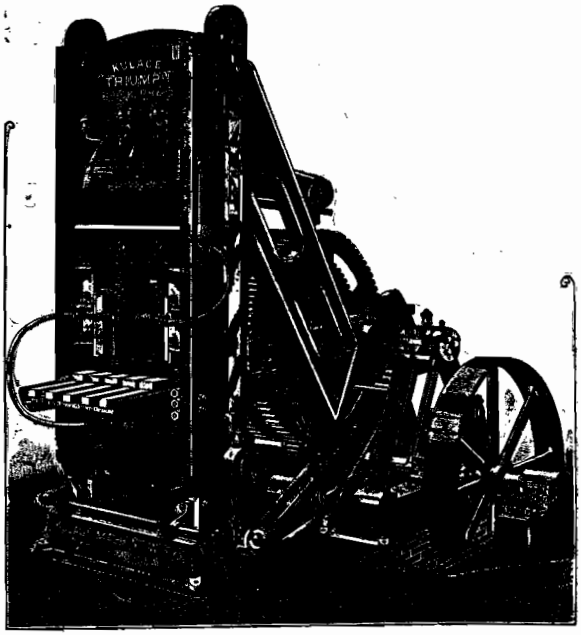


FIG. 10. TRIUMPH BRICK PRESS. (Front View.)

thickness. Its properties are essentially the same as those of the clay at the Owen pit above mentioned. It is found over a large area in sections 19, 20, 29 and 30 (36 north, 7 west), north of Hobart, and also south and east of that town, but in most places the stripping is so heavy as to prevent its utilization. In a well near the center of Hobart it was found to be overlain by 22 feet of sand. In the yard of J. A. Johnson, in the northwest quarter of section 20, seven feet of sand and six feet of yellow clay lie above it. Along Deep River it outcrops in a number of places, but usually in localities where it can not be utilized on account of the Spring overflows. Its constituents and properties are the same wherever found within the limits once occupied by the bay of Lake Chicago. This is shown by the chemical analyses, printed on succeeding pages of this paper, of samples taken at Garden City, Chesterton and near Michigan City.

THE CLAYS AND CLAY INDUSTRIES OF PORTER COUNTY.

The clays of Porter County, like those of Lake, are sedimentary in nature and belong to the two groups of "drift clays" and "marly clays." The drift clays are made into ordinary brick and drain tile at Hebron and Valparaiso, and the marly clays into pressed front brick at Porter, and ordinary brick at Garden City and Chesterton.

One-third of a mile west of Hebron the "Panhandle" Railway has exposed the drift clays to a depth of 14 feet. At this cut, in September, 1897, the following strata were disclosed:

1.	Soil	16 inches.
2.	Bluish "joint clay".....	3 feet.
3.	Hard yellow clay.....	7 to 10 feet.

The bluish clay immediately below the soil was broken into irregular four-sided masses two or three inches long and an inch thick. The yellow clay was a solid homogeneous body, with here and there a lime pebble or small bowlder embedded in its mass. Both clays effervesced freely with acids, showing the presence of a large percentage of lime carbonate.

In the south part of the town, H. Folsom has made brick from the upper clay for 28 years. The annual output is only enough to supply the local demand and varies between 100 and 500 thousand. Six inches of the surface are stripped and the remainder of it and two feet of the underlying clay are used; all below that containing too many lime pebbles. The brick are made on a "Quaker" machine, dried in an open yard and burned with wood in temporary or "scove" kilns. They sold, in 1897, at $5.50 per thousand at the yard.

One-half mile north of Hebron, Kenny Bros. have been making drain tile from a clay found in marshy ground near their plant. Six inches of the soil are removed and three feet of the tough, bluish, very plastic clay utilized. Sand and gravel set in at about three feet and prevent the use of the lower portion of the clay bed. After passing the clay through a crusher the tile are made on an "A. C. Hocket" machine, and are of excellent quality. The value of the annual output is but about $1,750.

In the south part of Valparaiso, Lambke Bros. are using the drift clay for making ordinary soft-mud brick and also a harder "sidewalk" brick for pavements and foundations. The clay used is obtained on a hillside and is quite free from pebbles to a depth of five feet, but below that distance they become more plentiful, and prevent its utilization. The clay is first passed through a disintegrator, then through a Williams pulverizer and over an oscillatory-inclined screen. It is then passed through a pug mill and a "Creager" machine, and the resulting brick are dried on pallets in open sheds. Two round downdraft kilns, each holding 43,000 brick, are used in burning the sidewalk brick, 600,000 of which were made in 1897, and sold at $6.75 per thousand. The building brick are burned in "scove" kilns of 280,000 capacity. Crude petroleum is used as fuel and costs at the plant $1.60 per hundred gallons. On account of the thorough preparation

which the clay receives, the brick made are of excellent quality and find a ready market in Valparaiso at $5.50 per thousand, delivered. The annual output is about one million.

In the north part of Valparaiso, Coovert & Clevenger are making drain tile from clay which they obtain from a swamp, one-half mile northeast from their plant. It is the characteristic tough blue clay which underlies the mucky soil of the swamps of this region. Three and one-half feet are used after stripping four inches. The clay is passed through two crushers, and then through an "Ohio" auger machine. The resulting tile are air-dried in sheds and burned 48 hours with crude oil. It is claimed that this fuel burns the product more quickly, requires less labor and produces better ware than any other. The value of the annual output at this plant is about $3,000; the price for four-inch tile in 1897 being $14.00, and for ten-inch, $75.00 per thousand, at the yard.

At Garden City, two miles southeast of Hobart, on the line between Lake and Porter counties, a fine bed of marly clay occurs which was deposited at the same time and by the same agencies as the bed at Hobart. The P., F. W. & C. and the "Nickle Plate" railways, which here run side by side, are just south of this deposit, and a switch from the latter enters the yard of the factory which has been erected. At this factory ordinary stiff-mud brick have, in the past, been made in large quantities for the Chicago market. The plant has been well equipped for making these brick in large numbers, but, unfortunately, has been owned and managed by parties who were not practical brick men, and who, therefore, could not successfully carry on the business. As a result, it has been idle for a large part of the time during the past three years. At the pit the following section was exposed in August, 1897:

1.	Soil	8 inches.
2.	Reddish marly clay	4 feet.
3.	Buff sand	2 feet.
4.	Bluish-gray marly clay	6 feet.
5.	Bluish sand	2 feet.
6.	Bluish-gray clay, fine grained	20 feet.

A well on the yard has been sunk to a depth of 150 feet through the bluish clay, No. 6, to gravel, and an inexhaustible supply of good water obtained. With the exception of the sand strata, Nos. 3 and 5, this deposit is very similar to the one at Hobart. The blue clay is the same fine-grained, silty material, with a very similar chemical composition, as the following analysis, made by Noyes, will show:

ANALYSIS OF BLUISH GRAY CLAY AT GARDEN CITY, INDIANA.

		Per Cent.
Silica	50.37	
Titanium oxide	.65	
Alumina	9.93	
Combined water	1.50	
Clay-base and sand		62.45
Ferric oxide	2.10	
Ferrous oxide	2.05	
Lime	10.26	
Magnesia	6.26	
Potash	3.04	
Soda	.79	
Fluxes		24.50
Carbon dioxide	12.50	
		12.50
Total		99.45

The samples analyzed were taken from near the surface of the bluish clay. If they had been gotten from a greater depth, as was the one from Hobart, the percentage of alumina would doubtless have been larger, and that of some of the fluxes less. The clay will be found to be well suited for the making of the same products as are made by the Owen Company at Hobart. Experiments will also doubtless show its fitness for structural terra cotta of good quality, since its constituents are very similar to those of one of the clays used by the largest factory manufacturing that product in New York, the Glens Falls Terra Cotta Company. An analysis of their clay is added for comparison:

ANALYSIS OF TERRA COTTA CLAY AT GLENS FALLS, N. Y.

Silica	48.35 per cent.
Alumina	11.83 per cent.
Oxides of iron	4.02 per cent.
Lime	15.38 per cent.
Magnesia	3.17 per cent.
Organic matter	1.18 per cent.
Potash and soda	6.05 per cent.
Carbon dioxide	10.52 per cent.

The high amount of lime and magnesia in the bluish-gray clays at Hobart and Garden City causes them to produce a light-colored ware. A mixture of this clay with the red clay above produces a speckled,

pinkish product, and the red clay alone a deep red product. A variety of different colored terra cotta can thus be made without the use of artificial coloring matter.

A new company has recently secured possession of the clay deposit and factory at Garden City and will make porous fire-proof products instead of brick. With a man who has a practical knowledge of the making of such wares in full control of the factory, there is little doubt of their ultimate success.

The same silty clays come near the surface in a number of places in the area formerly covered by the bay of the old glacial Lake Chicago, especially in sections 15, 22, 27 and 34 (36 north, 7 west), Portage Township, Porter County. They are at present at too great a distance from transportation facilities, but the time will come when their value for terra cotta and similar products will be better known, and to some of them railway switches will then be extended.

Near the junction of the Michigan Central and Lake Shore railways, at Porter, Indiana, is located the largest pressed front brick factory in the State. It is one of the several factories in different parts of the Union owned and operated by the Chicago Hyraulic Press Brick Company, and has been in operation since July, 1890. The clay used is a peculiar, fine-grained, buff material, entirely free from lime pebbles, and containing but a small percentage of lime carbonate as a constituent. It covers to a depth of six feet an area of 45 acres, owned by the company, in the northeast quarter of section 34 (37 north, 6 west), and is also the surface clay over quite an area in sections 27, 35 and 36, in the same township and range. Below it is usually found a bed of sand 25 or more feet in thickness.

In September, 1897, the clay was being gathered at the yard just north of the company's plant, and stored in sheds for winter use. A special harrow-shaped plow, designed and made at Findlay, Ohio, and propelled by a 12-horse-power traction engine, loosens the clay over an area six feet wide, to a depth of three inches. This plowing is done on a gradual slope, so as to get a uniform mixture of the clay and prevent uneven shrinkage in the brick. Ten rotary excavators, each holding enough clay for 300 bricks, follow the plow and gather up the clay. They convey it to the storage sheds, three in number, which, when full, hold enough to make seven millions of brick. From the sheds it is conveyed in carts and so dumped that it feeds itself between a set of steel rollers. These grind enough clay to make 24,500 brick every ten hours. After being ground the clay is elevated to the top of the building and passed through a disintegrator and two rotary or revolving screens. From the latter it descends into a perpendicular

"mixer box" eight feet in diameter, where it is acted upon by revolving iron arms, and reduced to as nearly a homogeneous mass as possible. From the mixer it passes into a five-die hydraulic press of the Company's patent and make. This subjects it to a pressure of 2,750 pounds per square inch. Three such presses, each capable of making 24,500 brick daily, are in the plant, and connected with each of these is a set of steel rollers, disintegrators, screens, etc., as noted above. Besides these there is a press for making brick of special shape, which has but two dies and makes but 2,500 brick daily.

From the presses the brick are wheeled on trucks to the kilns. These are of the "Groves" pattern, and 14 in number, each holding 130,000 standard-sized brick. The kilns are so connected with one another and with a system of large exhausters or "blowers" that as soon as one is filled and hermetically sealed, the cold air which it contains is drawn off, and hot air from a freshly burned kiln rushes in to take its place. In this way much heat is used for drying which would otherwise be lost. After drying for one week the brick are burned, with crude oil as fuel, for an equal length of time. The oil burners used are an especial invention of Mr. Soper, the Superintendent of the company. Sixteen of them are used in each kiln, and it is claimed that they effect a great saving of the fuel. The advantages of oil as a fuel are well shown in such a large plant. A great saving of labor and time is effected, and a product free from dust, ashes, smut or discoloring matter of any kind is obtained. From the kilns the brick are taken to the stock room, 710 feet long, 33 feet wide and 14 feet high, where several millions of front brick of many colors, as well as large supplies of "special shape" brick, are kept constantly on hands. A double railway track runs through this room, so that the brick can be loaded from either side with ease.

Nine different shades of red brick are made and three of brown, the latter color being produced by mixing a salt of manganese with the clay as it enters the steel rollers to be crushed. About 100 different forms of "special shape" brick are made, one or two of which are sold as high as 65 cents each. The patterns or dies for each of these are owned by the company, and are kept in a separate fire-proof building. The amount of capital invested in the plant is about $300,000.

One-half a mile east of the pressed-brick factory, the Chicago Brick Company are making soft mud brick in large numbers for the Chicago and other markets. These brick are made from the same stratum of fine grained, buff clay as are the pressed brick. At the pit this clay is ten feet in thickness and overlies the same kind of blue, marly clay as occurs at Hobart and Garden City. The brick are made on a Martin

machine at the rate of 35,000 daily for six months in the year. They are dried on pallets in sheds and are burned in permanent clamp kilns, of which seven, with a total capacity of 2,150,000, are in use. Wood is used for water-smoking and oil in burning, the two processes requiring twelve days.

One miles northeast of Chesterton, P. E. Anderson & Sons have been making brick and tile for ten years. For seven years the brick were made by hand, but since 1894 a Brewer brick and tile machine has been in use. A section of the pit at this yard is as follows:

1. Soil and surface—stripped..... 6 inches.
2. Yellow coarse-grained clay..... 5 feet.
3. Bluish marly clay with a few lime pebbles.....20 feet.
4. Bluish-gray marly clay, free from pebbles, pierced by bore .....35 feet.

The uppermost clay burns to a bright cherry red color, and makes a brick far above the average in quality. The next stratum, No. 3, burns pink and is mainly used in tile making. The lower stratum, No. 4, is very similar to the clay found at Hobart and burns to a cream color. An analysis of a mixture from strata Nos. 3 and 4 resulted as follows:

ANALYSIS OF BLUISH-GRAY CLAY AT CHESTERTON, INDIANA.

		Per Cent.
Silica	53.02	
Titanium oxide	1.30	
Alumina	10.72	
Combined water	2.21	
Clay-base and sand		67.25
Ferric oxide	2.54	
Ferrous oxide	2.22	
Lime	8.38	
Magnesia	5.28	
Potash	3.25	
Soda	.86	
Fluxes		22.53
Carbon dioxide	10.48	
		10.48
Total		100.26

The products made at this factory are dried in open air sheds and burned with wood. The brick are sold at the yard for $4.50 to $5.00 per thousand, and the four-inch tile at $11.00 per thousand. The clays

are suited for the making of pressed front brick, terra cotta and fireproofing. The blue marly clay is said to outcrop near City West in section 18 (37 north, 5 west), and also at the overhead bridge across the Michigan Central Railway one mile north of Chesterton.

THE CLAYS AND CLAY INDUSTRIES OF LAPORTE COUNTY.

Laporte County is in the third tier of counties from the western line of Indiana, and lies adjacent to the south border of the State of Michigan. Its northwestern corner is bordered by the shore of Lake Michigan for a distance of seven miles. The Kankakee River, flowing southwest, forms the larger portion of its southern boundary and receives from the county Mill Creek and several small tributaries. The area of the county is 562 square miles. Of this the northern third is somewhat broken and hilly and was formerly covered with timber. The central and southern portions contain about 200 square miles of fine prairie and a large area of Kankakee marsh land, much of which has been drained, and now forms excellent grazing and farming lands.

Numerous small lakes are scattered over the central or morainic portion of the county, and add much to the beauty of its scenery. The largest of these are Pine, Clear and Stone lakes, just northwest of Laporte, the county seat.

The limited time at my command allowed me to examine only the clays in the vicinity of Michigan City. Along Treaty Creek, northeast of that city, large deposits of an excellent bluish-gray marly clay come to the surface. Two miles east of the city Roeske Bros. have, a short distance from the creek, an extensive plant for the making of soft mud brick from a deposit of this and other clays. A section at their pit in September, 1897, showed as follows:

1.	Soil	6 inches.
2.	Buff sand	3½ feet.
3.	Reddish "loam"	2 feet.
4.	Yellow marly clay	2½ feet.
5.	Bluish-gray clay	16 feet.

After stripping the soil and a portion of the sand, the remainder, down to No. 5 of the section, is used in making red brick. The "loam," No. 3, can be used for lining ladles, etc., in iron furnaces. The same material is shipped in quantity to Chicago from near McCool, Porter County.* The layer of bluish-gray clay has been pierced by a bore to the depth of 40 feet without reaching its bottom. It burns to a whitish or cream color, and two-thirds of the output of the factory

*See page 71 of this volume.

are from it alone. The deeper the point from which the clay is obtained, the stiffer and more tenacious it is, and the better the quality of brick made from it. The following analysis of this clay, made by Dr. Noyes, shows its constituents to be practically the same as the deposit so extensively worked at Hobart for fire-proof products:

ANALYSIS OF BLUISH-GRAY CLAY FROM MICHIGAN CITY, INDIANA.

	Per Cent.	
Silica	50.47	
Titanium oxide	1.45	
Alumina	12.77	
Combined water	3.14	
Clay-base and sand		67.83
Ferric oxide	2.44	
Ferrous oxide	2.52	
Lime	8.17	
Magnesia	5.22	
Potash	3.70	
Soda	.73	
Fluxes		22.78
Carbon dioxide	9.80	
		9.80
Total		100.41

In the making of brick the clay, after being weathered for some time, is passed through a crusher, and then through a horizontal pug-mill, after which it is elevated by a belt-carrier to the top of a soft-mud machine. The brick are dried in sheds and burned in a peculiar "continuous" kiln. This kiln is divided into sixteen chambers, each capable of holding 16 to 17 thousand brick. After the fire is once started, the fuel, which is screened coal, is put in at the top of the chamber instead of at the bottom. Each chamber is connected by pipes with the ones adjacent to it, and the heat passes from chamber to chamber and "water-smokes" or dries the brick. In this way little heat is lost and the brick are burned for about 35 cents per thousand. Hocking Valley coal is used, costing $2.80 per ton at the plant, as it is claimed that Indiana coal is too dirty. Aside from their color, the brick made from the blue clay at this factory are of most excellent quality. When burned very hard they become a greenish cast and are then used for paving alleys, sidewalks, etc., and are sold at $8.00 per thousand, delivered. The ordinary quality bring $6.00 per thousand at Michigan City. Four and one-half millions of both grades were made in 1897.

As already noted, the same clay as is used by Roeske Bros., outcrops in quantity along Treaty Creek. The L. E. & W. Railway runs over some of the best deposits. There is thus room and excellent facilities for the erection in this vicinity of several large factories for the making of fire-proofing, terra cotta, pressed front brick and other products. Too high a percentage of fluxes are present for its utilization in making sewer pipe, paving brick and similar vitrified wares.

THE CLAYS AND CLAY INDUSTRIES OF ST. JOSEPH COUNTY.

St. Joseph County lies east of Laporte and is bounded on the north by the State of Michigan. It comprises an area of 477 square miles, the surface of which is diversified by prairies, marshes, "oak openings," and rolling timber lands. The "oak openings" are covered with a light sandy soil excellently suited to the raising of small fruits; the timberlands possess a subsoil of clay, covered with a rich dark soil, which under proper cultivation and rotation of crops, yields all the cereals in abundance. The prairies, both old and young—for the marshes are but incipient prairies—where properly drained, are unexcelled for the raising of any farm product except wheat, which in places winter-kills.

The Kankakee River rises about two miles southwest of South Bend, and flows in a southwesterly direction through the county. The most of the marsh land adjacent to it has been or is being drained. The St. Joseph River is the principal stream within the county; entering it a little north of the middle of the eastern boundary, flowing westerly about ten miles, and then northerly into the State of Michigan. On its great bend to the northward is the flourishing city of South Bend, possessing a population of almost 30,000, and noted for its manufactures, especially wagons and plows, which are shipped to all portions of the world.

The clays of St. Joseph County, which have been found the best suited for manufacturing, are in the immediate vicinity of South Bend. Along the St. Joseph River are thick deposits of a pearl-gray marly clay, exceedingly fine grained and plastic, which for many years has been made into light yellow building brick, or, when burned harder, into a darker, greenish-yellow paving brick. In the eastern part of the city, near the west bank of the river, C. Soens & Co., have been making these brick for a number of years. In October their pit was quite deep, and was partially filled with water, so that it was impossible to obtain a section of the most recently worked portion. On the western side the strata were as follows:

1.	Soil	8	inches.
2.	Sand, coarse-grained, reddish, impregnated and discolored with iron oxide	4½	feet.
3.	Gravel	3	feet.
4.	Sand—gray	3	feet.
5.	Clay, bluish-gray	15	feet.

From this bluish-gray clay, which in places is 50 feet thick, the brick are made. The deposit was evidently laid down in still water since it is wholly free from pebbles. Aside from the heavy stripping, which is a great draw-back to securing it in proper quantity, the clay is well suited to the uses to which it is put. In places small pockets of so-called "quicksand" occur, which lessen to some extent its value. The lower half of the clay stratum is better suited for burning the hard brick used for paving purposes. The clay effervesces very freely with acids, and probably contains 10 to 15 per cent. of the carbonates of lime and magnesia.

In the making of the brick the clay is first passed through a Wallace crusher and pug-mill, then through a Penfield stiff-mud, plunger machine, with a Freese "side-cut" attachment. They are dried on pallets and burned in temporary kilns, with both wood and coal for fuel, the former for water-smoking. The burning of ordinary brick from this clay requires about six days after the water-smoking process is finished. If paving brick are desired, about 48 hours longer are necessary. When burned the shorter time the brick in a large kiln appear of four different shades. The three or four outside layers are pinkish red; the next four or five a darker red; the next six or eight are yellow, while those in the center of the kiln are greenish-yellow and are said to be "vitrified," though not to the extent as are the average paving brick made of shale. Besides being darker in color, the brick from the center of the kiln are much smaller, being but 2x3⅜x7⅜ inches, as against 2½x4x8½ inches, the size of the standard building brick from the outer layers.

The output of the Soen's yard is about 25,000 daily for 5½ months in the year. The building brick bring $5.25 and the paving brick $7.50 per thousand delivered in the city.

On the east side of the river, about one-half mile north of the Soen's yard is another large yard owned and operated by Leeper & Longley. Their clay pit is in the second bottom or terrace of the St. Joseph River, and a section exposed in October, 1897, was as follows:

1.	Soil	8	inches.
2.	Sand and "loam"	4	feet.
3.	Coarse gravel	4½ to 7	feet.
4.	Bluish-gray marly clay	18	feet.

The clay has been proven by bores to be 50 feet thick. Brick made by this firm in 1888 were used in paving two blocks of a street that has been much used for nine years, and shows as yet but few signs of wear. Round down-draft kilns have been tried in burning the pavers, but did not prove satisfactory. The output is mainly a cream-colored, side-cut, building brick, made on a Penfield plunger machine, dried in an open yard, and burned with wood. Oil has been tried as fuel, but the claim is made that it stained the brick and so lowered their price. This yard, in 1897, had an output of three million, most of which were sold in South Bend.

The blue clay used by these yards ranges from 30 to 50 feet in thickness. It evidently covers a large area, since it overlies a bed of gravel, from which is secured the water supply of the city. The clay forms an impervious cover for this water-bearing stratum, and when pierced the water rises from two to ten feet above the surface. At the site of the old "Water Works" in the eastern part of the city, 32 wells have been put down 112 feet deep. An average section of these wells is as follows:

1. Soil and sand .....12 feet.
2. Blue clay .....40 feet.
3. Sand .....40 feet.
4. Gravel .....20 feet.

At the new Water Station, on North Michigan Street, are thirty wells, the average section of which is:

1. Soil and sand .....14 feet.
2. Gravel ..... 3 feet.
3. Clay .....30 feet.
4. Sand .....22 feet.
5. Gravel .....14 feet.

The brick made from this blue clay are hard, tough and durable. If the proper kilns and other facilities were erected, paving material of good quality could doubtless be made from it; but it is better suited for terra cotta, fire-proofing, flue linings and those numerous other products for which the ever increasing number of fire-proof buildings is creating a constantly growing demand.

About two miles southwest of South Bend are three factories which make soft-mud brick from a buff, porous, loamy "drift clay." This material, to a depth of four to seven feet, is free from carbonate of lime or lime pebbles, and burns to a handsome dark red. The brick made from it are hard, tough and durable, and above the average of those which go into the inner and side walls of buildings. The clay covers a large area in sections 21 and 22 (37 north, 2 east), being found on the surface of a ridge which rises 30 to 40 feet above the Kankakee marsh-land to the northward.

At the yard of Frank Fisher, in section 22, the clay used averages four feet in thickness and overlies a darker clay which contains pebbles of lime. Beneath the latter is the characteristic blue clay of the region. One-half mile southwestward, at the yard of John H. Shank, the porous buff clay is almost eight feet in thickness, and overlies a "hard pan" three feet in thickness, containing numerous pebbles. Beneath the latter is a bed of sand of unknown thickness. The three yards in this locality use soft-mud machines, dry on pallets and burn with wood. Their combined output in 1897 was about three millions, which were sold in South Bend at $5.50 per thousand. The buff clay is not suited for the making of drain tile, nor was I able to learn of any such tile being made in the county.

THE CLAYS OF JACKSON COUNTY.

At the earnest solicitation of Hon. Louis Schneck of Seymour, and several other gentlemen who were desirous, if possible, of locating a deposit of clay suitable for vitrified wares in Jackson County, I spent several days in the early part of July in an investigation of the clays along or within a few miles of the lines of the B. & O. S. W. and E. & R. railways, in that county. These lines of railway cross the county from east to west and pass through the only portion of it in which there is any likelihood of such clays being found close to the surface in commercial quantities.

Jackson County lies in the southern third of the State and about midway between its eastern and western borders. It comprises an area of 490 square miles. The East Fork of White River enters the county three miles west of its northeastern corner, and flowing southwesterly, divides its area into two triangular shaped districts, which are very unlike in their topography, and in the character of their soils. In the southeastern district the surface is mostly rolling, with low sandy hills 50 to 100 feet in height. The northwestern district is very broken, and is traversed by a number of ridges which rise from 250 to 300 feet above the plains of White River, and trend in a northeasterly and southwesterly direction. In places these spread out into broad table-lands, which possess a sub-soil of clay.

Few counties in the State can boast of better agricultural resources than Jackson. About three-fourths of its area is composed of tableland and river bottom and one-fourth clay land and sandy loam. No better crops of corn, oats and melons are produced in Indiana than are grown on the first and second bottom lands of White River west of Seymour; while the sandy loam soils of the southern part of the county are especially adapted to the raising of peaches and grapes.

The clays of Jackson County which are sufficient in quantity and of suitable quality for extensive manufacturing are the Knobstone shales which outcrop along White River southwest of Seymour and on the sides of a number of the ridges west and northwest of that city.

On the roadside, one-fourth mile east of White Creek, in the northwest quarter of section 32 (7 north, 5 east), is an outcrop of grayish soapstone or argillaceous shale, very fine grained, wholly free from grit, and, where weathered, very soft and plastic. It is overlain by a bowlder clay from three to ten feet in thickness, from which it is separated by a thin stratum of carbonate of iron. This shale deposit is about three miles north of the E. & R. Railway. There is no doubt but that it could be made into paving brick of excellent quality. It will also make pressed front brick, roofing tile and sewer pipe.

One-half mile farther west, in the northeast quarter of section 31 (7 north, 5 east), on the farm of Hon. L. Schneck, a brick and tile factory has been in operation since 1893. The brick are made from a buff loamy clay, evidently of glacial origin, the deposit of which covers 30 or more acres to a depth of 13 feet and overlies a stratum of sand, 12 feet in thickness. But five feet of the clay are used, since below that depth lime pebbles appear. These are not so many, however, but that they could be crushed with a dry-pan, and their harmful tendencies thus destroyed.

From this clay end-cut brick have been made on a Frey-Sheckler auger machine, which were used for paving alleys and street crossings in Seymour several years ago. They have since been subjected to much heavy traffic but show as yet no signs of wear.

A square down-draft kiln has been used in burning these brick and a handsome dark glaze was formed on their surface without the use of salt or other artificial substance. By mixing this surface clay with the above mentioned shale, one-half mile distant, in the proportion of two parts of the former to one of the latter, and then making the brick on a side-cut machine and burning in a standard round, down-draft kiln, there is little doubt but that paving brick of unexcelled quality would result. At present, however, the deposit is too far from transportation facilities and fuel to carry on the business on an extensive scale.

A deposit of true argillaceous shale, suitable for vitrified products, outcrops on the roadside in the southeast quarter of section 1 (6 north, 4 east), one mile west and two south of the brick factory above mentioned. It is ten feet in thickness where exposed and is overlain by bowlder clays.

West of the Station of Surprise, in the northwest quarter of section 9 (6 north, 4 east), there is an exposure of Waverly or "Knobstone"

shale in a ravine a few rods south of the E. & R. Railway. This bed of shale covers a large area in the ridges to the south and is capped with a thin covering of soil, bowlder clay, iron carbonate and geodes. The exposure is 15 feet in thickness, but the total thickness of the deposit was not determinable. It weathers into a soft, plastic, grayish clay. One hundred yards farther west the same shale is cut to a depth of 17 feet by the railway and is overlain with three feet of a mixture of the materials above noted.

One mile a little south of west of the above exposure, and 150 yards south of the railway on the land of John W. Lucas, east one-half of section 7 (6 north, 4 east), a bold bluff of the Knobstone shale rises 40 or more feet above the water of Salt Creek at its base. In this bluff are four parallel layers of large concretions of ironstone (siderite). One of these layers was three feet above the surface of the water on July 10th, 1897. Six feet higher was a second; eight feet higher a third, and two feet higher the fourth. Some of these concretions were flat, several feet across, and six to ten inches thick. Between these layers of ironstone the shale weathers in small quadrangular blocks.

This "knobstone" shale is called "soapstone" by the residents in that vicinity. The term "soapstone" rightfully belongs to the mineral steatite or talc, a magnesium silicate which does not occur in Indiana. However, the term is applied, in most parts of the State, to a very soft, fine-grained argillaceous shale, which is unctuous or greasy to the touch. The Knobstone shales, if properly weathered and then ground fine, will be found in every way suited for making vitrified products. In the bluffs above mentioned, and in others farther down the stream in the same and adjacent sections, they are found in practically inexhaustible quantities. Their proximity to a railway and to a good supply of water cannot be excelled. The only thing lacking is a fuel supply, which can be readily and cheaply obtained from the coal regions to the westward through which the railway passes.

South of Freetown, in sections 18, 19 and 30 (6 north, 4 east), many outcrops of the Knobstone shale occur in the hillsides. In general they are overlain with layers of geodes and ironstone clays. The latter, when exposed for some years to rain and frost, weather into small, quadrangular, brownish pieces called "creek gravel." This is often used in repairing roads, since but little true drift or water-worn gravel is found in the region.

Taking into consideration its location, quantity and quality, the best deposit of shale in Jackson County for vitrified products is at a point called "Blue Lick" on the south side of the B. & O. S. W. Railway in

the northeast quarter of section 6 (5 north, 5 east). The deposit is 50 or more feet thick, and consists of a soft, fine-grained, argillaceous variety of the Knobstone shale. It is wholly free from grit and lime impurities, contains but few concretions of ironstone, and weathers into a soft, unctuous, plastic clay. It outcrops along the ridge for a distance of several hundred yards and forms the main body of the ridge throughout its full width. The railway formerly ran at the very foot of the outcrop, but the shale weathered and fell down over the track to such an extent that the latter had to be moved several rods to the north. A railway switch can be put in with little expense, and cheap fuel can be obtained from the coal mines of Daviess and Knox counties.

Believing that this deposit of shale was in every way worthy of utilization for paving brick, I had a chemical analysis of it made by Dr. Noyes. The results of that analysis are here given side by side with those of an analysis, by the same chemist, of an average sample of the material used in the making of paving brick by the Wabash Clay Company of Veedersburg, Indiana, whose output is of excellent quality and the largest in the State.

ANALYSES OF SHALES FROM "BLUE LICK," JACKSON COUNTY, AND FROM VEEDERSBURG, FOUNTAIN COUNTY, INDIANA.

	BLUE LICK. Per Cent.		VEEDERSBURG. Per Cent.	
Silica	59.64		59.55	
Titanium oxide	1.05		1.00	
Alumina	19.14		16.21	
Combined water	4.36		5.62	
Clay-base and sand		84.19		82.38
Ferric oxide	3.39		2.18	
Ferrous oxide	4.20		7.13	
Lime	.26		.75	
Magnesia	2.31		1.58	
Potash	3.53		2.81	
Soda	.80		.28	
Fluxes		14.49		14.73
Carbon dioxide	.35		3.15	
		.35		3.15
Total		99.03		100.26

From these analyses it will be seen that the Blue Lick shale contains almost three per cent. more alumina, and is, for that reason, that much stronger and better than the one from Veedersburg.

In the report on the "Clays and Clay Industries of the Coal-bearing Counties of Indiana," published in the 20th Annual Report of this Department, the *average composition* of *the shales* used by *ten* of the leading paving brick and sewer pipe factories in Ohio was taken as a *standard of comparison* for the composition of Indiana shales suitable for vitrified products. That average showed the presence of

Clay-base and sand	84.78 per cent.
Fluxes	13.22 per cent.

By comparing with this average the composition of the "Blue Lick" shale as follows:

Clay-base and sand	84.19 per cent.
Fluxes	14.49 per cent.

we find a *very close* approximation to the standard of comparison and prove the chemical fitness of the shale for the making of paving brick and sewer pipe.

Edward Orton, Sr., in a paper on "The Clays of Ohio, Their Origin, Composition and Varieties,"* speaks of the division of the Waverly shales of that State which correspond to the Knobstone shale of Jackson County "as a great stratum 160 to 450 feet in thickness, consisting of light colored blue or gray shales that have unlimited possibilities of service in the practical way, but which have been almost completely ignored thus far. Their day, however, is sure to come. Their adaptation to paving block manufacture in particular will be recognized and it will be at once shown as soon as it is used that no better material for this purpose is found in our entire series than this shale can supply."

The use of brick for paving streets and roadways has as yet hardly begun in Indiana, yet, between 1890 and 1896, twenty-seven towns and cities (not including Indianapolis) of the State expended for paving brick and block alone $884,667, and for brick pavements $2,416,131. Of the sum expended for the pavers, no less than $647,022 were sent to the States of Ohio and West Virginia for brick, every one of which could have been made in Indiana and laid down at a handsome profit in the cities using them, for a less price than they were shipped in from other states.

At Seymour, several million brick have been brought from Ohio and laid down in the streets. These cost from $10.00 to $14.00 per thousand. The raw material for making them was to be found in abundance by the side of a railway within six miles of the spot where they were used. The extra amount paid for transportation of these brick would

* Geol. Surv. of Ohio, VII, 1893, 58.

have paid for a good plant for manufacturing them which, in the future, would have furnished labor for many hands. No paving brick factory exists at present in southern Indiana, except the one at Evansville. All the towns of that region of a thousand or more inhabitants, will within ten years, use brick for paving their leading streets. No cheaper or more durable pavement can be put down. All things considered, no better point exists for locating the factory to supply the brick for these future pavements, than at "Blue Lick," in Jackson County.

REMARKS ON THE CLAY ANALYSES.

The following analyses of clays were made especially for this report by Prof. W. A. Noyes, of the Rose Polytechnic Institute, of Terre Haute, Indiana. The analysis is, in each case, based on the substance dried at 135° C. The portions marked insoluble were found to be insoluble in acids and sodium carbonate.

No. 1. Average of the material used in the making of terra cotta lumber at Hobart, Lake Co., Indiana. See p. 128.

No. 2. Average sample of the upper portion of the bed of bluish-gray marly clay at Garden City, Porter Co., Indiana. See p. 133.

No. 3. Average sample of the bluish-gray marly clay from the pit of P. E. Anderson & Sons, Chesterton, Porter Co., Indiana. See p. 137.

No. 4. Average sample of the bluish-gray marly clay from the pit of Roeske Bros., Michigan City, Indiana. See p. 138.

Clays Nos. 1 to 4, inclusive, will be found in every way suitable for making terra cotta lumber, solid fire proofing, flue linings, foundation brick, under-roofing, column and girder covering, etc., etc.

No. 5. Average sample of Knobstone shale from "Blue Lick," Jackson Co., Indiana. Suitable for paving brick, sewer pipe, roofing tile and other vitrified products. See p. 146.

Chemical Analyses of Five of the Clays Mentioned in the Preceding Paper.

	1		2		3		4		5	
	Total.	Insoluble.	Total.	Insoluble.	Total.	Insoluble.	Total.	Insoluble.	Total.	Insoluble.
Silica (SiO_2)	50.56	31.35	50.37	35.62	53.02	35.21	50.47	30.20	59.64	30.22
Titanium Oxide (TiO_2)	1.00		.65		1.30		1.45		1.05	
Alumina (Al_2O_3)	13.11	3.06	9.93	1.95	10.72	2.94	12.77	2.51	19.14	1.61
Combined water (H_2O)	2.76		1.50		2.21		3.14		4.36	
Clay-base and sand	67.43		62.45		67.25		67.83		84.19	
Ferric Oxide (Fe_2O_3)	2.98		2.10		2.54		2.44		3.39	
Ferrous Oxide (FeO)	2.32		2.05		2.22		2.52		4.20	
Lime (CaO)	7.87		10.26		8.38		8.17		.26	
Magnesia (MgO)	5.06	2.14	6.26	2.35	5.28	1.65	5.22	1.38	2.31	.60
Potash (K_2O)	3.74		3.04		3.25		3.70		3.53	
Soda (Na_2O)	.70		.79		.86		.73		.80	
Fluxes	22.67		24.50		22.53		22.78		14.49	
Carbon dioxide (CO_2)	9.62		12.50		10.48		9.80		.35	
Total	99.72	39.55	99.45	39.92	100.26	39.80	100.41	34.09	99.03	32.43

Rational Analyses of Above Clays.

Quartz	23.61		28.78		24.89		21.39		25.57	
Feldspathic detritus	15.94		11.11		14.91		12.70		6.86	
Calcium carbonate	14.05		18.32		14.86		14.59		.....	
Magnesium carbonate	6.54		8.48		7.60		6.42		0.67	
Clay substance	39.86		33.28		37.74		44.90		66.90	

Statistics of the Clay Industries of Northwestern Indiana.

Name of Firm or Individual.	Location.	Capital Invested.	Products.	Machinery Used.	How Dried.	Value of Output in 1897.	No. Hands Employed.	Av'ge Daily Wages.	No. Months Worked.
Fowler Tile Works.	Fowler.	$10,000	Drain tile.	Potts disintegrator and pug mill; Freese brick and tile machine.	In sheds with exhaust steam.	.....	15	$1 45	7
Lochiel Tile Works.	Lochiel.	$7,000	Drain tile.	"Adrian" brick and tile machine.	Sheds by air.	.....	13	$1 25	6
Earl Park Elevator and Tile Co.	Earl Park.	$20,000	Pressed brick, ordinary brick, and drain tile.	Potts disintegrator; 9-foot dry pan; "Little Wonder" brick and tile machine; Boyd & White brick machine.	On floors with steam.	$7,000	20	$1 25	7
John Lawson.	Oxford.	$5,000	Drain tile.	Frankfort crusher; Hoosier tile machine.	Sheds by air.	$3,500	4	$1 30	6
Wm. Lawson.	Otterbein.	$6,000	Drain tile.	"Little Wonder" brick and tile machine.	In sheds with steam.	$3,500	8	$1 30	7
Darroch Bros.	Morocco.	$3,000	Drain tile.	Crusher; pug mill, and "Little Wonder" brick and tile machine.	In sheds by air.	$1,500	8	$1 25	7
M. E. Handley.	Beaver City.	$4,000	Drain tile and brick.	Frankfort crusher; Hoosier brick and tile machine.	In sheds by air.	$2,150	9	$1 25	6
Stucker & Coovert.	Mt. Ayr.	$3,000	Drain tile.	Freese brick and tile machine.	In sheds by air.	$3,750	6	$1 25	6

J. H. Haynes Co.	Brook.	$16,000	Terra cotta lumber; flue lining; solid fire-proofing; drain tile; ordinary brick, etc.	Crusher; pug mill; Adrian brick and tile machine.	In sheds by air.	$15,000	16	$1 50	7½
Goodland Tile Co.	Goodland.	$5,000	Drain tile, hollow brick and ordinary brick.	Crusher, pug mill and Adrian brick and tile machine.	In sheds by air.	$3,000	12	$1 35	7
A. E. & H. A. Alter.	Rensselaer.	$4,000	Drain tile.	Potts disintegrator; New Departure tile machine.	In sheds by air.	$3,750	7	$1 25	7
John Kohler & Son.	Rensselaer.	$5,000	Ordinary brick and drain tile.	Freese tile machine; "Ander-Chief" brick machine.	In sheds by air.	$3,500	10	$1 25	7
A. C. Robinson.	Pleasant Grove.	$2,500	Drain tile.	Crusher, pug mill and "Little Wonder" brick and tile machine.	In sheds by air.	$2,880	7	$1 25	7
Samuel Bowman.	Remington.	$5,000	Drain tile.	Potts disintegrator; Adrian brick and tile machine.	In sheds by air.	$2,375	6	$1 25	7
P. D. Clark.	Lowell.	$5,000	Ordinary brick and drain tile.	Crusher and "Little Wonder" brick and tile machine.	In sheds by air.	$5,000	8	$1 25	6
H. W. Wise.	Crown Point.	$2,500	Common brick and drain tile.	Penfield brick and tile machine.	Open yard.	$2,500	9	$1 25	6
Hobart Terra Cotta Lumber Co.	Hobart.	$60,000	Terra cotta lumber; floor arching; wall furring, etc.	Pug mill; Adrian brick machine; Vaughn & Taylor sewer pipe press.	Tunnel dryers with steam.	$60,000	46	$1 37	12

Statistics of the Clay Industries of Northwestern Indiana.—Continued.

Name of Firm or Individual.	Location.	Capital Invested.	Products.	Machinery Used.	How Dried.	Value of Output in 1897.	No. Hands Employed.	Av'ge Daily Wages.	No. Months Worked.
Kulage Brick and Tile Works.	Hobart.	$100,000	Pressed front brick.	Nine-foot dry pan; two "Challenge" and one "Triumph" brick machines.	.....	Plant not completed.	.....	.....	12
Garden City Brick Works.	Garden City Ind.	$30,000	Ordinary brick.	Crusher, pug mill and Chambers' stiff-mud, end-cut brick machine.	Tunnel dryers with steam.	$6,250	14	$1 30	4
H. Folsom.	Hebron.	$1,200	Ordinary brick.	Quaker brick machine	Open yard.	$600	4	$1 25	6
Kenny Bros.	Hebron.	$5,000	Drain tile.	Crusher, and A. C. Hocket tile machine.	Sheds by air.	$1,188	4	$1 25	6
Lambke Bros.	Valparaiso.	$8,000	Common brick.	Potts disintegrator; Williams pulverizer, and Creager soft-mud machine.	Sheds and pallets.	$7,500	20	$1 37	4
Coovert & Clevenger.	Valparaiso.	$2,500	Drain tile.	Two crushers; Ohio auger tile machine.	Sheds by air.	$3,000	5	$1 50	5
Chicago Hydraulic Press Brick Co.	Porter.	$300,000	Pressed front and special design brick.	Three crushers, three disintegrators, four hydraulic brick presses.	....	$175,000	75	$1 50	12
Chicago Brick Co.	Porter.	$15,000	Common brick.	Two pug mills, and Martin soft mud brick machine.	Sheds and pallets.	$25,000	35	$1 50	6

P.E. Anderson & Sons.	Chesterton.	$5,000	Common brick and drain tile.	Brewer brick and tile machine.	In sheds, by air.	$5,500	5	$1 40	6
Roeske Bros.	Michigan City.	$15,000	Common brick.	Crusher, pug mill, and Cramer soft mud machine.	Sheds and pallets.	$20,000	35	$1 37	6½
C. Soens & Co.	South Bend.	$8,000	Common brick.	Wallace crusher and pug mill; Penfield plunger, side-cut machine.	Sheds and pallets.	$12,000	22	$1 37	6½
Leeper & Longley.	South Bend.	$12,000	Common brick.	Pug mill; Penfield No. 10 plunger machine.	Open yard.	$17,000	30	$1 50	6
Frank Fisher.	South Bend.	$4,000	Common brick.	"Anderson Chief" soft mud machine.	Sheds and pallets.	$5,500	9	$1 50	6
Edw. Perkins.	South Bend.	$2,500	Common brick.	Quaker machine.	Sheds and pallets.	$3,000	7	$1 50	4
Jno. H. Shank.	South Bend.	$6,000	Common brick.	Quaker machine.	Sheds and pallets.	$7,500	14	$1 50	6
Elmer F. Hoover.	LaPorte.	$2,000	Common brick.	Hand made.	Open yard.	$3,200	10	$1 40	4