THE

Silver Creek Hydraulic Limestone

OF

Southeastern Indiana.

BY C. E. SIEBENTHAL.

1900.

LETTER OF TRANSMITTAL.

Bloomington, Ind., January 10, 1901.

Dear Sir—I have the honor to transmit herewith my report upon the "Silver Creek Hydraulic Limestone," written in 1899 and embodying the results of field work done in that year, but recently gone over and brought down to date. I take pleasure in acknowledging the services of Messrs. H. M. Adkinson and F. H. H. Calhoun, graduate students at the University of Chicago, who generously gave their assistance in the gathering of the data for the paper. The thanks of the Survey are also due to Prof. Stuart Weller, of the University of Chicago, for valuable assistance in the paleontological part of this report.

Respectfully submitted,

C. E. SIEBENTHAL.

Prof. W. S. Blatchley, State Geologist.

THE SILVER CREEK HYDRAULIC LIMESTONE OF SOUTHEASTERN INDIANA.

By C. E. Siebenthal.

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I. STRATIGRAPHY.

Historical Resume.

1827.—The earliest work upon the stratigraphy of this region which has come under the notice of the writer is that of Increase A. Lapham in 1827*. Lapham describes the lowest rocks at the Falls of the Ohio as consisting of limestone, near the top of which is intercalated a bed of hydraulic limestone or "water limerock," overlain by a thin layer of coarse-grained limestone, "probably oolite or roestone," and that overlain in turn by the black shale. He

* On the Geology of the Vicinity of the Louisville and Shippingsport Canal, A. J. S., Vol. XIV, 1828, pp. 65–69.

describes the hydraulic limestone thus: "Its color is bluish gray; structure conchoidal; adheres slightly to the tongue; emits an argillaceous odor when breathed upon; and it effervesces with acids." He mentions its use in the masonry of the canal.

1841.—James Hall,* speaking of the limestone at the Falls of the Ohio, says: "The upper part of the limestone, so far as lithological characters are concerned, is a continuation of the Helderberg group, the Onondaga salt group having thinned out almost entirely, having in fact no representation except a thin layer of water lime, which is seen at the Falls of the Ohio, and the canal below Louisville, but in other localities is of less importance and often scarcely to be recognized."

1843.—Dr. A. Clapp† in a communication, opposes Professor Hall's view that the waterlime represents the Onondaga salt group, and gives it as his belief that the waterlime is the equivalent of the Helderberg. The black slate he considers of Marcellus age.

1843.—D. D. Owen‡ correlates the black slate with the Marcellus shale and the limestone below, with the Helderburg of New York.

1843.—H. D. Rogers, in discussing Owen's paper, says that he could recognize no Hamilton in the west. He correlates the black shale with the Marcellus, and mentions finding *Orbicula corrugata* and a *Lingula* at New Albany.

1847.—Yandell & Shumard‖ follow Dr. Clapp in dividing the section at the Falls of the Ohio into the coralline, the shell, and the upper limestones and the black shale, subdivided thus:

Black slate	104 feet.
Upper limestone—	
Subcrystalline limestone	8 feet.
Water limestone	12 feet.
Shell limestone—	
Subcrystalline, with shells and trilobites	16 feet.
Coralline limestone—	
Upper coralline	20 feet.
Lower coralline with Catenipora	20+ feet.

The authors agree with M. de Verneuil, whom they cite as visiting the locality in company with them, in placing the line between the Silurian and Devonian at the parting between the upper and lower coralline limestones. The limestones lying between this line and the black slate are considered from their fossils as representing

* Notes Upon the Geology of the Western States, A. J. S., Vol XLII, 1842, p. 58.
† Proc. Phil. Acad. Sci., Vol. I, 1843, pp. 177-178.
‡ On the Geology of the Western States, A. J. S., Vol. XLV, 1843, pp. 151-152, 161-162.
‖ Contributions to the Geology of Kentucky, Louisville, Ky., 1847.

the Onondaga, the Corniferous and the Hamilton, and the Black slate is recognized as the equivalent of the Genessee shale.

1857.—Maj. Sidney S. Lyon,* in describing several species of crinoids from the crinoidal limestone, gives its thickness as varying from 4 to 8 feet. Underlying this is the hydraulic limestone, varying from 18 feet at the falls to 4 or 6 inches on Bear Grass Creek. He notes a conglomerate bed of ferruginous gravel in the lower part of the crinoidal limestone and another at the base of the hydraulic limestone.

1859.—Lyon and Casseday,† in describing *Megistocrinus rugosus* give it as occurring in rocks a few feet below the black slate on Bear Grass Creek, "in Devonian rocks of the age of the Hamilton Group." As near as may be judged from the description, the location must have been in the crinoidal limestone. This is the first reference of these rocks to the Hamilton.

1860.—Maj. Sidney S. Lyon‡ divides the beds at the Falls according to their characteristic fossils as follows:

Black slate	50 to 100 feet.
Encrinital limestone	8 feet.
Hydraulic limestone	20 feet.
Spirifer cultragulatus bed	3 feet.
Nucleocrinus bed	2 feet.
Spirifer gregaria and Turbo beds	10 feet.
Coral beds	10 feet.
Catenipora escharoides beds	40 feet.

The geological age of these beds is not discussed except that the author suggests that the Subcarboniferous age of the black slate is indicated by the goniatites of Rockford, Indiana. It has since been shown that the goniatites were derived from a stratum overlying the black shale. The author points out that the hydraulic limestone, to which he assigns a thickness of twenty feet at the Falls, has thinned out to four inches at a point three miles to the southeast, and states that all of the beds from the Encrinital limestone to the Catenipora limestone thin out and disappear within a distance of 20 miles south of Louisville.

1874.—Prof. W. W. Borden‖ gives the following succession of the rocks in Clark and Floyd counties:

*Kentucky Geological Survey, Vol. III, p. 484.
†A. J. S., Second Series, Vol. XXVIII, 1859, p. 244.
‡Trans. St. Louis Acad. Sci., Vol. I, 1863, pp. 612-621.
‖Geological Survey of Indiana, 1873, pp. 134-189.

New Albany black slate	104 feet.
Crinoidal limestone	3½ to 4 feet.
Hydraulic limestone	14 to 16 feet.
Corniferous limestone	22 feet.

The limestone below the Hydraulic limestone is placed in the Corniferous and the Hydraulic and Crinoidal limestones are placed in the Hamilton, to which the New Albany Black slate is provisionally added. (See section, loc. cit., p. 172.)

1875.—Professor Borden in the report on Scott County* notes the occurrence in the New Albany Black shale, of *Leiorhynchus quadricostatum* Hall, *Chonetes lepidus* Hall, and *Tentaculites (Styliola) fissurella* Con., and for this reason refers it to the Genessee which he makes a subdivision of the Hamilton period. From the Crinoidal limestone he cites *Tropidoleptus carinatus* Con., and *Chonetes coronatus* Con., which causes him to place that limestone, together with the Hydraulic limestone, in the Hamilton proper.

1879.—James Hall† reviews the work of previous writers, and gives a tabulated list of the fossils occurring in the Devonian limestones at the Falls of the Ohio, and their representation in the Hamilton and Chemung groups of New York. The list clearly substantiates Mr. Hall's view that the Encrinital and Hydraulic limestones are of Hamilton age. Out of a total of 90 species occurring in the Encrinital and Hydraulic limestones, 55 are represented in the Hamilton of New York, 15 are represented in the Corniferous of New York, and 14 are common to both Corniferous and Hamilton.

The upper limit of the Corniferous is characterized by the abundant presence of *Spirifer acuminatus*.

The New Albany Black shale, on paleontologic and stratigraphic grounds, is referred to the Genessee.

1897.—Dr. August Foerste‡ describes the occurrence of New Albany Black shale, the Crinoidal limestone, the Hydraulic limestone and the Corniferous, at various points in the vicinity of Charlestown, Indiana, but makes no effort at their correlation. At the cement quarry, one and one-half miles west of Charlestown, he notes that the lower part of the Crinoidal limestone contains many small rounded black pebbles.

1899.—E. M. Kindle‖ gives numerous sections and lists of fossils from many localities in the Devonian and Subcarboniferous of

* Geological Survey of Indiana, 1874, pp. 112-134.

† Palaeontology of New York, Vol. V, Part II, pp. 139-154.

‡ Indiana, Dept. Geol. and Natural Res., 22d Ann. Rep., pp. 213-288.

‖ Bulletins of American Palaeontology, No. 12. The Devonian and Lower Carboniferous Faunas of Southern Indiana and Central Kentucky.

southern Indiana, some of them within the area which we have under consideration. A brief résumé of the contentions which have arisen over the ages of the various formations is followed by the correlations which the author thinks best justified.

The Knobstone is divided into two formations. The upper one, consisting of sandstones and arenaceous shales, is found by its fauna to be the equivalent of a similar formation further north in Indiana, described by Hopkins* under the name of Riverside sandstone, and consequently that name is adpoted. The lower member, consisting of blue shales, had previously been named the New Providence shale. Lists of fossils are given from both members which show their affinities to be of the closest kind. The Knobstone as a whole is found to be the faunal equivalent of the Waverly sandstone of the Ohio section, and the Osage group of the Mississippian section. Selecting the most abundant and characteristic fossil in each, the upper member or Riverside sandstone is denominated the *Reticularia pseudolineata* zone, and the lower or New Providence shale, the *Rhipidomella oweni* zone of the Eocarboniferous.

The Rockford limestone holds a surprisingly rich fauna, the cephalopoda comprising one-third of the whole. Attention is called to its adventitious character. From the fact that in Kentucky a bed of shelly limestone, carrying a characteristic New Providence shale fauna, occupies a position between the Black shale and the New Providence shale, in other words, occupies the horizon of the Rockford limestone, the author argues the contemporaneity of the Rockford limestone and the lower part of the New Providence shale. On lithologic, stratigraphic and paleontologic grounds, the author rejects Meek's correlation with the Choteau limestone of Missouri, and makes it the equivalent of the Lithographic or Louisiana limestone of the later Missouri reports.

The formation is characterized as the *Munsteroceras oweni* zone the Eocarboniferous.

The New Albany Black shale, on account of its meagre and undiagnostic fauna, has offered the most difficult problem in correlation of all the Devonian. The weight of evidence, however, seems to most closely ally it with the Genessee shale of the New York section. It is made the *Styliola fissurella* zone of the Mesodevonian.

The Sellersburg beds, as proposed by the author, include the upper part of the Devonian limestone from the New Albany Black

*Indiana Department of Geology and Natural Resources, 20th Annual Report, 1895, p. 287.

shale down to the bottom of the lowest beds worked at the cement quarries in the vicinity of Sellersburg. The formations comprised within these limits are the cement beds and a thin, overlying bed of limestone. Faunally, these two members are very closely related, and they are both referred to the Hamilton. They form the *Spirifer granuliferus* zone of the Mesodevonian.

The Jeffersonville limestone is a term introduced by the writer to comprise the lower part of the Devonian, lying between the Sellersburg beds and the Silurian. The fauna has very close affinities with the Corniferous. It is denominated the *Spirifer acuminatus* zone of the Devonian.

Stratigraphy and Paleontology.

Though this investigation had to do with the members of the Devonian only, for the sake of completeness the members of the underlying and overlying formations, within the area comprised by the accompanying map, have been delineated upon it, and short descriptions are incorporated herein. The geological section with the New York and Mississippian equivalents as ordinarily given is as follows:

Subcarboniferous—	
Knobstone	Kinderhook.
Rockford limestone	Choteau.
Devonian—	
New Albany Black shale	Genessee.
Sellersburg limestone	Hamilton.
Silver Creek Hydraulic limestone	Hamilton.
Jeffersonville limestone	Corniferous.
Pendleton sandstone	Schoharie.
Silurian—	
Upper Silurian	Niagara-Clinton.
Lower Silurian	Hudson River.

Of these formations several are omitted from the map for the reason that their outcrops are too limited in extent to be delineated upon a map of that scale. Such formations may be located closely enough by the line of parting between the overlying and underlying formations. Notably, the Rockford limestone may be located by the line separating the Knobstone and the New Albany shale. The Sellersburg limestone has uniformly been included with the Silver Creek limestone where that formation has been delineated. The eastern border of the Silver Creek limestone has usually been found in a flat plain, without outcrops, and covered with drift. In such places by

means of well sections it was possible to do no more than distinguish between the limestone and the shale, and the parting as mapped is such, thus throwing the Sellersburg and Clear Creek limestones in with the Jeffersonville limestone. The Pendleton sandstone has not been found within the limits of this region, but what is probably that formation has been found not far north, and may be found here. Its proper horizon would be the parting between the Niagara and the Jeffersonville limestones.

The Knobstone was originally included by D. D. Owen with the next overlying formation under the name Calcareo-siliceous or Encrinital limestone series. It was first considered separately by Owen and Norwood* who considered "the formation of the knobs" to be the basal formation of the Carboniferous. The use of the word Knobstone to designate this formation first occurred in 1859 in the revised reprint of D. D. Owen's Geological Reconnoissance of Indiana. The formation consists of a series of alternating, friable, arenaceous shales and sandstones, ranging from 350 to 600 feet in thickness. The outcrop reaches its maximum development in Morgan, Brown and Jackson counties, where it varies from 30 to 40 miles in width. To the south it narrows rapidly, and west of the region covered by this report is in some places not over two miles in width. It is in the main unfossiliferous, but at intervals there are intercalated calcareous septaria and lenticular beds of limestone which hold rich faunas. In rare places the Knobstone itself is fossiliferous. Recently considerable work has been done upon the paleontology of this formation, the results of which are given in the paper by E. M. Kindle, which has been summarized above.

The Rockford Goniatite limestone was first noted by Owen and Norwood in the paper cited above, and referred by them to the Devonian. It is a thin but very persistent bed of ferruginous limestone and calcareous shale of limited areal extent, coming between the Knobstone and the New Albany shale and furnishing the famous fossils which led, after much controversy, to its recognition as the base of the Carboniferous.

The New Albany Black shale was named by Prof. W. W. Borden in 1873, from the city of that name, where its thickness was investigated by borings by Dr. Clapp, and found to be 104 feet. In other places it is reported as much as 140 feet, but in the region of the cement rock (where its whole thickness is not exposed) it varies from nothing to about 60 feet.

* Researches Among the Protozoic and Carboniferous Rocks of Central Kentucky, made during the summer of 1846, by D. D. Owen, M.D., and J. G. Norwood, M.D., St. Louis, 1847.

It is a black, fissile, in places sheety, shale, which sometimes carries enough bituminous matter to make it burn freely. It of course does not burn to ashes, but when the oil is all burned off the shale is left with a reddish, or drab, baked appearance. For a more detailed account of the black shale the reader is referred to the excellent article by Mr. Hans Duden in the Twenty-first Annual Report of this Department.

The earlier correlation of this shale was with the Marcellus of New York, but in time it came to be referred to the Genessee of New York. An able discussion of the whole matter is given by Mr. Geo. H. Girty of the U. S. Geological Survey in an article in the American Journal of Science for 1898, Vol. IV, pp. 384-395.

In the vicinity of Lexington, Professor Borden found the following fossils in the Black shale, viz.: *Leiorhynchus quadricostatum* Hall; *Chonetes lepidus* Hall; *Tentaculites (Styliola) fissurella* Hall; and *Cardiola radians*, all Genessee forms.

The Sellersburg limestone is that bed of white to gray crystalline limestone which overlies the cement rock, which underlies the New Albany Black shale, and which by various writers has been alluded to as the Crinoidal limestone, and to distinguish it from a crinoidal layer in the Corniferous, as the Upper Crinoidal limestone. It is an important formation, and while not very thick it is very persistent, stretching from the Falls as far north as the writer has investigated, that is, to the lower edge of Decatur County. In that region a stone occupying a similar stratigraphic position has been quarried and marketed under the title of the brown stone, or the North Vernon Blue stone. It seems undesirable to perpetuate this name, however, as more than one formation has been sold under that title, and moreover, the stone as sold is not the typical facies of the formation.

Recently E. M. Kindle, in the paper referred to above, has proposed the name Sellersburg beds to include both the Crinoidal and the Hydraulic limestones. The disparity in chemical composition and lithologic appearance of these two formations warrants the use, we think, of separate names, and for convenience of treatment we have adopted different names in this report. We have retained the term Sellersburg limestone, but have limited its application as noted in the beginning of this paragraph.

Any outcrop or quarry in the vicinity which exposes both the Black shale and the cement rock will also expose from five to eight and rarely 10 feet of the Sellersburg limestone. In rare instances, however, the Sellersburg limestone is absent from the section, notably in those given for the *Ohio Valley Cement Co.* quarry and the quarry

of the *Standard Cement Co.* In such cases there is an excessive thickness of the Silver Creek limestone, which comes about by the addition on top of several feet of the calcareous cherty bastard rock. It indicates that in localities the deposition conditions of the cement rock prevailed on through the time of deposition of the Sellersburg limestone.

It will be noticed in the detailed sections in the pages following that at or near the base of the Sellersburg limestone there is generally a conglomeritic band marked by small shining black pebbles, of which the interior is a dull drab color. In very rare instances fragments of fossils are found in these pebbles, notably the characteristic *Chonetes yandellus.* Frequently the basal portion of the limestone is sandy and occasionally there is a definite arenaceous stratum intercalated between the cement rock and the Sellersburg limestone, and in this the pebbles will be especially abundant. These pebbles are clearly rounded and waterworn, and, coming as they do, in the sandy matrix, the natural conclusion is that they represent a basal conglomerate formed by the beating of the waves upon the "bastard" layers of the cement rock, wearing away the more calcareous portions and rounding down the siliceous concretions to the shape of the pebbles, at the same time staining them a dark color. However, the chemical composition of the pebbles presents a serious objection to this view. Qualitative tests show that they are highly phosphatic. But the concretionary masses in the "bastard" layers of the cement rock are siliceous, sometimes pure flint, and are not phosphatic to more than a barely appreciable extent. For the present the origin of the pebbles must remain in abeyance.

In this connection it is interesting to note that the black nodular phosphates of Tennessee described by Hayes* have pebbles very much as these, and occupy very much the same stratigraphic position. Also that the phospate beds of North Arkansas, described by Dr. J. C. Branner,† have just such pebbles which are the source of the phosphate.

These phosphatic pebbles are of economic interest, but not of economic importance, since it is not probable that they will be found within the State in sufficient abundance to justify exploitation for fertilizing purposes.

At the top of the limestone and coming between that and the black shale there is almost invariably a bed of iron ore about two inches in thickness. In many places this is conglomeritic, notably

*Sixteenth Ann. Rep. U. S. G. S., 1894-5, Part IV, pp. 610-630, Seventeenth Ann. Rep. U. S. G. S., 1895-6, Part II, pp. 519-550.

†Transactions A. I. M. E., Vol. XXVI, 1896, pp. 580-598.

in the side of the cut which faces the depot at Lexington, Scott County. Here the small pebbles are imbedded in two inches of solid bright iron pyrites. In other places the iron bed is replaced by a gritty calcareous stratum, similar in all respects to that beneath the Sellersburg limestone, and bearing pebbles indistinguishable from the pebbles in that formation, except that usually this conglomerate is more stained with iron than that at the base of the limestone. In one place, at Hess's Ford on the Muscatatuck River, among the pebbles in the upper conglomerate was one of a crystalline texture, which is plainly a stranger to Indiana. It might have found its way there in the maw of some fish, however.

In another place the shale is separated from the Sellersburg limestone by a stratum of iron ore one inch in thickness. The top of the limestone is wrinkled or wavy and in the hollows there is collected conglomerate.

As has been shown in the review of the literature on the preceding pages, the earlier custom was to refer the whole limestone series to the Upper Helderberg or Corniferous of New York. Lyon and Casseday were the first to refer rocks (which we doubtfully identify with the Sellersburg limestone) to the Hamilton. But in 1874 Prof. W. W. Borden,* as above noted, gave a table of correlation of which the following is part:

New Albany Black shale	?
Crinoidal limestone	Hamilton Group.
Hydraulic limestone	
Corniferous limestone	Corniferous.

In the text he makes it clear that he is in doubt about the age of the black shale because of the lack of fossils. But one year later† he cites *Leiorhynchus quadricostatum* Hall, *Chonetes lepidus* Hall, *Tentaculites (Styliola) fissurella* Hall and *Cardiola radians*, all Genessee species, from the New Albany Black shale and refers it to the Genessee period of the Hamilton group. From the Crinoidal limestone he cites *Tropidoleptus carinatus* Con. and *Chonetes coronatus* Con., two of the three Hamilton forms *par excellence* and naturally reiterates his reference of this formation to the Hamilton.

Prof. Jas. Hall, in 1879, came to the conclusion that the Crinoidal and Hydraulic limestones were not Upper Helderburg as he had before supposed, and set about showing that everybody else, as well as himself, had been mistaken. He quotes Professor Borden's table of correlation above from the report of 1873 as follows:‡

* Geol. Surv. of Ind., 1875, p. 172.
† Geol. Surv. of Ind., 1874, pp. 122, et seq.
‡ Paleontology of New York, Vol. V, Part II, pp. 139-154.

New Albany Black shale.....
Crinoidal limestone ..... } ? Hamilton Group.
Hydraulic limestone. .....
Corniferous limestone .....Upper Helderburg Group.

Attention is called to the position of the interrogation point. In a foot note* Mr. Hall says: "Since this reference does not appear in the succeeding reports, the view then entertained may have been subsequently modified." This in spite of the fact that on the preceding page he quotes Professor Borden in the report for 1874 as citing *Tropidoleptus carinatus* and *Chonetes coronatus* Con. (Hamilton Group of New York), as occurring in the crinoidal limestone. Apparently Professor Hall thought that the author had provisionally referred the formation to the Hamilton, but on finding it contained *Tropidoleptus carinatus* and *Chonetes coronatus* he had lost all confidence in his correlation and was afraid to suggest another. It might be noted that Professor Hall attributes the whole correlation to Prof. Cox, whereas both of the county reports referred to bear Professor Borden's name at the head. It is clear then that to Prof. W. W. Borden is due the honor of first clearly recognizing the Hamilton age of the Crinoidal (Sellersburg) limestone and the Hydraulic (Silver Creek) limestone.

Many lists of fossils from the Hamilton in the vicinity of the Falls of the Ohio have been given, but usually no distinction has been made as to whether they came from the crinoidal limestone or the hydraulic limestone. The following lists of fossils from the Sellersburg limestone are appended with the full knowledge that they are far from complete and might be much extended by closer and further search.

From the Belknap quarry, one mile south of Sellersburg, were obtained the following forms:

Stropheodonta perplana Con.
Stropheodonta concava Hall.
Stropheodonta demissa Con.
Spirifer hobbsi Nett.
Spirifer granulosus Con
Spirifer audaculus Con.
Rhipidomella vanuxemi Hall
Camarotoechia sappho Hall.
Centronella impressa Hall.
Pentagonia unisulcata Con.
Productella spinulicosta Hall.
Pholidostrophia iowaensis Owen.
Atrypa reticularis Linn.
Capulus dumosum Con.
Orthonychia conicum Hall.
Platyostoma lineatum Con.
Phacops rana Green.
Proëtus macrocephalus Hall.
Proëtus sp? (large pygidium only).
Diphyphyllum sp?
Zophrentis sp?
Crinoid stems.
Bryozoa, several genera.

*Loc. cit., p. 154.

From the Sellersburg limestone overlying the cement rock in the quarry of the Indiana Cement Co., two miles south of Charlestown, the following species were collected:

Megistocrinus rugosus L. and C.	*Athyris fultonensis* Swal.
Ancyrocrinus bulbosus Hall.	*Orthonychia conicum* Hall.
Gennaeocrinus kentuckiensis Shum.	*Pleurotomaria?* sp.

The Silver Creek Hydraulic Limestone lies beneath the Sellersburg limestone, and between it and the Jeffersonville limestone and is thus the lower part of the Sellersburg beds of Kindle. It ranges in thickness from 15 or 16 feet in the Silver Creek region, to eight or 10 feet in the Charlestown region, and five or six feet in the vicinity of Lexington, thinning out rapidly to the north and disappearing altogether as a persistent formation in the northern part of Scott County. It receives its name from the fact that it is typically developed in the vicinity of Silver Creek, in Clark County, Indiana. Furthermore, the first cement sold under a special name was called the Silver Creek cement; hence the name is quite fitting. It is a homogenous, fine-grained, bluish to drab argillaceous magnesian limestone, the calcined form of which has the property of *hydraulicity.*

As the texture and composition of this rock are taken up in detail in another place, we will not concern ourselves further with their consideration at this point.

The first attempt at correlating this formation with those of the East was made by James Hall in 1841, when he correlated the Hydraulic limestone with the water-lime (Onondaga) and the Sellersburg limestone with the Helderburg. This was soon shown to be an error, and in time the Hamilton age of the formation was recognized. Though even yet the descriptive articles in the statistical publications generally put down the Silver Creek limestone and the Milwaukee Hydraulic limestone as of Upper Silurian age. As shown by the fossils the age of this formation is the same as that of the Sellersburg limestone, and what has been said in regard to the controversy over the age of the latter applies as well to the Silver Creek limestone. The most characteristic fossil is the little *Chonetes yandellanus* Hall, which is found in great numbers everywhere in this limestone. *Atrypa reticularis* and *Spirifer granulosus* are also abundant both in this limestone and in the Sellersburg limestone.

Hall gives a list of 90 species occurring in the Crinoidal (Sellersburg) and Hydraulic (Silver Creek) limestones; but in the list the two faunas were not separated. In connection with this investigation

collections have been made from the cement rock at different points in the neighborhood of Sellersburg, and a list of the species found is here appended:

Chonetes yandellanus Hall.
Tropidoleptus carinatus Con.
Atrypa reticularis Linn.
Spirifer fornacula Hall
Spirifer granulosus Con.
Spirifer varicosus Hall.
Stropheodonta concava Hall.
Stropheodonta perplana Con.
Camarotoechia sappho? Hall.
Aviculopecten princeps Con.
Phacops bufo? (pygidium only).

The Jeffersonville limestone is that mass of white to bluish gray, crystalline, fossiliferous, flaggy limestone lying below the Silver Creek limestone and above the Niagara. It has a thickness of 22 to 30 feet in the region of Clark County, but gets much thicker to the north, ranging up to 50 and 60 feet in the neighborhood of North Vernon.

This limestone has long been recognized as Corniferous in age, and until recently has always been referred to as the Corniferous. In the paper by Mr. Kindle, however, which has been cited above, the formation is called the Jeffersonville limestone from the fact that it is typically exposed at the Falls of the Ohio, near that city, which has long been a favorite collecting ground for Corniferous fossils. As has been noted on a preceding page, Major Lyon subdivided the rocks of this formation into several beds characterized by the predominance of certain fossils. It has not been feasible or possible in this investigation to carry out these subdivisions, but they do not militate against the employment of the larger geographical name.

The upper member of the Jeffersonville limestone is marked by the abundant occurrence of *Spirifer acuminatus*, *Stropheodonta demissa* and *Stropheodonta hemispherica*.

The following species were collected from the Jeffersonville limestone immediately beneath the Silver Creek limestone where it outcrops in the road in the western corner of Section 113, two miles northeast of Sellersburg:*

Spirifer acuminatus Con.
Spirifer fornacula Hall.
Stropheodonta concava Hall.
Stropheodonta demissa Con.
Stropheodonta perplana Con.
Schizophoria propinqua Hall.
Glyptodesma erectum Con.
Capulus dumosum Con.
Euomphalus decewi Bill.
Bellerophon sp?
Favosites hemisphericus Troost.
Zaphrentis gigantea Lesueur.

*A section of the rocks at this point is given on page 352.

Rhipidomella vanuxemi Hall.
Atrypa reticularis Linn.
Athyris fultonensis Swallow.
Paracyclas elliptica Hall.
Phacops cristata Hall.
Proëtus crassimarginatus? Hall.
Bryozoa, several genera.
Fish teeth.

In the west bank of Silver Creek by the side of the Sellersburg and Watson road, at a distance of 10 to 15 feet below the top of the Jeffersonville limestone, the following forms are found:

Spirifer gregarius Clapp.
Spirifer fornacula Hall.
Spirifer acuminatus Con.
Chonetes mucronatus? Hall.
Atrypa reticularis Linn.
Stropheodonta perplana Con.
Stropheodonta concava Hall.
Stropheodonta demissa Con.
Athyris fultonensis Swallow.
Camarotoechia sappho? Hall.
Leptaena rhomboidalis Wilckens.
Rhipidomella vanuxemi Hall.
Glyptodesma erectum Con.
Aviculopecten princeps Con.
Paracyclas elliptica Hall.
Bellerophon pelops? Hall.
Euomphalus decewi Billings.
Turbo shumardi Verneuil.
Loxonema sp?
Dalmanites (*Coronura*) *aspectans* Con.
Zaphrentis gigantea Lesueur.
Bryozoa, several genera.
Crinoid stems and plates.

Pendleton Sandstone.—This formation was named by Prof. E. T. Cox in 1869,* from the village of Pendleton, Madison County, Indiana, where it is best exposed. He more fully described it in 1878.† It consists of 15 feet of heavy-bedded soft white sandstone, the upper part of which is fossiliferous. Above are the fossiliferous limestones of the Corniferous and below, those of the Niagara. The fossils listed from this sandstone at the original locality are as follows:

Spirifer fimbriata.
Spirifer umbonata
Conocardium trigonale
Zaphrentis gigantea.
Pleurotomaria sp?
Diphyphyllum caespitorum?
Cladopora fibrosa?
Tentaculites scalariformis.

Professor Hall‡ has pronounced the fossils to be of the age of the Schoharie Grit of New York, the basal portion of the Corniferous. These rocks are described from Huntington and Madison counties.

Well sections in the neighborhood of Alert, Decatur County, show several feet of sandstone at about the right stratigraphic position to be the equivalent of the Pendleton sandstone.

* Geological Survey of Indiana, 1869, p. 7.
† Geological Survey of Indiana, 1878, pp. 60–62.
‡ Loc. cit., p. 60, foot-note.

Just over the Waldron shale, the uppermost member of the Silurian, on Huckleberry Branch in section 31 of township 7 north, range 9 east, is found a bed of four feet of heavy yellow sandstone, the lower part of which is dark blue when freshly broken, and has a fetid smell. The upper part is fossiliferous, containing *Atrypa reticularis, Zaphrentis* and Cyathophylloid corals and is somewhat conglomeritic in places, with small quartz pebbles. Down stream some distance the Waldron shale is underlain by the argillaceous limestone which contains characteristic Niagara forms of *Orthoceras, Pentamerus, Caryocrinus,* etc.

A similar sandstone, not known to be fossiliferous, shows at the north end of the bridge over Graham's Creek, in the southeast quarter of section 30, township 6 north, range 9 east.

These sandstones are tentatively held to represent the Pendleton sandstone and to mark the lower limit of the Devonian.

Upper and Lower Silurian.—The rocks of these groups have been recently studied in Indiana by Aug. F. Foerste, to whose papers in the Twenty-first and Twenty-fourth reports of this Department the reader is referred for the details of distribution and geologic structure.

LOCAL DETAILS OF THE DISTRIBUTION AND STRUCTURE OF THE SILVER CREEK HYDRAULIC LIMESTONE.

Clark County.

River Region.—The cement rock crops out for 150 yards up and down the river bank by the site of the old Beach Mill, a section at which is as follows:

	Ft.	*In.*
Heavy bedded bluish-gray limestone	3	0
Gritty limestone with black pebbles in bottom	2	6
Cement rock with chert and lime "blotches"	1	6
Cement rock	10	0
Shaly limestone with Spirifer acuminatus	1	0
Massive shaly limestone	3	0

The shaly limestone shows a thickness of 10 or 12 feet on the point where the U. S. Government is blasting, between the Whirlpool and the Big Eddy. It is underlain by seven or eight feet of heavy crystalline limestone with many corals, which is the coralline bed of the Corniferous (Jeffersonville limestone.)

Two feet of cement rock with *Chonetes yandellanus* outcrops at the mouth of the sewer which empties into the Ohio about 400 yards

above the Indiana end of the middle bridge. From its position it must overlie the six feet of massive shaly limestone with *Spirifer acuminatus* and *Stropheodonta hemispherica* which shows in the bank a little way down the river. This last must correspond to 10 or 12 feet of similar rock mentioned above as cropping out on the point between the Whirlpool and the Big Eddy. Between these two outcrops, on Whirlpool Point, the underlying coralline limestone shows to a thickness of about 20 feet and about midway the *Spirifer gregarius* bed occurs. The river cuts across a small anticline 20 to 25 feet in height.

Cement rock is also reported to occur at the foot of Broadway street, Jeffersonville, and under the Indiana end of the upper bridge.

The county quarry in the north half of section 11 shows this section:

	Ft.	*In.*
Soil, red loam	3	0
Bluish shale, decomposed	1	0
Ferruginous shale, decomposed	2	0
Black, lignite-like band	1	0
Hard buff fetid limestone, concholdal fracture	2	0
Bastard cement with many chert bands	6	0
Concealed below.		

At the forks of the road by the cemetery one mile east of Watson the following section is exposed:

	Ft.	*In.*
Soil and cherty slag	3	0
Bastard rock, with characteristic fossils	6	0
Shaly cement rock	1	0
Cement rock, fossiliferous	9	0
Shaly limestone	2	0
Soft impure limestone	0	4
Crystalline limestone	20	0

The shaly limestone below the cement carries *Stropheodonta demissa, Athyris fultonensis* and *Spirifer audaculus*. The four-inch band of limestone furnishes a large gastropod and pebbles similar to those at base of New Albany Black shale and Sellersburg limestone, except that they are rather larger and not so well rounded.

One mile northeast, along the section line, 300 yards west of the schoolhouse, four or five feet of the cement rock shows, overlaid by chert; northwest along the road, the cement passes over into bastard rock and disappears altogether on the north side of the branch in the same section. The branch valley cuts down through some 20 feet of the Jeffersonville limestone.

Near a spring in the western part of section 39, the cement, characterized by *Chonetes yandellanus*, shows to a depth of five feet and is underlain by the *Stropheodonta demissa* bed and overlain by six to eight feet of mixed chert and drab limestone.

At forks of road in south corner of section 53 there are indications of shale overlying three to four feet of chert and gray limestone which is underlain by two feet of somewhat fetid, fine-grained drab limestone, blue on unweathered surface, containing *Chonetes yandellanus*. The bottom of the ledge is concealed.

Between this point and Charlestown the outcrop traverses the top of a flat ridge and is concealed by soil and drift so that it can be determined only in a general sort of way.

Silver Creek Region.—The cement rock disappears beneath the New Albany Black shale in the bed of Silver Creek about a mile below the Black Diamond mill. It has its outcrop in the slopes of the west bank of the creek and in the tributaries which come in from the west as far up as the lower side of section 85, where it finally disappears beneath the Black shale. In the descriptions of the properties of the firms engaged in the manufacture of this cement will be found sections of the Black Diamond, Banner, Hoosier, Globe, Belknap, New Albany, Golden Rule, Speed's and Haussdale quarries. An examination of these in their proper order will give a clear idea of the character of the cement ledge on the west bank of Silver Creek. To these may be added a section observed near the west bank of the creek near the center of section 168:

Soil and drift	8 to 10 feet.
Crystalline limestone	3 feet.
Cement	10 feet.

The bottom of the cement must be about level with the bed of the creek.

The details of the distribution may be gained from the general map appended to the report.

The cement rock shows to a depth of six or eight feet just north of Stony Point church, on the north bank of Stinking Fork Creek, in the west corner of section 152. It is underlain by the *Stropheodonta demissa* bed and overlain by drift. Cement rock shows 500 yards west on the road to Silver Creek church and in the road one-half mile northwest of Stony Point church.

Cement rock with a covering of Sellersburg limestone shows in the road near the creek in the east corner of section 170. The full thickness can not be seen as the bottom is concealed.

In the east corner of section 190, the Sellersburg limestone shows a thickness of five feet below the shale. The lower part of the ledge is sandy. The cement rock crops out below several feet in thickness, but the bottom of the ledge can not be seen.

Along the road between sections 153 and 154, and sections 171 and 172 the cement rock shows beneath the shale to a depth of five or six feet without the full thickness being exposed.

In the side of the slope to the small drain which crosses the road near the center of section 154 this section is seen:

New Albany black shale	12 to 15 feet.
Bastard limestone	8 feet.
Cement rock	12 feet.

A small brook which crosses the road in the western part of section 136 exposes cement eight to ten feet overlain by 50+ feet of Black shale. A mile west along the same road in the south corner of section 153 the cement rock has a thickness of 10 feet as exposed. At the angle in the road in the north central part of section 134 the following section is seen:

New Albany black shale	15 feet.
Gray crystalline limestone	3 feet.
Bastard limestone with chert	3 feet.
Cement rock	5 feet.

The bottom of the cement ledge is not exposed, but down the branch at the same level shaly limestone shows, with *Stropheodonta demissa* and *Chonetes yandellanus* very plentiful. The *Chonetes* is also present in the cement rock.

One-half mile west of the above section in the west corner of section 134 the cement shows a thickness of 10 or 11 feet, underlain by the *Stropheodonta demissa* bed. The cement is apparently of good quality and there would be little stripping in the neighborhood.

The road leading west from the last station between sections 133 and 151 shows thickness of cement of six and eight feet without the bottom being exposed. As shown on the map large areas here would have only dirt stripping and would be found of good quality.

A well on the land of A. P. Hauss in the south corner of section 151 was as follows:

Soil and clay	8 feet.
Cement rock	16 feet.
Crystalline limestone	3 feet.

A section of Speed's new quarry is given in the description of that property. (See p. 385.) The knoll just south of the quarry shows a thickness of 20 feet of Black shale.

Further south along the same road near its intersection with the road on the line between sections 113-132 we get this section:

New Albany black shale	2 feet.
Gray crystalline limestone with pebbles at base	3 feet.
Gritty buff cement rock	6 feet.
Fine-grained buff cement rock	8 feet.
Crystalline limestone	20 feet.

A list of fossils found in the crystalline (Jeffersonville) limestone immediately beneath the cement rock is given on page 346.

In section 68 the creek bluff shows a section of the Charlestown limestone 28 to 30 feet in thickness.

At the east corner of section 49 we get the section:

	Ft.	*In.*
Siliceous limestone	1	6
Crystalline limestone	2	6
Cement rock	4 to 6	

The bottom of the cement rock is not shown.

Sections at the quarries of the Ohio Valley Cement Co., Silver Creek Cement Co., Kentucky and Indiana Cement Co., and the Queen City Cement Co., will be given in the descriptions of those properties.

A section at the county quarry near the center of section 24 gives the following:

Soil	1 foot.
New Albany black shale	3 feet.
Fine grained crystalline limestone	5 feet.
Bastard black limestone with chert	5 feet.
Cement below.	

Three hundred yards north of the crossing of the B. & O. Railway and the road on the line between sections 51 and 52 there is an outcrop of cement rock as follows:

New Albany black shale	6 feet.
Heavy blue crystalline limestone	10 feet.
Cement rock with *Chonetes yandellanus*	5 feet.
The section is underlain by the *Stropheodonta demissa* bed.	

At the northeast corner of section 51 the cement has thickened to 8 feet, and a half mile further on to 10 feet. Six hundred yards southwest of the east corner of section 134 we have this section:

New Albany black shale	2 feet.
Gray crystalline limestone	2 feet.
Chert	3 feet.
Cement rock, fair quality	10 feet.

Near the middle of the southeast side of section 114 a well section is as follows:

Soil	10 feet.
New Albany black shale	1 foot.
Bastard rock	4 feet.
Cement rock	7 feet.

At the angle in the road near the center of section 94 there is the following exposure:

Soil	3 feet.
Bastard rock	7 feet.
Cement rock	7 feet.

In the south corner of section 116 the exposure is as follows:

Soil	3 feet.
New Albany black shale	2 feet.
Bastard rock	5 feet.
Cement rock	8 feet.

Continuing on toward Charlestown the Black shale shows a thickness of 35 or 40 feet.

On the north bank of Pleasant Run on the line between sections 116 and 117 this section is shown:

Black shale	2 feet.
Residual chert on surface	6 feet.
Cement rock	10 feet.
Heavy gray crystalline limestone	2 feet.
Shaly gray crystalline limestone	2 feet.
Heavy gray crystalline limestone	2 feet.
Heavy limestone to bed of creek	25 feet.
Coralline limestone in creek	0 feet.

Along the road which runs up Pleasant Run a half mile northwest of Charlestown there is an exposure of cement rock seven feet in thickness, overlain by cherty rock, of which one foot is visible. The cement rock contains many *Spirifer granulosus* and *Chonetes yandellanus*.

A well at A. C. Smith's on the highest part of West Charlestown yielded this section:

Soil and clay	6 feet.
Rotten black shale	2 feet.
Bastard rock with chert	4 feet.
Gray crystalline limestone	1 foot.
Cement rock below	?

South and East of Charlestown.—At the north corner of section 74, as well as further south in the same section and other high points in the neighborhood, the limestone contains *Stropheodonta demissa* and probably comes just beneath the cement rock of which no sign appears.

At the east edge of the town of Charlestown on the New Washington road a well at the house of Mr. Jas. A. Johnson gave this section:

Soil and clay	10 feet.
Cement rock	14 feet.
Hard limestone	8 feet.

Just east of Mr. Johnson's the drain exposes 10 feet of massive shaly limestone containing *Stropheodonta demissa.*

Where the road crosses the stream in section 119 the Jeffersonville limestone is exposed to a thickness of 20 feet.

North of where the road crosses Nine Penny Branch in section 138 this section is exposed:

Soil	10 to 12 feet.
Bastard rock	5 feet.
Sandy limestone	5 feet.
Cement rock	8 feet.

A section of the Standard Cement Co.'s quarry is given under the description of that property. Near the center of section 157 is this section:

Shale	15 feet.
Sandy crystalline limestone	12 feet.
Cement rock	6 feet.
Heavy bedded crystalline limestone	12 feet.
Fine grained drab limestone	20 feet.

In the western corner of section 157 the following is exposed:

New Albany black shale	2+ feet.
Bastard rock with much flint	4 feet.
Cement rock with *Chonetes yandellanus*	6 feet.
Jeffersonville limestone	2+ feet.

Where the road goes up the hill in the south corner of section 176 we get this section:

Drift	8 to 10 feet.
Shale	? feet.
Cement rock, shaly	9 feet.
Jeffersonville limestone	25 feet.

At the forks of the road near the center of section 177 this is the section:

	Ft.	In.
Till	4 to 5	..
New Albany black shale	10	..
Gray crystalline limestone	1	8
Shaly buff cement	8	..
Shaly crystalline limestone	12	..

The bed below the cement shows *Spirifer acuminatus* and *Stropheodonta demissa.*

One-half mile southeast of New Market, where the road goes up the hill, this section is exposed:

	Ft.	In.
Drift	8 to 10	0
New Albany black shale	0	6
Hard gray crystalline limestone	4	0
Buff cement rock with *Chonetes yandellanus*	12	0

The limestone beneath the cement shows *Stropheodonta demissa.*

At two places along the road between Runyon postoffice and Fourteen Mile Creek, at the forks of the road one-half mile east of Runyon postoffice, is a fine grained drab limestone containing *Chonetes yandellanus* in abundance and *Spirifer gregarius.* It is overlain by about a foot of fossiliferous shaly limestone and underlain by cherty limestone.

A limestone similar in all respects outcrops in the road at the east corner of section 123. It is overlain by 12 to 14 inches of impure limestone with *Chonetes yandellanus* and *Spirifer gregarius* and underlain by a tough dark fetid limestone.

At the big spring near the center of section 163 there is this section:

Shaly crystalline limestone	2 feet.
Drab fine-grained fetid cement rock	5 feet.
Heavy bedded crystalline limestone	4 feet.

The overlying limestone contains a great many *Spirifer gregarius* and some *Chonetes yandellanus, Euomphalus, Stropheodonta,* etc. The lower two feet contains a great many corals.

Near where the New Washington-Charlestown road crosses the northeast line of Clark's Grant there is an outcrop of eight feet of drab fetid limestone with a few corals, which appears to belong to the massive magnesian limestone which overlies the Waldron shale in this region.

In the branch just south of New Washington is the following section:

Crystalline gray limestone	4 feet.
Drab fetid fine-grained limestone	18 feet.
Yellow clay shale	3 feet.

The drab limestone seems to correspond to the limestone described in the preceding paragraphs and the yellow shale possibly represents the Waldron shale.

In the south corner of section 214 there is this exposure:

New Albany black shale	5 to 20 feet.
Cement rock	8 to 10 feet.

The cement rock shows thin white streaks which contain *Chonetes yandellanus, Fenestella, Spirifer granulosus,* etc.

In the east corner of section 196, the cement rock with a thickness of seven feet, is overlain by shale and underlain by shaly limestone. The upper four feet of the cement is a drab impure rock carrying *Chonetes yandellanus, Stropheodonta hemispherica, Spirifers,* and a Trilobite.

Fetid limestone, overlain by chert and containing many *Chonetes yandellanus,* outcrops on the New Market-Washington road 200 yards west of the bridge over Fourteen Mile Creek, and probably represents the cement rock.

Cement rock crops out a few feet in thickness at different places along the West Fork of Fourteen Mile Creek to Justice postoffice, where the following section is had:

	Ft.	*In.*
Till and drift	0 to 8	0
New Albany black sheety shale	2	0
Bluish gray crystalline limestone	1	6
Iron ore	0	3
Cement rock	8	0
Shaly limestone	4	0

SCOTT COUNTY.

The cement rock crops out in the West Fork of Fourteen Mile Creek on up to the village of Chelsea. The limestone towards the northeast becomes much more impure and argillaceous, and is tougher and does not break with a conchoidal fracture, as may be seen where the road leading south from Chelsea postoffice crosses the tributaries of Fourteen Mile Creek.

The eastern limit of the Sellersburg limestone traverses the flat ridge to the east of Chelsea, which is covered with a depth of from 12 to 40 feet of soil and drift. Outcrops do not occur, so the distribution must be gotten from well sections which distinguish only between shale and limestone. The line as laid down on the map is from such data.

Lexington and Vicinity.—One mile east of Lexington, in the south bluff of Town Creek, in the northeast quarter of the northwest quarter of section 2, township 2 north, 8 east, the cement shows five or six feet in thickness, overlain directly by the Black shale and underlain by shaly limestone in the bed of the branch. Five hundred yards down the creek toward Lexington the ledge has increased in thickness to seven feet.

Opposite the B. & O. S.-W. depot in Lexington this section occurs:

	Ft.	*In.*
Soil	2	0
New Albany black shale	10	0
Ferruginous conglomerate	0	3
Heavy ledge crystalline limestone	2	0

The conglomerate consists of black pebbles, like those described from the bottom of the Sellersburg limestone, with coarse sand, all imbedded in a matrix of solid bright iron pyrites. The cement rock is concealed at this place.

A section at the pike quarry at the north corner of the town of Lexington is as follows:

	Ft.	*In.*
New Albany black shale	5 to 10	0
Blue crystalline limestone	2	6
Cement rock	5	0
Gray crystalline limestone (Jeffersonville)	15	0

A mile northwest the overlying limestone thickens up to five feet, but soon dips below the level of the creek and disappears.

Woods Fork.—Just below where the road crosses Woods Fork in the northeast quarter of section 28, township 3 north, 8 east, this section is exposed:

	Ft.	In.
New Albany black shale.....6 to	8	0
Conglomeritic iron ore.....	1	0
Heavy crystalline limestone.....	5	6
Cement rock, fair looking.....	0	8
Shaly limestone with *Stropheodonta demissa*.....	4	0

At a spring house in the northeast quarter of the southeast quarter of section 21, township 3 north, 8 east, the exposure is as follows:

	Ft.	In.
Soil and drift.....	4	0
New Albany black shale.....	6	0
Massive crystalline limestone.....	3	0
Blue argillaceous cement rock.....	1	2
Heavy crystalline limestone.....	6	0

Where the road crosses Woods Fork in section 15, same township, 3 north, 8 east, blue cement rock four inches thick is exposed, overlain by four feet of crystalline limestone, and that in turn by Black shale. On the north side of the same creek the cement is underlain by twelve feet of Jeffersonville limestone with *Chonetes yandellanus*, *Stropheodonta hemispherica*, *Stropheodonta demissa* and a *Spirifer*.

At the forks of the road 400 yards south of the northwest corner of section 25, township 3 north, 8 east, a foot of yellow calcareous shale outcrops, overlain by five feet of crystalline limestone.

In the northeast quarter of the southwest quarter of the same section two feet of characteristic cement rock shows, overlain by three feet of crystalline limestone and underlain by 10 feet of Jeffersonville limestone.

Near the center of the same section the drab cement rock outcrops three feet in thickness, overlain by two feet of hard blue limestone with *Tropidoleptus carinatus*.

In the southwest quarter of the northeast quarter of section 20, township 3 north, 8 east, the cement rock is represented by 12 inches of fetid limestone overlain by 2 feet of crystalline limestone.

In the northwest quarter of the northwest quarter of section 24, township 3 north, 8 east, the cement is represented by a clay parting between nine feet of crystalline limestone above and 15 feet of similar limestone below.

Hog Creek.—Near the center of section 14, township 3 north, 8 east, the cement, represented by a thin clayey stratum, is overlain by 12 feet of crystalline limestone.

Where the road crosses Hog Creek in the southeast quarter of section 15, township 3 north, 8 east, four to 12 inches of cement rock is overlain by four feet of crystalline limestone and that in turn by shale.

In the bluff along the creek in the southwest quarter of the same section we have this exposure:

	Ft.	*In.*
New Albany black shale	2	0
Flaggy crystalline limestone	4	0
Fetid buff cement rock	0	8-10
Crystalline limestone (Jeffersonville)	15	..

Near the B. & O. Railway in the northeast quarter of section 20, township 3 north, 8 east, the cement a foot in thickness is overlain by crystalline limestone 30 inches in thickness.

Going up a drain in the northwest quarter of section 16, township 3 north, 8 east, the cement thins to three or five inches, then to one or two inches, and then thins out completely, and this is the most northerly extension of the cement rock as a persistent bed.

II. TOPOGRAPHY.

In general the topography of the region with which we are concerned is that of a dissected plateau sloping gently toward the west, where rises the sharp escarpment of the bold range of Knobs. The slope of the surface of this plateau is very nearly that of the underlying limestone, especially in the region lying between the Pennsylvania and B. & O. railways from Otisco to Jeffersonville and Memphis. The tops of the flat ridges in this region are covered with the New Albany Black shale, beneath which outcrop the Sellersburg and Silver Creek limestones. The streams cut down into the Jeffersonville limestone, and those flowing to the southwest keep along in the same horizon, the fall of the stream being just about equal to the dip of the rock. On the western side of the plateau, as the Knob escarpment is approached, the Black shale increases in thickness and begins to make a more rolling topography. But in the region to the east, lying between Charlestown, Otisco, Lexington and the Ohio, where the Black shale is thin or entirely wanting, the country is flat as a floor, but trenched here and there by streams. At the river bluffs it

pitches off abruptly in an escarpment about 400 feet in height. The country southeast and east from Watson is flat and the trenches cut by the streams are invisible a short distance away, so that the topography has every appearance of being in a youthful stage, probably post-glacial. But wells on these flats show 10 feet of soil and clay without drift, apparently indicating that the region has not been occupied by the ice. Unmistakable till and drift occur, however, in the neighborhood of Charlestown, on the hill just south of Speed's new quarry, in the eastern part of section 131, and in the south corner of section 168, as well as in other places. One mile west of Sellersburg on the road to Hamburg there is beside the road an outcrop of four to five feet of gravel embedded in a sandy clay strongly resembling till. The gravel consists of rounded sandstone, knobstone and quartz pebbles, ranging up to one inch in diameter, although the quartz pebbles rarely exceed one-quarter inch in diameter. Mixed with these are angular fragments of chert, limestone and sandstone.

From these deposits and from the glaciated aspect of the country in certain sections, as well as for reasons which will appear later, we think that the whole region, west as far as Silver Creek and south as far as Jeffersonville, was occupied by an ice sheet which left its impress on the soft Black shale topography without leaving a great amount of drift. No evidence of buried channels has been found, with the exception of that thought to indicate an old channel of the Ohio. If the topography is post-glacial, the preglacial topography must have existed in the Black shale and have been carried away entirely by the ice. We find no evidence that this region has been occupied by the great Collett Glacial river as has been urged.*

PLEISTOCENE TERRACES.

The Flatwoods.—In the sketch map opposite the dotted line represents the edge of the Paleozoic rocks, and the broken lines, numbered from I to IV, represent the terraces. Lying between the Paleozoic border and the upper terrace, or No. 1, and occupying the greater part of sections 32, 33, 45, 46 and 47, is a region called the Flatwoods. It is almost level, sloping very gently to Silver Creek on the northwest. Along the southern edge it rises slightly higher and is slightly irregular, having higher hummocks of sand. Where it first starts from the Paleozoic this terrace is about 40 feet above Terrace No. 3. But after Terrace No. 2 puts off from it in the east part of section

* Geological Survey of Indiana, 1881, p. 60.

31, it stands but 10 or 15 feet above that terrace and seems finally to die away in a series of hummocks before reaching Silver Creek. The

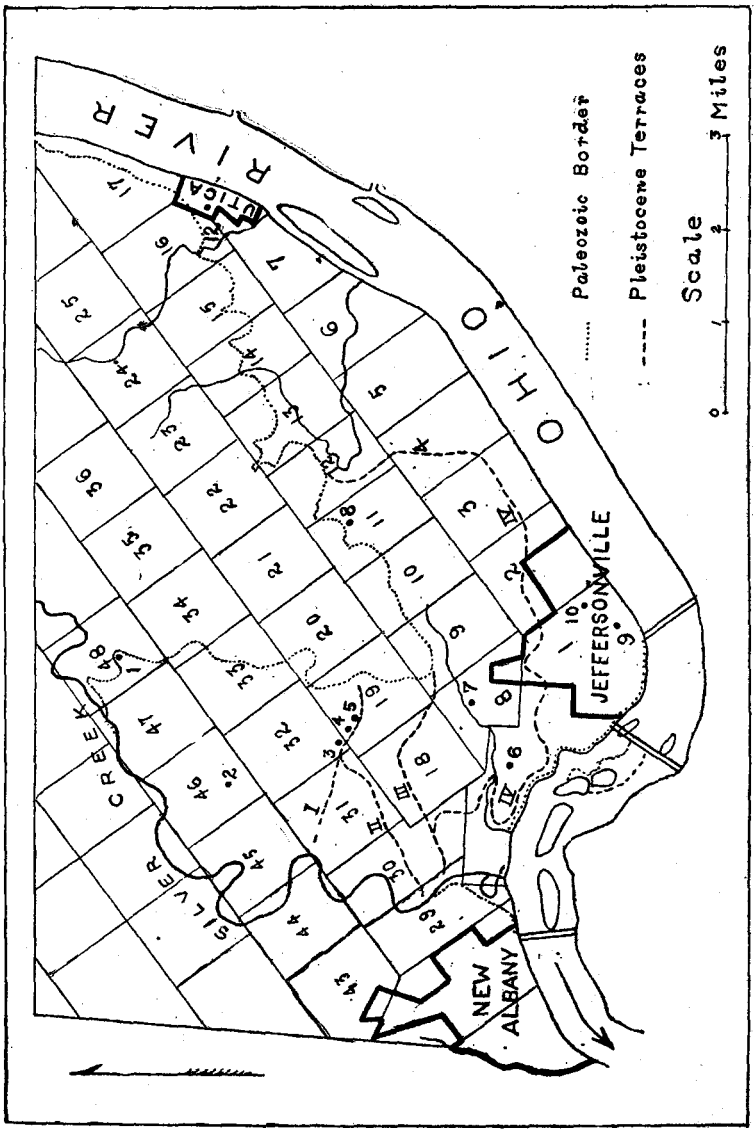


Fig. 71. Pleistocene Terraces in the vicinity of Jeffersonville and New Albany.

impression is unavoidably forced upon one that this was a spit which projected out from the Paleozoics and was gradually built up into a bar which closed the bay occupied now by the Flatwoods and allowed

that to fill up with sediment. The wells in the Flatwoods region seem to bear out this conception.

Well No. 1, in the engine room of the Silver Creek Cement Co.'s mill is reported to go 190 feet through black, mucky, slimy, stinking clay, striking gravel, but no bed rock. It seems probable that there is an error in the reported depth of this well, though it must be of more than ordinary depth. It lies in a recession of the Paleozoic border, and any unusual depth without striking bed rock can only be explained on the supposition that the bore was put down in an old buried valley. But it is difficult to explain a valley 190 feet in depth at this point, when the Ohio scarcely reached any such depth. It is our conception that this well struck the valley of some small stream emptying into this bay when it was at a level something like 90 or 100 feet lower than now. More well sections are needed to show this, however.

Well No. 2. A well was put down 60 feet here in the middle of the Flatwoods, which struck clay and sand, but no rock.

Well No. 3, on Mr. Stacy's place, struck potter's clay at 14 feet and went through 42 feet of this, interbedded with sand.

Well No. 4, at John Yarborough's, shows 46 feet of sand.

Well No. 5, James D. Applegate's, has 53 feet of sand and clay.

A well in the east corner of section 32 struck logs and sticks at 20 feet.

Terrace No. 2 puts off from No. 1 near the east corner of section 31 at an elevation some 10 feet below it and 30 feet above Terrace No. 3, and is similar as regards structure to Terrace No. 1. No well sections were obtained upon this terrace.

Terrace No. 3.—This terrace starts as a spit-like projection from the southernmost extension of the Paleozoic in the vicinity of the cemetery one mile north of Jeffersonville, bears north of west one mile, then turns south of west and crosses Silver Creek at the bridge on the New Albany and Charlestown pike. It is about 20 to 25 feet above Terrace No. 4, has the beach ridge formation in front, sloping gently back to the base of the terrace above it. No well sections were obtained in this terrace.

Terrace No. 4 leaves the Paleozoic upland near the middle of section 12, bears south to within a quarter of a mile of the Ohio, then southwest parallel to the river for a mile, thence west through the north edge of the city of Jeffersonville, striking the river in the vicinity of Howard Park, a suburb of Jeffersonville, just east of the old village of Clarkville, follows the river for a mile, then turns north and joins Terrace No. 3 in the southern part of section 30.

This terrace is about eight or 10 feet above high water mark of 1884, and 15 or 16 feet above the flood plain, which was overflowed six to eight feet in 1884.

Well No. 6, in Howard Park, passed through bluish to yellowish mottled clay for 20 feet, then sand and gravel for 25 feet.

Well No. 7 struck rock at the depth of 40 feet.

Well No. 8, at Henry Mahanda's, soil and clay 40 feet, gravel five feet. Bed rock is probably not far below. This would put it at or below the level of low water in the Ohio.

All these terraces are continued down the river beyond Silver Creek, but beyond that point they have not been examined by the writer. It is to be hoped that in the future opportunity may offer for a more comprehensive study of these terraces which have such a direct connection with the Pleistocene history of this region.

A PREGLACIAL CHANNEL OF THE OHIO.

Mr. John Bryson was, so far as the writer is aware, the first to suggest,* though without much reason for so doing, that the Ohio had a preglacial channel to the north of the present channel. Certain facts that have come under the observation of the writer seem to bear out that view, though far from demonstrating it, and leaving much to be determined in the future. Attention was called above to the section of *Well No. 6,* in Howard Park, where no rock was found at a depth of 45 feet, presumably about the level of low water in the Ohio River. Yet sections by Professor Borden and the writer at the old Beach Mill on the river bank just opposite the site of the well show a thickness of 25 to 35 feet of limestone above low water mark. And these rocks continue to outcrop all the way up the river to the Louisville and Jeffersonville bridge. This indicates a rim of rock along the river and a basin or valley behind.

The First National Bank building of Jeffersonville is located about two blocks from the river. The foundation is reported to rest on solid bed rock at a depth of 15 feet, while *Well No. 9,* 15 feet away, struck the limestone at 35 feet. *Well No. 10,* at the corner of Mechanic and Chestnut streets, about a quarter of a mile north of *No. 9,* went 80 feet before striking bed rock. This would make the level of the rock some 40 feet below the reef at the falls. *Well No. 12,* at Mr. Biggs', in Utica, went 120 feet, all in gravel. The bottom of the well must be 80 feet below the level of low water in the Ohio. This, of course, indicates nothing more than that the preglacial channel of the Ohio was at least 80 feet deeper than it now is.

*American Geologist, Vol. V, 1890, pp. 186–188.

It has seemed to us possible that one of the preglacial branches of the Ohio left the present course of the river about Utica, flowed along the bottom skirting the edge of the Paleozoic upland to the neighborhood of Jeffersonville, then turning northward made an oxbow bend out through the Flatwoods, re-entering the Ohio between Clarksville and the mouth of Silver Creek. A serious objection to this view seems to be encountered in the record of *Well No. 7*, which struck rock at 40 feet, right where one would expect the deepest part of the hypothetical channel. Nevertheless, it seems necessary to employ the Ohio to perform the excavation which took place prior to the formation of the Flatwoods. Certainly Silver Creek would be unequal to the task, running as it does over a rock bottom just before it enters the Flatwoods, and at a level not more than 20 feet below that of the Flatwoods.

If the Ohio once moved out through the region of the Flatwoods at a level much below this present level, then back in a narrow defile, the predecessor of Silver Creek pouring over the limestone wall might give us the deep gorge which later became filled with blue mud, as shown in the section of *Well No. 1* as given above.

If such were the case, the river must have been dispossessed of this channel by the advancing ice sheet. Deprived of this deeper channel, the Ohio must have flowed at a much higher level at some later time, before it found its present course over the reef at the Falls. The interval in which it flowed at the higher level was contemporaneous with the formation of the terraces.

III. ECONOMIC GEOLOGY OF THE SILVER CREEK HYDRAULIC LIMESTONE.

Texture and Composition.

In texture the cement rock is a very fine grained limestone, the grain being so fine as to require a good hand lens to distinguish it. It is usually without traces of stratification and occurs massively, breaking with a sub-conchoidal fracture. In some of the quarries, however, the ledge is divided horizontally by bedding planes into two or more ledges which in places are reported to have different values for cement. The universal practice, however, is to take the workable ledge from top to bottom as it comes, giving a uniform quality to the product. Where the cement rock is fossiliferous, as it commonly is, the fossils, bryozoa especially, show roughly by their position the planes of their deposition.

Impurities are comparatively rare in this formation. The upper part of the ledge sometimes contains "blotches" of white appearance, consisting of calcareous or siliceous material. The fossils are sometimes solidified. Minute crystals of iron pyrites are sometimes disseminated through the rock.

The color in the freshly exposed rock ranges from light drab through dark drab to bluish drab. On the weathered surfaces it shows buff. The fossiliferous streaks are generally darker.

The chemical composition shows the rock to be magnesian argillaceous limestone with a mixture of more or less ferric iron. Two of the analyses of Rosendale stone show quite a percentage of calcium sulphate, but this is possibly an error of analysis, or a local development.

The appended table gives analyses of six Indiana cement limestones, seven New York cement limestones, three of the Milwaukee and one from Illinois, each with the properly accredited authority:

CHEMICAL ANALYSES OF HYDRAULIC LIMESTONES.

	LOCALITY.	Calcium Carbonate $CaCO_3$.	Magnesium Carbonate $MgCO_3$.	Silica SiO_2.	Ferric Oxide Fe_2O_3.	Alumina Al_2O_3.	Oxide of Manganese Mn_2O_3.	Potassa and Soda K_2O and Na_2O.	Lime CaO.	Magnesia MgO.	Calcium sulphate $CaSO_4$.	Organic, Water and Undetermined.	Total.	Authority.
1	Silver Creek, Indiana, "Ohio Valley"	54 31	16.90	18.33	1.67	4.98	.....	.....	0.14	0.33	.....	1 19	97.85	W. A. Noyes, Analyst.
2	Silver Creek, Indiana, "Black Diamond"	51.95	32.97	9.69	1.95	2.77	.....	.....	0.10	0.11	.....	0.36	99.90	W. A. Noyes, Analyst.
3	Silver Creek, Indiana, "Belknap's Falls City"	52.50	35 09	9.80	1.40	2.03	.....	.....	0.04	0.11	.....	0.47	101.44	W. A. Noyes, Analyst.
4	Silver Creek, Indiana, "Speed's"	61.70	16.74	13.65	1.45	3.46	.....	.....	0.15	0.25	.....	0.45	97.85	W. A. Noyes, Analyst.
5	Silver Creek, Indiana, "Hausdale"	60.69	15.90	15.21	1.44	4.07	.....	.....	0 07	0.32	.....	0.86	98.56	W. A. Noyes, Analyst.
6	Rosendale, Ulster County, N. Y	45.91	26.14	15.37	11.38		.....	.....	.....	.....	.....	1.20	100.00	Mineral Industry, Vol. I, 1892, p. 49.
7	Rosendale, Ulster County, N. Y., "Light"	50.82	17.74	22.66	2.39		0.55	Tr.	.....	.....	4.37	1.39	100.00	Mineral Industry, Vol. I, 1892, p. 49.
8	Rosendale, Ulster County, N. Y	44.34	23.92	22 14	3.80		0.88	Tr.	.....	.....	3.94	0.83	99.85	Mineral Industry, Vol. III, 1894, p. 90.
9	Rosendale, Ulster County, N. Y	46.00	17.76	27.70	1.26	2.34	.....	4.02	.....	.....	.....	.....	99.08	Geological Survey of Indiana, 1873, p. 120.
10	Rosendale, Ulster County, N. Y	45.54	25.94	15.37	2.25	9.13	.....	.....	.....	.....	.....	1.20	99.43	Mineralogy of New York, L. C. Beck, p. 78.
11	Chittenango, Madison County, N. Y	44.64	37.44	11.76	1.50	2.73	.....	.....	.....	.....	.....	1.50	99 57	Mineralogy of New York, L. C. Beck, p. 80.
12	Chittenango, Madison County, N. Y	48.40	34.30	13.85	1.75	.....	.....	.....	.....	.....	.....	1.70	100.00	Mineralogy of New York, L. C. Beck, p. 80.
13	Milwaukee, Wisconsin	45.54	32.46	17.56	3.03	1.41	.....	.....	.....	.....	.....	.....	100.00	Trans. A. I. M. E., Vol. VIII, p. 507.
14	Milwaukee, Wisconsin	48.29	29.19	17.56	2.24	1.40	.....	.....	.....	.....	.....	.....	98.68	
15	Milwaukee, Wisconsin	41.34	34.88	16.99	1.79	5.00	.....	.....	.....	.....	.....	.....	100.00	
16	Utica, Illinois	42 25	31.98	21.12	1.12		.....	.....	.....	.....	.....	1.07	97.54	Mineral Industry, Vol. I, 1892, p. 49.
17	Louisville, Kentucky	50.43	18.67	25.78	.....	2.93	.....	.45	.....	.....	.....	.....	98.25	Geological Survey of Kentucky, Vol. II, 1857, p. 220.

Inasmuch as the first five analyses in the foregoing table have been somewhat recast to make them harmonize with the other analyses, the official report of Professor Noyes to the State Geologist is here inserted.

ROSE POLYTECHNIC INSTITUTE,
TERRE HAUTE, IND., January 16, 1900.

Prof. W. S. Blatchley:

Dear Sir—I have analyzed the samples of hydraulic limestone left with me in October last with the results given below.

The labels were:

No. 1. Ohio Valley Quarry, n. e. cor. sec. 34, Clark's Grant.
No. 2. Speed's Quarry, sec. 132, Clark's Grant.
No. 3. Belknap's Quarry, sec. 89, Clark's Grant.
No. 4. Black Diamond Quarry, s. e. cor. sec. 66, Clark's Grant.
No. 5. Hausdale's Quarry, sec. 149, Clark's Grant.

	1. Ohio Valley.	2. Speed's.	3. Belknap's.	4. Black Diamond.	5. Hausdale's.
Insoluble in hydrochloric acid ..	25.90	18.68	12 75	13.03	21.26
Lime (CaO), soluble in acids.....	30.41	34.55	29 40	29.08	33.99
Magnesia (MgO), soluble in acids	8.48	7 97	16.71	15.70	7.57
Ferric Oxide (Fe_2O_3), soluble in acids	0.47	0.43	0.85	1.15	0.39
Alumina (Al_2O_3), soluble in acids	0.27	0.30	0.25	0.80	0,32
Loss on ignition.....	33.46	36.65	40 47	39.29	35.16
Total.....	98.99	98.58	100.43	99.05	98.69

The results of the analysis of the insoluble portion and the composition, on the supposition that the soluble lime and magnesia are in the form of carbonates, are as follows:

	1. Ohio Valley.	2. Speed's.	3. Belknap's.	4. Black Diamond.	5. Hausdale's.
Soluble portion— Calcium Carbonate ($CaCO_3$)....	54.31	61.70	52.50	51.95	60.69
Magnesium Carbonate ($MgCO_3$)	16 90	16.74	35.09	32.97	15.90
Ferric Oxide (Fe_2O_3).....	0.47	0.43	0.85	1.15	0.39
Alumina (Al_2O_3)	0.27	0.30	0.25	0 80	0,32
Insoluble portion — Silica (SiO_2)	18.33	13.65	9.80	9.69	15.21
Ferric Oxide (Fe_2O_3)	1.20	1.02	0.55	0.80	1.05
Alumina (Al_2O_3)	4.71	3.16	1.78	1.97	3.75
Lime (CaO)	0.14	0.15	0.04	0.10	0.07
Magnesia (MgO).....	0.33	0.25	0.11	0.11	0.32
Undetermined.....	1 19	0.45	0.47	0.36	0.86
Total.....	97.85	97 85	101.44	99.90	98.56

For greater simplicity the iron is all put down as ferric oxide, though a part of it is in the ferrous state and the soluble portion is probably mostly in the form of ferrous carbonate ($FeCO_3$). The part of the insoluble portion recorded as "undetermined" probably consists mainly of alkalies.

The high footing of No. 3 is probably due to the presence of some soluble compound of "lime" or "magnesia" other than the carbonate. See the other footing for the same analysis.

W. A. NOYES.

QUARRYING.

Stripping.—Two methods of stripping off the earth preparatory to quarrying are practiced; and since the earthy covering may range from a few inches to 10 or 15 feet, the most economical method for the case in hand is quite a desideratum. The first method, and the one usually followed in the smaller quarries and in those larger quarries where the stripping is light, is the ordinary one of plows and scrapers operated by horse power. An improved method, which is followed at Speed's quarry and at some of the larger concerns operating open-wall quarries, is to prepare to strip a large area at once by laying down a temporary track along one side of the area, upon which track is placed a common hoisting engine with large drum and cable. The earth is loosened by large plows which are drawn by steam across the area to be stripped, and returned by a single horse. The same method is pursued with the large wheel scrapers, which, when loaded, are drawn by horses to the dumping ground. The final cleaning up must be done with shovel and wheelbarrow.

With regard to the rock stripping, the ordinary methods of blasting and carting are used. In some cases the rock stripping is crushed and used for road metal or railway ballast. The Black shale has also had a limited employment for such purposes.

Blasting and Loading.—When the cement ledge has been stripped it is then ready for quarrying and transportation to the kilns. An electric system of blasting is employed in the larger quarries. Holes are drilled with steam drills at intervals of several feet and charged with dynamite, which is exploded simultaneously by means of a pull-up electric battery. Such of the rock as is less than six to 12 inches in its largest dimension is ready to go directly to the kilns, but all larger than that must be made smaller with a sledge hammer. In the majority of cases the quarry is in juxtaposition to the line of kilns. An inclined track leads from the quarry up to the top of the line of kilns and passes across their open tops. Up this track is brought the limestone and coal. At the foot of the incline

is a small turntable, and from this tracks lead to the coal pile and to those parts of the quarry where the work is active. The cement rock is loaded upon small iron dumping trucks; these may be made into trains and hauled by a horse to the turntable, if far distant, but usually are pushed by hand. They are pulled one at a time up the incline by a hoisting engine at the top of the incline, and pushed along by hand to the proper kiln.

Speed's quarry is situated about a mile and a half from the mill and connected with it by a steam tramway. A small locomotive draws a train of small flat cars. The quarry is so arranged that a long face is being worked at once. Parallel to this and at a convenient distance is a temporary track on which is a traveling crane. The temporary track of the tramway parallels this at the right distance. The rock is loaded upon a square flat box with a bail attached. By means of this bail the box is lifted by the crane and placed on one of the flat cars and an empty box put in the place of the full one at the quarry face. Having arrived at the mill the boxes are emptied into the crusher, which reduces the rock to the proper size for burning, doing away with the expense of breaking large pieces by hand in the quarry.

Mining.

Mining or tunneling has usually been resorted to when the stripping became so heavy as to render further open quarry work unprofitable, but in a few instances, notably at the new Banner and Hoosier mills, and others, tunneling has been the order from the start. In the latter instance a pit large enough to give room for the turntable and the slope of the incline has been dug through the New Albany Black shale, the Sellersburg limestone and the cement ledge. From this pit entries are driven in any direction desired. It may be noted here that the Banner Co.'s opening is near the east side of their property and the major part of their tunneling will have to be to the westward. Now the natural dip of the rocks over this whole region is to the west. Since the cement ledge here lies at or near the level of Silver Creek, it will be strange if water does not follow down the entries and rooms and collect along the working faces, to the great trouble and vexation of the miners. Probably a much better plan would be to locate the opening or shaft near the western side of the property and work the rooms eastward against the dip, allowing them to drain themselves into a sump at the shaft where the water can be easily handled.

Attention might at this place be directed to the fortunate stratigraphic relation of the cement rock, overlying the limestone and shale, which makes possible tunneling and long wall mining in a limestone formation with no greater thickness of roof than is usually found in this district. Were the roof either all limestone or all shale, mining would not be possible. In the former case the limestone would be cut up in two directions by a network of seams, caused by the solution of percolating waters along the joint cracks, and would, of course, not be capable of self-support over rooms 100 feet square, as are worked in this region. It is only because the covering of impervious shale acts as a roof and sheds off the underground water, that the limestone has remained unaffected. Further, were the roof of shale alone, its strength would not be sufficient to sustain roofs of the size described; draw slate would be continually falling, and some of the slate would come away with the limestone, necessitating hand sorting, all making operation more expensive.

The method of mining, briefly, is as follows: At some side of the quarry, where the roof is thick enough to be suitable (generally in practice where the stripping is too deep for profitable open quarrying), single entries are driven into the ledge from 20 to 40 feet in width and at an equal distance apart. Once back in the ledge all the stone is taken away excepting pillars 10 to 15 feet square and 40, 50, 60, or even 100 feet apart. The entries and rooms are lighted with electric arc lights and ventilated by air escaping from the compressed air drills. The rock is shot down, just as in coal mining, except that "under-mining" by either pick or machine is unnecessary. Holes are bored by an Ingersoll rock drill driven by compressed air, and mounted on an upright bar which, by means of a jack-screw base, can be braced between the roof and the floor of the mine.

From 35 to 40 charges of powder are put in and discharged by a pull-up electric battery. This will bring down rock sufficient to make from 150 to 200 barrels of cement. Charges are usually fired at the noon hour and just before leaving in the evening, giving the rock a chance to all get down without interrupting work.

The rock may be reduced to the proper size for calcining by hand or by crushing, just as in open quarrying. It is then loaded on self-dumping cars, varying in design and size with the different works, and drawn to the kiln by horse or steam power.

ULSTER COUNTY METHODS.—With one exception all the plants engaged in hydraulic cement manufacture in the famous Rosendale District of Ulster County, New York (producing about one-half of

the total product of the United States), raise the rock by mining rather than by quarrying.* The region is one of violent folding and faulting, rendering mining unavoidable. The mines are worked on the slope and the location so chosen that the head of the slope is on a level with the top of the kilns. The slopes preclude hand or horse haulage and necessitate rope haulage, involving the erection of elaborate rope haulage plants. When sudden changes of dip occur it necessitates independent haulage stations and grading of tracks. Of necessity the entries and rooms must be driven with the dip, requiring close attention to pumping the water away from the working face. As yet the water has not interfered to any serious extent. The greatly increased cost of production entailed by the dipping of limestone is counterbalanced by proximity to markets, and cheap transportation for fuel and product furnished by the Delaware and Hudson Canal and competitive railroads. The great sale of Rosendale cement has ensued from its early occupation of the market and its proximity to the great populous centers of the East.

Calcination.—As noted before, the cement rock may be reduced to kiln size by hand at the quarry or may be crushed at the kilns in a Blake or some similar form of crusher. It then goes to the kilns. The kilns are uniformly ordinary continuous up-draft kilns. In the older plants they were arranged in a line, and surrounded by a solid masonry wall. The later plants have kilns of cylindrical sheet steel resting on a masonry foundation. When ten or more kilns are in use it is customary to arrange them in two parallel lines with the draw doors facing the track between, which leads to the mill. Both kinds are lined with fire brick. The kiln draws together near the bottom and is closed by several grate bars, with a room beneath to receive the iron car into which the calcined cement is drawn. The kiln is charged with a kindling charge of wood and coal, upon which is dumped cement rock and coal in the proportion of two loads of rock to one of coal until the kiln is filled. The fire is lighted, and as the charge sinks with the consumption of fuel more coal and stone is added, always keeping the kiln full. At the end of about 72 hours' burning the lower part is ready to draw. This process is kept up continuously, drawing from the bottom and adding at the top, the passage from the top to bottom taking about 72 hours.

Grinding.—The loaded cars of calcined cement go up an incline and as the rock is dumped into the hopper of the coarse crusher, a man stands ready here with long tongs and picks out all "green" and overburned stone. The green stone is sent back to the kilns, the

* New York, 13th Rep. State Geol., Vol. I, pp. 379-384.

overburned or "clinker" carted away. The product from the coarse crusher passes over a screen and about one-half is fine enough to go through, which part is fit for cement and goes directly to the barrels. The tailings go next to the re-grinder, a coffeemill arrangement with steel cones. The product passes over a screen of the same mesh as that following the coarse crusher. About one-third of the product goes through and goes to the barrel. The tailings go to the buhrs. The product of the buhrs goes through a screen of the usual mesh and four-fifths passes through and goes to the barrels. The other one-fifth is returned to the buhrs. The buhrs are constructed like ordinary buhr mills, except that the grinding surface is of rock emery instead of French buhr. Formerly Catskill granite (?) was used for the grinding surface, but the wear on each stone was about one-fourth inch per day, sufficient to obliterate the dress, and require re-dressing every night. The life of such a stone was but a single season, whereas the rock emery stones wear but one-sixteenth of an inch on each stone per month, and the life of the stone is eight or 10 years. The emery has consequently displaced the other stone.

The usual arrangement of grinding and screening machinery is as follows: One screen for each two coarse crushers, one for each re-grinder and one for each two sets or "run" of buhrs.

Double break roller mills were tried at the Speed mill, but were found unsatisfactory and the buhrs replaced. The first break was corrugated and the second break was smooth, and all the rolls were run at the same speed.

The new Banner mill now being erected (September, 1898) is putting in Griffin grinding mills. The proprietors have great hopes that these mills will reduce the number of re-grindings and boltings necessary to bring the cement to the proper fineness. It is claimed that these mills will take the product of the coarse crushers direct and reduce 95 per cent of it to the standard fineness. If so it will effect an appreciable saving in the cost of production.

Other forms of grinding mills which are coming into vogue are the Williams mill and the Clark mill. These are generally used to replace the re-grinders, that is, take the product from the coarse crusher and pass it on to the Griffin mill, which takes the place of the buhr in finishing the product.

The cement as it comes from the grinders is sometimes hot enough to set fire to the wooden conveyors and elevator boxes, though they are lined with sheet iron.

From the mill where the cement is packed in barrels or paper bags, it goes to the stock house. The favorite plan is to have the

quarry, the kilns, the mill and the stock house in a line, along one side of which runs the railway switch, ending at one edge of the quarry where the coal dump is situated. The cooper shop, a necessary adjunct, is generally situated on one side with a chute for the barrels leading into the packing room. The course of the cement from quarry to stock room is graphically shown in the following flow sheet:

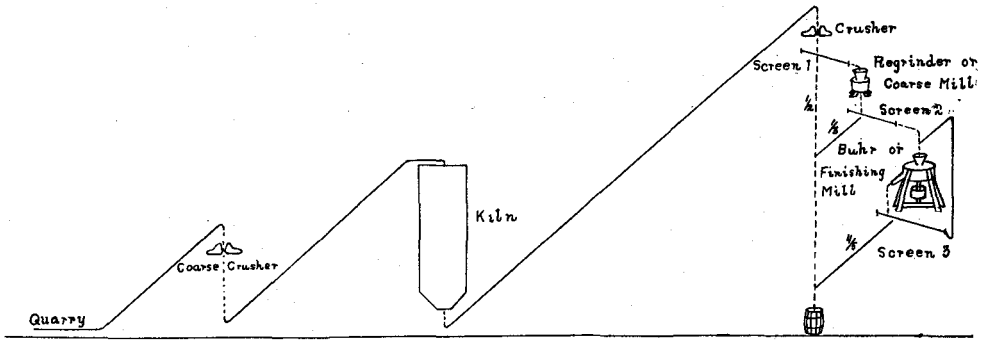


Fig. 72. Flow Sheet of a Typical Cement Plant.

Testing.—For testing fineness a convenient apparatus consists of a small sieve of the proper mesh and a glass tube holding perhaps one-half pint and graduated to 100 parts. This tube is filled even with the ground cement and emptied into the sieve and shaken until all has gone through that will. The remainder is poured into the tube and its percentage of the whole read. This subtracted from 100 gives the per cent. of fineness.

When the tests to determine the value of stamp sand and standard sand in mortars were made, the results of which are given in a table on a following page, tests of the fineness were also made, and the results are given in the following table. The first column gives the percentage of the whole mass of that part of the cement which passes through a sieve having 2,500 meshes to the square inch. The second column giving the percentage with a mesh 6,400 to the square inch. The last column gives the percentage with a mesh 10,000 to the square inch.

TABLE OF FINENESS OF CEMENTS.

Name of Cement.	*1.*	*2.*	*3.*
Portland	96%	87%	84%
Buffalo	84%	76%	74%
Akron	95%	85%	82%
Louisville	84%	75%	72%
Rosendale	94%	92%	89%

For testing strength a Fairbanks testing scale is used. The cement is mixed "neat," that is with water alone, and moulded into "∞" shaped briquettes which give a cross-section of one square inch in the middle. These are allowed to "set" varying lengths of time. The clamps of the scale are then adjusted to the ends of the test briquette and the sliding weight moved out the scale arm until the briquette is pulled apart. The scale arm will show the number of pounds weight it has sustained.

During the year 1894 a series of tests was instituted under the direction of Mr. Edward Kidwell to demonstrate the truth or falsity of the prevalent belief that "sharp" sand, as that from a stamp mill, will make a much stronger mortar than that made with ordinary waterworn quartz sand.

The results as given,* though somewhat contradictory, show in the total an increase of over 50 per cent. in tensile strength of mortar made with stamp sand as compared with that made with standard sand. Incidentally the table gives sufficient data for a comparison of the strength and value of five of the most used cements in the United States. A reproduction of some of the more essential points is given in the following table. The briquettes and cubes were mixed, immersed and tested, with the water and air ranging about 65 to 70 degrees. For each test of tensile strength six briquettes of standard size were made, and for each test of compressive strength two one-inch cubes were made. Tests were made both for seven days' immersion and 28 days' immersion of neat cement, of a 1—1 composition of cement and standard sand and of a 1—1 composition of cement and stamp sand. In the table which follows only the averages of the six briquettes and the two cubes have been taken. In the first column the amount of water used in the briquettes is given, and in the other columns the average pounds per square inch of tensile or compressive strength of the specimen tested.

*Mineral Industry, Vol. III, 1894, pp. 95-96.

TABLE OF CEMENT TESTS, INVOLVING TENSILE STRENGTH AND CRUSHING STRENGTH.

NEAT CEMENT.

NAME OF CEMENT.	RECORD OF 7-DAY TESTS.			28-DAY TESTS.	
	Per Cent. Water.	Tensile Strength.	Compressive Strength.	Tensile Strength.	Compressive Strength.
Portland	29	368.8	1,483.5	506.4	2,000
Buffalo	33	107.6	691.5	260.3	1,320.5
Akron	33.5	45.4	328	137.6	629
Louisville	38	81.3	403	130.5	619.5
Rosendale	38	44.5	188.5	108	377
1 PART CEMENT TO 1 PART STANDARD SAND.					
Portland	20.6	213.6	1,152.5	311	1,980
Buffalo	21	46.6	280	131	532.5
Akron	19	47	157	69.6	375
Louisville	26	37	240	68.5	235.5
Rosendale	23	15.6	108	84.8	264
1 PART CEMENT TO 1 PART STAMP SAND.					
Portland	14.5	223.5	1,587.5	415	2,000
Buffalo	20	55.5	322	167.1	1,117.5
Akron	18.5	45.1	222 5	82.3	468.5
Louisville	22	41.5	235	102.8	469.5
Rosendale	21	14.6	134.5	72	325

Portland made by Brooks, Shookridge & Co., Grays, Essex, Eng.
Buffalo made by Buffalo Cement Company, New York.
Akron made by Cummings Akron Company, Akron, N. Y.
Louisville made by Falls City Cement Company, Louisville, Ky.
Rosendale made by Newark and Rosendale Cement Company, New York.

Transportation.—All the cement mills of this region are located upon one or the other of the two railroads, the Jeffersonville division of the B. & O. Railway, or the Jeffersonville branch of the P., C., C. & St. L. Railway, and have adequate transportation facilities. The latter road has a local freight train which does nothing but make up the cement business.

Capacity.—The 13 plants in Indiana which were active in 1900 operated 116 kilns, having a daily capacity of 16,000 barrels, or 5,000,000 annually. The production for 1900 was 2,512,000 barrels, showing that the plants are taxed but one-half of their capacity. Most of the plants have been in associations which prorated the orders. Some firms have bid up the quota of other firms year by year and thus some plants have been in operation most of the time while others were idle.

The production of cement for the Louisville district (14 plants in Indiana and 1 in Kentucky) for the years 1882-1889, inclusive, is taken from *Mineral Resources U. S.*

Year.	*Barrels.*	*Value.*	*Year.*	*Barrels.*	*Value.*
*1882	633,000	$696,300	1886	925,210	$782,428
*1883	820,000	820,000	1887	1,189,000	921,475
*1884	780,000	702,000	1888	1,214,000	880,150
*1885	800,000	640,000	1889	1,338,464	885,617

In the following table the first two columns are taken from *Mineral Resources U. S.*, the second two from *Rothwell's Mineral Industry* for comparison, and the last two were personally collected by the writer.

PRODUCTION OF HYDRAULIC CEMENT IN THE LOUISVILLE DISTRICT.

Year.	*Barrels.*	*Value.*	*Barrels.*	*Value.*	*Barrels.*	*Value.*
1890	1,533,579	$1,150,184	.....	.....	.....	.....
1891	1,513,009	983,456	.....	.....	.....	.....
1892	2,100,000	1,365,000	2,142,782	$964,252	.....	.....
1893	1,750,350	525,105	1,750,350	962,692	.....	.....
1894	2,000,000	800,000	2,225,000	1,057,500	.....	.....
1895	1,703,000	681,000	1,701,023	597,091	.....	.....
1896	1,636,000	654,400	1,434,337	504,049	.....	.....
1897	1,731,287	692,515	1,539,818	615,927	.....	.....
1898	2,040,000	816,000	1,929,018	482 254	.....	.....
1899	2,922,453	1,022,858	3,534,344	883,536	2,883,000	$518,940
1900	.....	.....	.....	.....	2,512,000	502,400

The grand total for the period, 1882-1900, inclusive, presents the very respectable figure of $15,001,481.

Associations.—The Union Cement Association was in existence in 1873 when Professor Borden reported on Floyd and Clark counties.† Each plant was apportioned a certain quota of cement to manufacture and overproduction and destructive competition were thus avoided. This agreement had elapsed in 1892, when the Western Cement Company was organized for like purposes. This association held out until 1898, when the competition of new, independent mills broke the established scale of prices, since which time has ensued a scramble for business in which profits have been lost sight of, and cement has been sold on the narrowest possible margin or on no margin at all.

The Union Cement and Lime Co. (D. Belknap & Co.), operating the Black Diamond mill and the Falls City mill in Indiana and the Black Diamond River mill in Louisville, and the Louisville Cement Co. (J. Speed & Co.), operating the Speed mill and the Queen City

* Estimated from production of Hydraulic cement in U. S. for those years.
† Geological Survey of Indiana, 1873, pp. 134-139.

mill in Indiana and the Hulme mill in Louisville, have preserved the organization of the Western Cement Company, and still do business under its regulations.

The Central Cement Company is an association of the Clark County Cement Co., the New Albany Cement Co., the Kentucky and Indiana Cement Co., the Banner Cement Co., and the Globe Cement Co. It has been in existence one year and has worked quite successfully.

The other mills act quite independently. At this writing (Jan., 1901) strong efforts are being made to effect an association of all the cement companies interested in the district.

FIRMS CONNECTED WITH THE CEMENT INDUSTRY.—Hydraulic limestone was first discovered in Onondaga County, in New York, in 1818, in connection with the construction of the Erie Canal, and the cement was thereafter used in the construction of the canal. Cement was first manufactured in Erie County in 1824, and in the Rosendale district in 1832.

The hydraulic limestone at the Falls of the Ohio was, curiously enough, first noticed in the construction of another canal, the Louisville and Shippingsport Canal, as has been noted on a preceding page, in the year 1826 or thereabouts, and used in the construction of all masonry work.

1.* *Beach Mill.*—A flouring mill, erected about 1832 at the village of Clarksville, by Lawson Verey, was later changed into a cement mill, and after passing through the hands of various owners came into the possession of Wm. F. Beach, who was operating it in 1873 when Prof. W. W. Borden made his survey for the report on Floyd and Clark counties.† At this time three kilns and two run of buhrs were in operation. The limestone was secured from the river bank adjacent by tunneling. The spring floods of the Ohio gave great inconvenience to the operation of tunnels, often flooding them completely. The formation of a trust and the purchase of the Beach Mill's quota by other firms allowed the mill to rust away in idleness until the flood of 1884 completed the destruction. To-day, but a pile of foundations marks the site of the pioneer of one of Indiana's most important industries. Professor Borden gives the following section at the quarry:

* The number refers to the number of the plant on the accompanying map.
† Geological Survey of Indiana, 1873, pp. 152-153.

	Ft.	In.
New Albany black shale	0	5
Crinoidal limestone	4	2
Hydraulic limestone, dark, with hornstone concretions	..	11
Hydraulic limestone	13	7
Corniferous	6	..
	25	1

The section of the river bluff near the old works obtained by the writer under the present unfavorable conditions is as follows:

	Ft.	In.
Heavy bedded bluish-gray limestone	3	0
Gritty limestone with black pebbles at base	2	6
Hydraulic limestone with chert and lime splotches	1	6
Hydraulic limestone	10	0
Shaly limestone with *Spirifer acuminatus*, etc	1	0
Massive shaly limestone	3	0
	21	0

2. *Gheen's Mill.*—A mill built by W. S. Hohn & Co. in 1868 near the center of section 48, Clark's Grant, has been operated by the Silver Creek Cement Co., producing the Silver Creek Brand of cement. In 1878 it became the property of C. W. Gheen & Co., the present owners. The original quarry was opened in the northeast corner of section 34, just west of the one now operated by the Ohio Valley Cement Co. In 1881 a quarry was opened in the creek bank upon the same section as the mill. When the stripping became heavy, tunneling was resorted to. Floods in the creek gave much trouble, however, and in 1892 a slope was driven to the hydraulic limestone nearer the mill and worked for about 300,000 barrels of cement. The last year in operation was in 1896. Its quota has been manufactured by the Falls City Cement Co., and the Ohio Valley Cement Co. In 1873 four kilns and two run of buhrs were in operation. At present there are eight kilns and four run of buhrs, having a capacity of 800 barrels per day.

A section of the older quarry by the creek is as follows:

	Ft.	In.
New Albany black shale	8	0
Heavy bedded encrinital limestone	6	0
Shale parting varying from 0 to	0	8
Encrinital limestone, lower 3 inches conglomeritic	1	0
Hydraulic limestone, few fossils, no "blotches"	8	0
Hydraulic limestone, concealed by creek	6	0

The black pebbles are distributed throughout a 2 to 3-inch sandy, gritty stratum, set off sharply in places from the underlying cement rock by a clay seam one-fourth inch in thickness. The sandy stratum thickens and thins, consequently there is a local irregularity of the contact line above and below but the general level around the quarry is well preserved. There are fossils but very rarely in the sandy stratum, but they are plentiful in the crystalline limestone above into which the scattering black pebbles extend for two or three inches. Very rarely the pebbles contain fossils, notably the *Chonetes yandellanus*, which is so characteristic of the cement rock.

The cement rock here is a pure homogeneous blue rock with a notable absence of those white calcareo-siliceous patches and blotches which are so apt to appear in the upper part of the ledge and injure its usefulness.

3. *The Ohio Valley Mill* was established in 1881, but has not been operated since 1898. The mill has a capacity of 800 barrels per day, with six kilns and three run of buhrs. Cement rock was last worked on leased land immediately east of the original quarry of the Silver Creek Cement Co. The rock is obtained by driving an entry 50 feet wide, a distance of 450 feet having been reached. The width of the entry makes artificial lighting and ventilation unnecessary. The motive power for the wall drills is compressed air.

A stone crusher is in operation at the quarry disposing of all the waste piles of the bastard rock stripping. The chert nodules make the rock very valuable for road metal.

A section of the quarry is as follows:

New Albany black shale	2 feet.
Bluish fine-grained bastard limestone	4 feet.
Ditto, with regular bands of chert	6 feet.
Cement rock	12 feet.

The upper member of the bastard limestone betrays a tendency to crystalline structure and in places occur numbers of *Spirifer granulosus* and stylolites with fossil cappings. Also a few large chert concretions occur. The lower member is remarkable for the evenness of the bands of cherty concretions. The two members probably represent an argillaceous phase of the Sellersburg limestone rather than the cement rock. Six inches of the cement which does not shoot loose from the roof has to be "drawn" to prevent falls.

ANALYSIS OF OHIO VALLEY CEMENT ROCK.

Calcium carbonate ($CaCO_3$)	54.31
Magnesium carbonate ($MgCO_3$)	16.90
Silica (SiO_2)	18.33
Ferric oxide (Fe_2O_3)	1.67
Alumina (Al_2O_3)	4.98
Lime (CaO)	0.14
Magnesia (MgO)	0.33
Undetermined	1.19
Total	97.85

4. *The Sable & Gilmore Mill* was one of the first to be built. It was located on the south bank of Silver Creek in the northeast corner of section 48 not far above where the railroad crosses. It ceased running about 1866 and about 1869 was torn down and moved to Watson, where it is now operated by the Queen City Cement Co. A section of the old quarry is as follows:

New Albany black shale	2 feet.
Hard crystalline fossiliferous limestone	7 feet.
Characteristic bluish cement rock	8 feet.
Cement concealed by creek	6 feet.

The lower four inches of the limestone overlying the cement rock contains the usual small rounded black pebbles.

5. *Black Diamond Mill* (Belknap & Co.)—This mill was erected in 1876 by Belknap & Co., and is just across the creek and below the preceding in the east corner of Section 86. Operations were closed in 1892 as it was found more economical to manufacture the mill's quota at the larger mill of the same company; though this mill was operated seven months in 1900 to supply an unusually heavy demand. The mill has a capacity of 700 barrels daily, operating six kilns and four run of buhrs. The cement rock was obtained by mining with compressed air as a motive power for the drills. This mill earned for its product a splendid reputation, and all of the product of the Falls City Mill and the Black Diamond River Mill in Louisville is now marketed under the Black Diamond brand. It is said that the good name of this brand resulted from the great care used in picking out the over-burned and underburned cement and because the cement was not ground so hot as was the general custom.

A section of the quarry face at the openings of the entries is as follows:

Soil	8 to 12 feet.
New Albany black shale	2 feet.
Crystalline limestone (no black pebbles)	6 feet.
Cement rock	16 feet.

The mine is at this time (Dec., 1900) partly filled with water, lying as it does, about six feet below the level of Silver Creek.

ANALYSIS OF BLACK DIAMOND CEMENT ROCK.

Calcium carbonate ($CaCO_3$)	51.95
Magnesium carbonate ($MgCO_3$)	32.97
Silica (SiO_2)	9.69
Ferric oxide (Fe_2O_3)	1.95
Alumina (Al_2O_3)	2.77
Lime (CaO)	0.10
Magnesia (MgO)	0.11
Undetermined	0.36
Total	99.90

6. *Hoosier Mill.*—The Hoosier Cement Co. erected in the fall of 1899 a plant for the manufacture of cement. It is situated just across the railroad from the preceding and has been in operation one year. It operates three Campbell patent kilns, with bases built for two more, and two sets of buhrs. Mining has been the rule from the start, and the location is well suited to that process. For those entries driven to the north and east the mine will probably be self draining or entirely dry. The section below shows that the ledge of cement rock, which is of splendid quality, is also of good thickness.

Soil	4 feet.
New Albany black shale	6 feet.
Blue-gray crystalline limestone (lower part with pebbles)	5 feet.
Cement	15 feet.

7. *The Banner Mill,* in the northeast corner of section 66, 500 yards north of the preceding; a new, complete, up-to-date plant for the manufacture of cement. The capacity of the new mill is 700 barrels daily, operating five kilns, of especial design, and two Williams & Griffin grinding mills. The cement rock is obtained by mining with the use of compressed air and electric lighting. Atten-

tion has been called in the section on *Methods of Mining* to the fact that the slope of this company is on the east side of the property and that the entries must run with the dip, with the probability of a resulting bother of drainage.

A section at the slope shows:

Soil	6 to 8 feet.
New Albany black shale	12 feet.
Gray crystalline limestone	5 feet.
Cement	16 feet.

The limestone overlying the cement seems to thicken to six to seven feet on the south and is reputed eight feet thick in the prospecting wells. It shows a small number of black pebbles at the base. A section of one of these wells in the mill yard is given as follows:

Soil	10 feet.
New Albany black shale	15 feet.
Hard gray limestone	8 feet.
Cement	16 feet.
Hard flinty limestone	56 feet.

Salt water was struck at this point and the well, which was for steaming purposes, was discontinued.

8. *The Globe Mill* was erected in 1897. It is situated in the west corner of section 67 and has a capacity of 650 barrels daily, operating 5 Campbell patent kilns and one run of buhrs. The cement rock up to the present has been obtained by open quarrying but mining has just been started. A section on the upper side of the quarry shows as follows:

Soil	6 to 8 feet.
New Albany black shale	6 to 8 feet.
Hard gray fossiliferous limestone	5 feet.
Cement rock	16 feet.

The upper foot or so of the cement ledge has some concretionary splotches of lime and chert. A well at the mill gives this section:

Soil	10 feet.
New Albany black shale	10 feet.
Hard gray limestone	5 feet.
Cement rock	16 feet.
Hard gray limestone	40 feet.

9. *Falls City Mill* (Belknap & Co.)—This plant is situated one mile south of Sellersburg in the eastern part of section 89, and was

opened in 1866. In 1873 there were in operation four kilns with a daily capacity of 400 barrels. Now there are 20 kilns with a daily capacity of 2,500 barrels. At first the cement rock was obtained by open quarrying until something like 15 acres had been worked out, and then mining was resorted to. The entries are run 40 to 50 feet wide without timbering, and some of them are 600 to 800 feet long. The drills are driven by compressed air, which furnishes ventilation, though there is, in addition, an air shaft in the rear part of the mine. The mine is lighted by electricity. The rock is drawn to the mouth of the mine by mules; there a small locomotive draws it to the crusher. The company also owns a small locomotive used for switching purposes in the yards. The stripping in the south part of the quarry is quite heavy, but enough rock to make 1,500,000 barrels of cement has been stripped and the stripping crushed and sold to the county for road metal for enough to pay the expense of stripping.

A section of the quarry and quarry well is as follows:

	Ft.	*In.*
Soil	5	0
New Albany black shale	10	0
Bluish gray crystalline limestone	5 to 6	0
Cement rock	15	4
Hard crystalline limestone	56	0

The lower few inches of the limestone overlying the cement has the characteristic rounded black pebbles. The upper foot or so of the cement rock has scattering calcareous splotches.

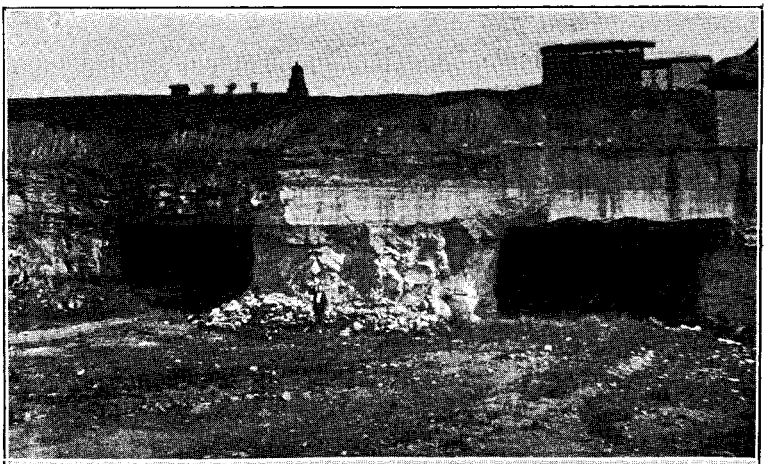
ANALYSIS OF BELKNAP'S FALLS CITY CEMENT ROCK.

Calcium carbonate ($CaCO_3$)	52.50
Magnesium carbonate ($MgCO_3$)	35.09
Silica (SiO_2)	9.80
Ferric oxide (Fe_2O_3)	1.40
Alumina (Al_2O_3)	2.03
Lime (CaO)	0.04
Magnesia (MgO)	0.11
Undetermined	0.47
Total	101.44

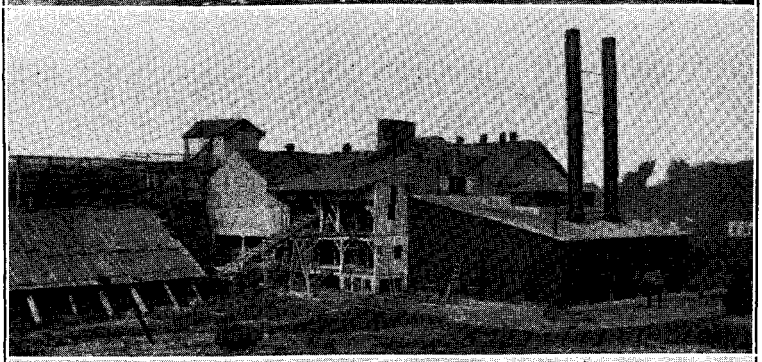
10. *The Clark County Mill* was established in 1889. The mill is situated three-fourths of a mile south of Sellersburg in the west quarter of section 90. The daily capacity is 900 barrels, the number of kilns seven, the number of run of buhrs two. The rock is quarried in an open quarry and stripping is done by steam, as described in the

PLATE 14.

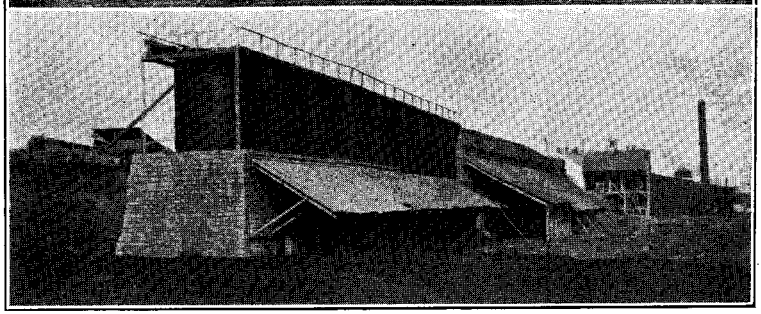
a



b



c



VIEWS OF FALLS CITY PLANT OF UNION CEMENT AND LIME CO.

(a) Portion of quarry, showing two tunnels.
(b) Cement mill.
(c) Kilns.

section on *Quarrying*. A section of the quarry at the upper side is as follows:

Soil	10 feet.
New Albany black shale	2 feet.
Hard light blue to gray crystalline limestone	4 feet.
Cement rock, upper ledge	4 feet.
Cement rock, lower ledge	10 feet.

The lower four to six inches of the overlying limestone is conglomeritic, most of the pebbles being in a drab, gritty bed of parting. The pebbles contain a good deal of iron, which stains the rock on exposure. The rock itself contains some flecks of pyrite here and there and decomposes readily into a black, ferruginous, residual clay, in which the characteristic fossils of formation are found in fine preservation, generally silicified.

11. *Golden Rule Mill.*—This plant was erected in 1898, about a mile northeast of Sellersburg in the west corner of section 112. It has a capacity of 500 barrels daily, operating three kilns and one run of buhrs. Open quarrying is employed at present. A section of a well at John J. Weber's, just south of the quarry, is as follows:

Soil and clay	8 feet.
New Albany black shale	9 feet.
Hard gray crystalline limestone	3 feet.
Cement rock	16 feet.

12. *United States Mill.*—This plant is situated in the north corner of the same section (112) as the preceding. It has a daily capacity of 800 barrels, operating six kilns and two run of buhrs. A section at the quarry is as follows:

Soil	4 feet.
Blue cement rock, upper ledge	3 feet.
Blue cement rock, middle ledge	2 feet.
Blue cement rock, lower ledge	8 feet.

The soil is residual from the decomposition of the limestone overlying the cement rock, and contains the pebbles found in that formation. The upper ledge of the cement rock consists of three 12-inch strata, much decomposed, and separated by arenaceous clayey partings. The middle ledge contains a great many of the lime and chert concretions. The lower ledge is the one which is used, and is the characteristic blue cement rock.

13. *Speed Mills* (J. Speed & Co.)—These mills are situated at Speed Station, and were erected in 1866. In 1873 there were in

operation eight kilns and four run of buhrs, having a daily capacity of 1,000 barrels. Now the plant consists of two independent mills, with a capacity of 4,000 barrels daily, and operating 31 kilns, 10 run of buhrs, seven coarse crushers, one Clark mill, 10 re-grinders and 18 screens.

Cement rock was long gotten from an open quarry near the mill, and something like 25 acres of ground was worked over. Recently a new quarry was opened near the middle of section 132, at a distance of one and three-fourths miles from the mills, but connected with them by a steam tramway. The new quarry is most advantageously situated for open quarrying, being located upon a flat ridge upon which the stripping will not average more than four or six feet, and that almost entirely earth. The large amount of earth stripping has led the company to develop the system of stripping by steam, as described in the section on *Quarrying*. A section of the quarry is as follows:

Soil	2 feet.
New Albany black shale	3 feet.
Black buckshot clay	1 foot.
Soft buff arenaceous rock	1 foot.
Cement rock	16 feet.

The shale exposed in this section is much decomposed and gray in color. The limestone below has decomposed entirely, giving the residual black buckshot clay, containing the characteristic fossils and black pebbles of the Sellersburg limestone. Below comes a bed of buff ocreous, arenaceous stone, apparently a weathered sandy part of the cement rock. This is cast aside in quarrying. The upper four inches of the ledge has the calcareous and siliceous blotches which have heretofore been described. The ledge itself is perfectly massive, having no vertical joint cracks and but one horizontal parting. The methods of quarrying and loading employed at this quarry have been described in the section headed *Quarrying*.

ANALYSIS OF SPEED'S CEMENT ROCK

Calcium carbonate ($CaCO_3$)	61.70
Magnesium carbonate ($MgCO_3$)	16.74
Silica (SiO_2)	13.65
Ferric oxide (Fe_2O_3)	1.45
Alumina (Al_2O_3)	3.46
Lime (CaO)	0.15
Magnesia (MgO)	0.25
Undetermined	0.86
Total	98.56

14. *Hausdale Mill.*—This mill is situated in the northern part of section 149, two and one-half miles north of Sellersburg. It was erected in 1891 and has a daily capacity of 1,000 barrels, operating eight modern kilns and four run of buhrs. A section of the quarry shows:

	Ft.	*In.*
New Albany black shale	3 to 4	0
Black dirt stratum	2	6
Cement rock	16	0

The shale is gray to buff in color and much decomposed. The limestone beneath has decomposed into the residual clay stratum, the bottom part of which is very black and contains a few rounded black pebbles.

The cement rock is in three ledges. The lower one is quite blue and makes white cement, though when overburned it is like iron ore and very hard. The upper ledges are the characteristic cement rock. The rock is obtained by open quarrying, there being no roof or necessity for mining, as yet.

ANALYSIS OF HAUSDALE CEMENT ROCK.

Calcium carbonate (CaO_3)	60.69
Magnesium carbonate ($MgCO_3$)	15.90
Silica (SiO_2)	15.21
Ferric oxide (Fe_2O_3)	1.44
Alumina (Al_2O_3)	4.07
Lime (CaO)	0.07
Magnesia (MgO)	0.32
Undetermined	0.86
Total	98.56

The foregoing mills are all situated upon or connected by switches with the Louisville division of the Pennsylvania Railway. Those following are situated upon the Jeffersonville branch of the B. & O. Railway.

15. *K. & I. Mill.*—This mill is situated in the eastern corner of section 34 and was erected in 1888. It has a capacity of 900 barrels daily, operating eight kilns and two Williams grinding mills. The rock was quarried from open quarries for a time, when mining was resorted to, and entries have been driven 800 feet to the southeast, reaching nearly to the county road. Compressed air is used in two Rand wall drills and the escaping air ventilates the mine, which is

lighted by electricity. The rock is drawn from the mine to the foot of the incline by horsepower. A section of the quarry is as follows:

	Ft.	*In.*
Arenaceous drab limestone	2	0
Chert	0	10
Cherty "bastard" rock	9	0
Cement	10	0

The gritty drab limestone at the top of the section containing many *Spirifer granulosus* and *Atrypa reticularis* probably represents the Sellersburg limestone. The bastard rock contains a great deal of chert in the form of bands of concretions, amounting to perhaps one-half of the whole rock mass. A rock crusher, to use the chert and cherty limestone for road metal, ought to be a good investment here.

16. *Queen City Mill* (J. Speed & Co.)—This, which is the old Sable & Gilmore mill, was moved to Watson about 1869(?) It has been closed since 1893, the company finding it more economical to manufacture their quota at their large mill at Speed Station. The mill has a daily capacity of 600 barrels with six kilns and four run of buhrs. The rock was obtained by open quarrying. A section of the quarry is as follows:

	Ft.	*In.*
Cherty bastard rock	8	0
Shale	0	1 to 3
Cement (bottom concealed)	12	0

The ledge of bastard rock contains a great many white flint concretions with dark centers, aggregated around various fossils, as gastropods and bryozoa. The matrix contains *Spirifer granulosus, Atrypa reticularis* and *Chonetes yandellanus.* A thin shale parting comes between the bastard rock and the cement ledge. The cement ledge is massive and contains the same fossils as the bastard rock.

17. *Haymaker Mill.*—This mill, which is in the extreme southern corner of section 95, about two miles south of Charlestown, is a new and complete one, having been erected in 1892. It has a daily capacity of 1,000 barrels, operating eight kilns and four run of buhrs. The rock is obtained by open quarrying. A section of the quarry is as follows:

	Ft.	In.
Red soil	2	6
New Albany black shale	1	2
White crystalline encrinital limestone	4	6
Arenaceous gray limestone	0	6 to 8
Cement rock	8	0
Dark blue cement shale (bottom concealed)	2	0

The encrinital limestone just below the New Albany Black shale is exceedingly rich in crinoids, though mostly of one species, *Megistocrinus rugosus.* It also contains a number of the characteristic black pebbles distributed through a distance of six or eight inches from the bottom. The gritty stratum just below contains a great many of those pebbles which are somewhat ferruginous. It contains further a few fossils, as *Spirifer granulosus*, etc. The dark blue shale stratum at the bottom of the section is used for cement. The cement rock contains but few *Chonetes yandellanus,* but has *Spirifer mucronata(?), Spirifer acuminatus, Atrypa reticularis, Bryozoa* and a trilobite.

18. *Standard Mill.*—This, the most eastern of the cement works, is situated about two miles north of Charlestown, in the west corner of section 138. It was erected in 1897. The rock is obtained by mining, five entries having been driven some distance into the ledge. The mine is equipped with Rand wall drills and a compressed air plant. The mill has a capacity of 500 barrels daily, operating five kilns and two run of buhrs. A section of the quarry is as follows:

Soil	4 feet.
New Albany black shale	2 feet.
Bastard limestone	8 feet.
Cement rock	8 feet.

The bastard ledge contains no fossils, but many cherty concretions. The cement ledge also contains a good many of these.

19. *The Black Diamond River Mill* (Belknap & Co.), in Louisville, should be described as being intimately connected with the Indiana mills. Cement rock is quarried from the reef at Falls of Ohio during low water.

20. *The Hulme Mill* (J. Speed & Co.), at Shippingsport, likewise uses cement rock from the Falls of the Ohio.

For convenience of reference a tabular view is herewith presented of the different mills, their equipments and capacities.

CAPACITY AND EQUIPMENT OF CEMENT MILLS.

NAME OF MILL.	Company.	Brand.	Year Opened.	Year Closed.	Daily Capacity.	Number of Kilns.	Number of Crushers.	Number of Regrinders.	Number of Buhrs or Mills.	Number of Screens.	Number of Drills.	Method of Exploitation.
(1) Beach Mill	Wm. F. Beach	Red	1832(?)	1884	300	3	....	....	2 buhrs	....	....	Mining.
(2) Gheen's Mill	Silver Creek Cement Co	Acorn	1868	1896	800	8	....	....		....	....	Quar.Min.
(3) Ohio Valley Mill†	Ohio Valley Cement Co	Fern Leaf	1881	1898	600	6	2	....	3 buhrs	1	2	Quar.Min.
(4) Sable & Gilmore Mill	Sable & Gilmore	Diamond	?	1866								Quarry.
(5) Black Diamond Mill‡	Union Cement and Lime Co	Black Diamond	1866	....	700	6	1	1	4 buhrs	4	2	Mining.
(6) Hoosier Mill	Hoosier Cement Co	Hod and Shovel	1898	....	400	3	1	1	2 buhrs	2	2	Mining.
(7) Banner Mill‡	Banner Cement Co	Banner	1898	....	700	5	1	....	2 Williams mills 2 Griffin mills	3	2	Mining.
(8) Globe Mill‖	Globe Cement Co	Globe	1897	....	650	5	1	1	1 buhr	3	1	Quar.Min.
(9) Falls City Mill*†	Union Cement and Lime Co	Anchor and Black Diamond	1866	....	2,500	20	4	4	3 Clark mills	7	5	Quar.Min.
(10) Clark County Mill	Clark County Cement Co	Trowel and Hammer	1889	....	900	7	1	2	1 buhr	3	1	Quarry.
(11) Golden Rule Mill	Golden Rule Cement Co	Arm and Hammer	1898	....	500	3	1	2	1 buhr	3	1	Quarry.
(12) U. S. Mill	United States Cement Co	Flag	1892	....	800	6	1	2	2 buhrs	3	1	Quarry.
(13) Speed Mill*	Louisville Cement Co	Star	1866	....	4,000	32	7	12	1 Clark mill 10 buhrs	18	3	Quarry.
(14) Haussdale Mill	New Albany Cement Co	Crown	1891	....	1,000	8	1	2	4 buhrs	4	1	Quarry.
(15) K. and I. Mill†	Kentucky and Indiana Cement Co	Eagle	1888	....	900	8	2	....	1 buhr 2 Williams mills	3	3	Quar.Min.
(16) Queen City Mill†	Louisville Cement Co	Star	1869	1893	700	6	1	1	4 buhrs	3	3	Quar.Min.
(17) Haymaker Mill	Indiana Cement Co	Lion	1892	....	1,000	8	2	2	4 buhrs	4	3	Quarry.
(18) Standard Mill†	Standard Cement Co	Big Four	1897	....	500	5	1	2	2 buhrs	2	2	Quar.Min.
(19) Black Diamond River Mill	Union Cement and Lime Co	River Black Diamond	.....	....	.....	....	....	....	.....	...	....	
(20) Hulme Mill	Louisville Cement Co	Star	.....	....	.....	....	....	....	.....	....	....	

*Two locomotives. †Air drills. ‡Air drills and electric lights. ‖Steam drills.