CATALOGUE OF FOSSILS

FOUND IN THE

Hudson River, Utica Slate and Trenton Groups,

AS EXPOSED IN THE

SOUTHEAST PART OF INDIANA, SOUTHWEST PART OF OHIO, AND NORTHERN PART OF KENTUCKY.

BY S. A. MILLER, ESQ., OF CINCINNATI, O.

In 1842* Professor James Hall, of New York, stated that the shale at Newport, Kentucky, containing *Triarthrus becki*, is of the age of the Utica Slate of New York, and that the rocks below in Kentucky are the equivalent of the Trenton Group of New York.

In 1865 Professor F. B. Meek proposed to substitute the name Cincinnati Group for the older and well understood Hudson River group of the New York and Canadian geologists. As this could not be done, other geologists have tried to substitute the name "Cincinnati Group" for rocks of the age of the Hudson River, Utica Slate or Trenton Groups wherever found in the Western States. The attempt to substitute the name of the "Cincinnati Group" for one or

Am. Jour. Sci. and Arts, vol. 42.

more of these well-defined and clearly characterized groups of New York and Canada has caused a great deal of useless discussion and no small amount of confusion in the nomenclature of these rocks.

The Cincinnati geologists, neglecting the study of the Trenton Group of Kentucky, and overlooking the evidences pointing to the Utica Slate age of the small exposures in the banks of the Ohio, near Cincinnati, contented themselves, with the study of the richer fields, in the exposures of the Hudson River group in Ohio and Indiana, and permitted geologists from abroad, who knew little or nothing of the rocks in question, to flatter them with a local name until the absurdity of the position became so manifest and the injury to science so apparent that they resolved, notwithstanding their local pride, to abandon the worse than useless synonym, and to raise their voice in behalf of exact science and the well established law of priority in geological nomenclature.

The action taken will be best understood by quoting the proceedings at the special meeting of the Cincinnati Society of Natural History, as follows, to-wit:

*"SPECIAL MEETING OF THE CINCINNATI SOCIETY OF NATURAL HISTORY TO CONSIDER QUESTIONS OF GEOLOGICAL NOMENCLATURE.

"At a special meeting of the Cincinnati Society of Natural History, called to consider questions of geological nomenclature, held at the rooms of the society, on the 23d day of January, 1879, at 3 o'clock P. M.—L. S. Cotton, vice-president, in the chair—on motion of S. A. Miller, Esq., it was

"*Resolved*, That a committee of ten, who take a special interest in the study of the Lower Silurian rocks of southwestern Ohio, southeastern

* My own views on the Lower Silurian rocks, in this report, were written in 1877. So far as Indiana is concerned, I see no cause to make any changes, but in view of the ability of the committee of the Natural History Society of Cincinnati, their long acquaintance with, and fine opportunities to study the rocks at Cincinnati, leads me to agree with them in placing the lower part of the group in Ohio in the Utica slate.

E. T. C.

Indiana and Kentucky, be appointed by the chair to report to this society upon what seems to them to be the correct nomenclature of these rocks.

"Whereupon the chair appointed as such committee, S. A. Miller, Esq., Prof. A. G. Wetherby, Fred. Braun, Esq., Prof. Geo. W. Harper, Prof. John Mickleborough, Paul Mohr, Esq., Prof. John W. Hall, Jr., C. B. Dyer, Esq., E. O. Ulrich, Esq., and Dr. R. M. Byrnes.

"The committee thereupon reported as follows:

"*To the Cincinnati Society of Natural History:*

"Your committee, appointed to report upon what seems to be the correct nomenclature of the Lower Silurian rocks of southwestern Ohio, southeastern Indiana, and Kentucky, represent:

"That the fossils found in the strata, for twenty feet or more above low water mark of the Ohio river, in the first ward of the city of Cincinnati, and on Crawfish creek, in the eastern part of the city, and in Taylor's creek, east of Newport, Kentucky, at an elevation of more than fifty feet above low water mark in the Ohio river, indicate the age of the Utica Slate Group of New York. A fauna is represented in these rocks that is not found above or below them. Within this range we find the *Triarthrus becki, Leperditia byrnesi, Leptobolus lepis, Buthotrephis ramulosa*, and several species of Graptolites, Crinoids, Bryozoans, and Brachiopods that seem to be confined within its limits. Moreover, the brown slates and greenish-blue shales and concretionary nodules give a lithological character to the strata which distinguish them from the strata both above and below. From the evidences thus furnished by the lithological character of the strata, and the distinct character of the fossil remains, we refer all the strata containing the *Triarthrus becki* to the age of the Utica Slate Group of New York.

"Above the range of the *Triarthrus becki*, the fossils, as well as the position of the rocks, indicate the age of the Hudson River Group of New York, and we have no hesitation in so referring them, and entertain no doubt of the correctness of the reference.

"The fossils from Paris, Lexington, the High Bridge over the Kentucky river, and from other places in Kentucky, as well as the lithological character of the strata, furnish abundant evidence of the existence of the Trenton Group over an extensive tract of country in that State. In the State of Kentucky, we have the Trenton, Utica Slate and Hudson River Groups well represented, and the rocks have a northerly dip from Paris and Lexington toward the Ohio river, but at what rate per mile we are not advised.

"In Southeastern Indiana neither the Trenton nor Utica Slate appear, and, consequently, we refer all the Lower Silurian rocks of that State to the Hudson River Group.

"The Trenton Group is not exposed at Cincinnati, nor at any point in Ohio west of the city, but we think it is probable that it may be represented in the banks of the Ohio river a few miles east of the city. The Utica Slate is represented in Ohio only in the banks of the river, at the city of Cincinnati, and east of the city, and in the excavations near the mouths of the streams which enter the river east of the city. Consequently all the Lower Silurian rocks in Southwestern Ohio belong to the Hudson River Group, except those represented by the small exposures in the banks of the river at Cincinnati, and east of the city, in the immediate vicinity of the river.

"The conclusion to which we have come is, that all the Lower Silurian rocks which we have had under consideration, are to be referred to the Trenton, Utica Slate and Hudson River Groups, and that the name 'Cincinnati Group' should be dropped, not only because it is a synonym, but because its retention can subserve no useful purpose in the science, and because it will, in the future, as in the past, lead to erroneous views and fruitless discussion. And we would add that so far as any investigations of these rocks have been made, they have not led to any other or further subdivisions than those which we have adopted, and which have been so thoroughly and firmly established by the geologists of the State of New York.

"S. A. MILLER,	A. G. WETHERBY,
"FRED. BRAUN,	GEO. W. HARPER,
"JNO. MICKLEBOROUGH,	PAUL MOHR,
"JOHN W. HALL, JR.,	C. B. DYER,
"E. O. ULRICH,	R. M. BYRNES.

"After some discussion and remarks in favor of the report, by R. B. Moore, Esq., and others, the report was received, and the committee discharged; and there being no other business before the society, on motion, it adjourned."

It will be observed that only a few fossils in the following catalogue are referred to the Trenton Group of Kentucky. This is to be accounted for on the Ground that this Group is to the Cincinnati geologists a comparatively unexplored field. As long as all the rocks were referred to the "Cincinnati Group," collectors would naturally seek the richest grounds for hunting and neglect the less exposed and more difficult places. Ohio and Indiana furnished the finest exposures and those most favorable, because composed of shales and thin limestones. The beautiful plains in the Blue-grass region of Kentucky offer but few exposures of the underlying Trenton rocks, and those are generally confined to displays of massive stone in the banks of the streams where fossils are collected under difficulties.

The rocks having been correctly subdivided, we may expect, in the future, to find the Trenton Group quite thoroughly explored and a more accurate knowledge of its fossils in the possession of our collectors, as well as a definite determination of the fossils which are limited in their range to the Utica Slate.

PLANTÆ.

Aristophycus—Miller & Dyer, 1878. Cont. to Pal., No. 2. [Ety. *aristos*, best of its kind, excellent; *phukos*, a sea plant.]

" **ramosum**—Miller & Dyer, 1878. Cont. to Pal., No. 2. Hud. Riv. Gr. [Sig. branchy.]

" **ramosum** *var.* **germanum**—Miller & Dyer, 1878. Cont. to Pal., No. 2. Hud. Riv. Gr. [Sig. near of kin.]

Arthraria—Billings, 1874. Pal. Foss. Vol. 2. [Ety. *arthron*, a joint.]

" **biclavata**—S. A. Miller, 1875. Cin. Quar. Jour. Sci., Vol. 2. Hud. Riv. Gr. [Sig. double-clubbed.]

Blastophycus—Miller & Dyer, 1878. Jour. Cin. Soc. Nat. Hist. [Ety. *blastos*, a bud; *phukos*, sea weed.]

" **diadematum**—Miller & Dyer, 1878. Jour. Cin. Soc. Nat. Hist. Lower part Hud. Riv. Gr. [Sig. diademed.]

Buthotrephis—Hall, 1847. Pal. N. Y., Vol. 1. [Sig. growing in the depths of the sea.]

" **gracilis**—Hall, 1847. Pal. N. Y., Vol. 1. Hud. Riv. Gr. [Sig. slender.]

" **gracilis** *var.* **intermedia**—Hall, 1852. Pal. N. Y., Vol. 2. Hud. Riv. Gr. [Sig. intermediate.]

" **ramulosa**—S. A. Miller, 1874. Cin. Quar. Jour. Sci., Vol. 1. Utica Slate Gr. [Sig. full of little branches.]

Chlœphycus—Miller & Dyer, 1878. Cont. to Pal., No. 2. [Ety. *chlœ*, young grass; *phukos*, a sea plant.]

" **plumosum**—Miller & Dyer, 1878. Cont. to Pal., No. 2. Lower part of Hud. Riv. Gr. [Sig. feathered.]

Dactylophycus—Miller & Dyer, 1878. Cont. to Pal., No. 2. [Ety. *dactylos*, a finger; *phukos*, a sea plant.]

" **quadripartitum**—Miller & Dyer, 1878. Cont. to Pal., No. 2. Lower part Hud. Riv. Gr. [Sig. four-parted.]

" **tridigitatum**—Miller & Dyer, 1878. Cont. to Pal., No. 2. Lower part Hud. Riv. Gr.. [Sig. three-fingered.]

Dystactophycus—Miller & Dyer, 1878. Cont. to Pal., No. 2. [Ety. *dystaktos*, hard to arrange; *phukos*, a sea plant.]

" **mamillanum**—Miller & Dyer, 1878. Cont. to Pal., No. 2. Upper part Hud. Riv. Gr. [Sig. having breasts, or protuberant.]

Heliophycus—Miller & Dyer, 1878. Cont. to Pal., No. 2. [Ety. *helios*, the sun; *phukos*, a sea plant.]

" **stelliforme**—Miller & Dyer, 1878. Cont. to Pal., No. 2. Hud. Riv. Gr. [Sig. star-shaped.]

Licrophycus—Billings, 1862. Pal. Foss., Vol. 1. [Ety. *Likros*, a fan; *phukos*, a sea plant.]

" **flabellum**—Miller & Dyer, 1878. Jour. Cin. Soc. Nat. Hist. Upper part Hud. Riv. Gr. [Sig. a fan.]

Lockia—James, 1879. Palæontologist. [Ety. proper name.]

" **siliquaria**—James, 1879. Palæontologist, Utica Slate Gr. [Sig. pod-like.] Mr. James has published a number of names with brief descriptions in a paper called the "Palæontologist." This species can be readily identified, and is found in abundance in the bank of the Ohio river, below Covington, Ky. I have admitted into this catalogue, from his "Palæontologist," only such species as I have identified.

Protostigma—Lesquereux, 1877. Trans. Am. Phil. Soc. [Ety. *protos*, first; *stigma*, a dot or puncture.]

" **sigillarioides**—Lesquereux, 1877. Trans. Am. Phil. Soc. Upper part of Hud. Riv. Gr. [Sig. like a fossil of the genus *sigillaria*.] I regard this as a sea plant, though Prof. Lesquereux has published it as a land plant.

Psilophytum—Dawson, 1859. Quar. Jour. Geo. Soc., Vol. 15. [Ety. *psilon*, smooth; *phyton*, stem.]

" **gracillimum**—Lesquereux, 1877. Trans. Am. Phil. Soc. Utica Slate and lower part Hud. Riv. Gr. Professor Lesquereux published this as a land plant, but I think it is a Graptolite, and have referred it to *Dendrograptus gracillimus*.

Rusophycus—Hall, 1852. Pal. N. Y., Vol. 2. [Ety. *rusos*, rugose; *phukos*, a sea plant.]

" **asperum**—Miller & Dyer, 1878. Jour. Cin. Soc. Nat. Hist. Lower part Hud. Riv. Gr. [Sig. rough.]

" **bilobatum**—Vanuxem, 1842. (*Fucoides bilobatus.*) Geo. Rep. N. Y. Hud. Riv. Gr. [Sig. two-lobed.]

" **pudicum**—Hall, 1852. Pal. N. Y., Vol. 2. Hud. Riv. Gr. [Sig. shame-faced.]

Sphenophyllum—Brongniart, 1828. Prodr. Hist. Veg. Foss. [Ety. *sphen*, a wedge; *phyllon*, a leaf.]

" **primævum**—Lesquereux, 1877. Trans. Am. Phil. Soc. Hud. Riv. Gr. (?) Prof. Lesquereux published this as a land plant. I do not think it is. If it is a fossil, it is a Graptolite.

Trichophycus—Miller & Dyer, 1878. Jour. Cin. Soc. Nat. Hist. [Ety. *trichos*, hair; *phukos*, sea plant.]

" **lanosum**—Miller & Dyer, 1878. Jour. Cin. Soc. Nat. Hist. Upper part of Hud. Riv. Gr. [Sig. woolly.]

" **sulcatum**—Miller & Dyer, 1878. Cont. to Pal., No. 2. Lower part of Hud. Riv. Gr. [Sig. furrowed.]

ANIMAL KINGDOM.

SUB-KINGDOM PROTISTA.

CLASS RHIZOPODA.

Pasceolus—Billings, 1857. Rep. of Prog. Can. Sur. [Ety. *pasceolus*, a leather money bag.]

" **claudei**—S. A. Miller, 1874. Cin. Quar. Jour. Sci., Vol. 1. Hud. Riv. Gr. [Ety. proper name.]

" **darwini**—S. A. Miller, 1874. Cin. Quar. Jour. Sci., Vol. 1. Hud. Riv. Gr. [Ety. proper name.]

CLASS PORIFERA.

Brachiospongia—Marsh, 1867. Am. Jour. Sci. and Arts, 2d Ser., Vol. 44. [Ety. *brachium*, an arm; *spongia*, sponge.

" **digitata**—Owen, 1857. (Scyphia digitata.) Geo. of Ky., Vol. 2. Trenton Gr. of Ky. [Sig. fingered.]

" **lyoni**—Marsh, 1867. Am. Jour. Sci. and Arts, 2d Ser., Vol. 44. Trenton Gr. of Ky. [Ety. proper name.]

" **roemerana**—Marsh, 1867. Am. Jour. Sci. and Arts, 2d Ser., Vol. 44. Trenton Gr. of Ky. [Ety. proper name.]

Microspongia—Miller & Dyer, 1878. Jour. Cin. Soc. Nat. Hist. [Ety. *mikros*, small; *spongia*, sponge.]

" **gregaria**—Miller & Dyer, 1878. Jour. Cin. Soc. Nat. Hist. Hud. Riv. Gr. [Sig. gregarious.]

SUB-KINGDOM RADIATA.

CLASS POLYPI.

Aulopora—Goldfuss, 1826. Germ. Petref. [Ety. *aulos*, a pipe; *poros*, a pore.

" **arachnoidea**—Hall, 1847. Pal. N. Y., Vol. 1. Hud. Riv. Gr. [Sig. like a cobweb.]

Chetetes—Fischer, 1837. Oryct. du Gouv. Moscow. [Ety. *chaite*, hair.] Following the best authors, I refer the species usually referred to this genus, from the Lower Silurian rocks, to the genus Monticulipora.

Climacograptus—Hall, 1865. Can. Org. Rem. Decade 2. [Ety. *climax*, a small ladder; *grapho*, to write.]

" **bicornis**—Hall, 1847. (Graptolithus bicornis.) Pal. N. Y., Vol. 1. Hud. Riv. Gr. [Sig. two horned.]

" **typicalis**—Hall, 1865. Can. Org. Rem. Decade 2. Hud. Riv. Gr. [Sig. type of the genus, though the genus was founded upon *G. bicornis*.]

Columnopora—Nicholson, 1874. Lond. Geo. Mag. N. S., Vol. 1. [Ety. *columna*, a column; *porus*, a pore.]

" **cribriformis**—Nicholson, 1874. Lond. Geo. Mag. N. S., Vol. 1. Upper part Hud. Riv. Gr. [Sig. seive-formed.]

Constellaria polystomella—Nicholson. Syn. for Stellipora antheloidea; or, at most, a mere variety.

Dendrograptus—Hall, 1865. Can. Org. Rem. Decade 2. [Ety. *dendron*, a tree; *grapho*, to write.]

" **gracillimus**—Lesquereux, 1877. (Psilophytum gracilimum.) Trans. Am. Phil. Soc. Utica Slate and lower part of Hud. Riv. Gr. [Sig. very slender.]

Favistella—Hall, 1847. Pal. N. Y., Vol. 1. [Ety. *favus*, honey comb; *stella*, a star.]

" **stellata**—Hall, 1847. Pal. N. Y., Vol. 1. Upper part of Hud. Riv. Gr. [Sig. starred.]

Megalograptus—S. A. Miller, 1874. Cin. Quar. Jour. Sci., Vol. 1. [Ety. *megale*, great; *grapho*, to write.]

" **welchi**—S. A. Miller, 1874. Cin. Quar. Jour. Sci., Vol. 1. Upper part Hud. Riv. Gr. [Ety. proper name.]

Monticulipora—D'Orbigny, 1850. Prodr. de Palæont. [Ety. *monticulus*, a hillock; *porus*, a pore.]

" **approximata**—Nicholson, 1874. (Chetetes approximatus.) Quar. Jour. Geo. Soc., Vol. 30. Hud. Riv. Gr. [Sig. near to—from its near approach to *M. dalei*.]

Monticulipora—attrita—Nicholson, 1874. (Chetetes attritus, and later Dekayia attrita) is merely a weathered form of different species.

" **briareus**—Nicholson, 1875. (Chetetes briareus.) Ohio Pal., Vol. 2. Utica Slate Gr. [Ety. mythological name.]

" **calceolus**—Miller & Dyer, 1878. Jour. Cin. Soc. Nat. Hist. Hud. Riv. Gr. [Sig. a little shoe.]

" **caliculus**—James, 1875. (Chetetes calicula.) Catalogue Cin. Foss. Utica State Gr. [Sig. a little cup.]

" **clathratula**—James. (Chetetes clathratulus). Syn. for Cyclopora jamesi.

" **clavacoidea**—James, 1875. (Chetetes clavicoideus.) Catalogue Cin. Foss. Hud. Riv. Gr. [Sig. club-shaped.]

" **corticans**—Nicholson. (Chetetes corticans.) Syn. for Monticulipora tuberculata.

" **dalei**—Edwards & Haime, 1851. (Chetetes dalei.) Pol. Foss. des Terr. Palæoz. Hud. Riv. Gr. [Ety. proper name.]

" **decipiens**—Rominger, 1866. (Chetetes decipiens.) Proc. Acad. Nat. Sci. Phil. Hud. Riv. Gr. [Sig. doubtful.] This may be a syn. for *Cyclopora jamesi.*

" **delicatula**—Nicholson, 1874. (Chetetes delicatulus.) Quar. Jour. Geo. Soc., Vol. 30. Upper part Hud. Riv. Gr. [Sig. quite slender.]

" **discoidea**—Nicholson, 1875. (Chetetes discoideus.) Ohio Pal., Vol. 2. Hud. Riv. Gr. [Sig. disc-like.]

" **fibrosa**—Goldfuss, 1826. (Calamopora fibrosa.) Germ. Petref. Trenton and Hud. Riv. Gr. [Sig. fibrous.]

" **fletcheri**—Edwards & Haime, 1851. (Chetetes fletcheri.) Pol. Foss. des Terr. Palæoz. Hud. Riv. Gr. [Ety. proper name.]

" **frondosa**—D'Orbigny, 1850. Prodr. de Palæont. Hud. Riv. Gr. [Sig. branchy.]

" **gracilis**—Nicholson, 1874. (Chetetes gracilis.) Quar. Jour. Geo. Soc., Vol. 30. Hud. Riv. Gr. [Sig. slender.]

" **jamesi**—Nicholson, 1874. (Chetetes jamesi.) Quar. Jour. Geo. Soc., Vol. 30. Lower part Hud. Riv. Gr. [Ety. proper name.

Monticulipora—lycoperdon—Say, 1847. (Favosites lycoperdon.) Hall in Pal. N. Y., Vol. 1. Trenton and Hud. Riv. Gr. [Sig. puff-ball-shaped.]

" **mammulata**—D'Orbigny, 1850. Prodr. de Palæont. Hud. Riv. Gr. [Sig. mammillated.]

" **newberryi**—Nicholson, 1875. (Chetetes newberryi.) Ohio Pal., Vol. 2. Hud. Riv. Gr. [Ety. proper name.]

" **nodulosa** — Nicholson, 1874. (Chetetes nodulosus.) Quar. Jour. Geo. Soc., Vol. 30. Upper part Hud. Riv. Gr. [Sig. covered with small knots.]

" **onealli**—James, 1875. (Chetetes onealli.) Catalogue Sil. Foss. Lower part Hud. Riv. Gr. [Ety. proper name.]

" **ortoni**—Nicholson, 1874. (Chetetes ortoni.) Quar. Jour. Geo. Soc., Vol. 30. Hud. Riv. Gr. [Ety. proper name.]

" **papillata**—McCoy, 1850. Ann. and Mag. Nat. Hist., 2d Ser., Vol. 6. Hud. Riv. Gr. [Sig. covered with papilli.]

" **pavonia**—See Cyclopora pavonia.

" **petechialis**—Nicholson, 1875. (Chetetes petechialis.) Ohio Pal., Vol. 2. Hud. Riv. Gr. [Sig. spotted.]

" **pulchella** as identified by Nicholson (chetetes pulchellus) is M. fibrosa.

" **quadrata**—Rominger, 1866. (Chetetes quadratus.) Proc. Acad. Nat. Sci. Upper part Hud. Riv. Gr. [Sig. four-cornered.]

" **rhombica**—Nicholson. (Chetetes rhombicus.) Syn. for M. quadrata.

" **rugosa**—Edwards & Haime. (Chetetes rugosus.) It is merely a form of M. dalei. Moreover, the name was pre-occupied.

" **sigillarioides**—Nicholson, 1875. (Chetetes sigillarioides.) Ohio Pal., Vol. 2. Utica Slate and lower part Hud. Riv. Gr. [Sig. like a sigillaria.]

" **subpulchella**—Nicholson, 1875. (Chetetes subpulchellus.) Ohio Pal., Vol. 2. Hud. Riv. Gr. [Sig. somewhat like *M. pulchella.*] This is a variety of M. fibrosa.

" **tuberculata**—Edwards & Haime, 1851. (Chetetes tuberculatus.) Pol. Foss. des Terr. Palæoz. Hud. Riv. Gr. [Sig. tuberculated.]

Monticulipora—undulata—Nicholson, 1875. Pal. Province of Ontario. Hud. Riv. Gr. [Sig. undulated.] This is the large, irregular form which is usually regarded as a variety of M. lycoperdon.

Palæophyllum—Billings, 1858. Rep. of Progr. Can. Sur. [Ety. *palaios*, ancient; *phyllon*, a leaf.]

" **divaricans**—Nicholson, 1875. Ohio Pal., Vol. 2. Upper part Hud. Riv. Gr. [Sig. wide apart.]

Protarea—Edwards & Haime, 1849. Pol. Foss. des Terr. Palæoz. [Ety. *protos*, first; *araios*, spongy.]

" **vetusta**—Hall, 1847. (Porites vetustus.) Pal. N. Y., Vol. 1. Upper part Hud. Riv. Gr. [Sig. ancient.]

Stellipora—Hall, 1847. Pal. N. Y., Vol. 1. [Ety. *stella*, a star; *porus*, a pore.]

" **antheloidea**—Hall, 1847. Pal. N. Y., Vol. 1. Hud. Riv. Gr. [Sig. like a coral of the genus *Anthelia*.]

Streptelasma—Hall, 1847. Pal. N. Y., Vol. 1. [Ety. *streptos*, twisted; *elasma*, lamella.]

" **corniculum**—Hall, 1847. Pal. N. Y., Vol., 1. Upper part Hud. Riv. Gr. [Sig. a little horn.]

Tetradium—Dana, 1848. Zooph., Vol. 8. [Ety. *tetras*, four.]

" **fibratum**—Safford, 1856. Am. Jour. Sci. and Arts, 2d Ser., Vol. 22. Upper part Hud. Riv. Gr. [Sig. threaded.]

CLASS ECHINODERMATA.

Agelacrinus—Vanuxem, 1842. Geo. Rep. 3d Dist. N. Y. [Ety. *agele* a herd; *krinon*, a lily.]

" **cincinnatensis**—Roemer, 1857. Verh. Naturh. Rhein. Westph., Vol. 8. Hud. Riv. Gr. [Sig. proper name.]

" **pileus**—Hall, 1866. Pamphlet Hud. Riv. Gr. [Sig. a cap.]

" **septembrachiatus**—Miller & Dyer, 1878. Jour. Cin. Soc. Nat. Hist. Upper part Hud. Riv. Gr. [Sig. having seven arms.]

" **vorticellatus**—Hall, 1866. Pamphlet Hud. Riv. Gr. [Sig. whorled.]

Anomalocrinus—Meek & Worthen, 1868. Geo. Sur. Ill., Vol. 3. [Ety. *anomos*, irregular; *krinon*, a lily.]

" **incurvus**—Meek & Worthen, 1865. (Heterocrinus incurvus.) Proceedings Acad. Nat. Sci. Hud. Riv. Gr. [Sig. incurved—from an incurved arm.]

Anomalocystites—Hall, 1859. Pal. N. Y., Vol. 3. [Ety. *anomos*, irregular; *kustis*, a bladder.]

" **balanoides**—Meek, 1872. Am. Jour. Sci. and Arts, 3d Ser., Vol. 3. This species is referred by Prof. A. G. Wetherby to the crustacea under the name *Enopleura balanoides*.

Cyclocystoides—Billings & Salter, 1858. Can. Org. Rem. Decade 3. [Ety. *kuklos*, a circle; *kustis*, a bladder; *eidos*, form.]

" **bellulus**—Miller & Dyer, 1878. Jour. Cin. Soc. Nat. Hist. Supposed to be from the Utica Slate, but possibly from the lower part of the Hud. Riv. Gr. [Sig. beautiful.]

" **magnus**—Miller & Dyer, 1878. Jour. Cin. Soc. Nat. Hist. Hud. Riv. Gr. [Sig. large.]

" **minus**—Miller & Dyer, 1878. Jour. Cin. Soc. Nat. Hist. Hud. Riv. Gr. [Sig. small.]

" **mundulus**—Miller & Dyer, 1878. Jour. Cin. Soc. Nat. Hist. Hud. Riv. Gr. [Sig. neat, trim.]

" **parvus**—Miller & Dyer, 1878. Jour. Cin. Soc. Nat. Hist. Hud. Riv. Gr. [Sig. little.]

Dendrocrinus—Hall, 1852. Pal. N. Y., Vol. 2. [Ety. *dendron*, a tree; *krinon*, a lily.]

" **caduceus**—Hall, 1866. Pamphlet.* Upper part Hud. Riv. Gr. [Sig. the herald's staff.]

" **casei**—Meek, 1871. Am. Jour. Sci. and Arts, 3d Ser., Vol. 2. Upper part of Hud. Riv. Gr. [Ety. proper name.]

" **cincinnatensis**—Meek, 1872. Proc. Acad. Nat. Sci. Hud. Riv. Gr. [Ety. proper name.]

" **dyeri**—Meek, 1872. Proc. Acad. Nat. Sci. Hud. Riv. Gr. [Ety. proper name.]

*[NOTE.—I have used the word "Pamphlet" as an abbreviation for advance sheets of the Reports of the New York State Museum of Natural History.]

Dendrocrinus polydactylus—Shumard, 1857. (Homocrinus polydactylus.) Trans. St. Louis Acad. Sci. Upper part Hud. Riv. Gr. [Sig. many-fingered.]

" **posticus**—Hall, 1866. Pamphlet. Hud. Riv. Gr. [Sig. posterior.]

Glyptocrinus—Hall, 1847. Pal. N. Y., Vol. 1. [Ety. *glyptos*, sculptured; *krinon*, a lily.]

" **angularis**—Miller & Dyer, 1878. Jour. Cin. Soc. Nat. Hist. Hud. Riv. Gr. [Sig. angular.]

" **baeri**—Meek, 1872. Am. Jour. Sci. and Arts, 3d Ser., Vol. 3. Upper part Hud. Riv. Gr. [Ety. proper name.]

" **decadactylus**—Hall, 1847. Pal. N. Y., Vol. 1. Middle part Hud. Riv. Gr. [Sig. ten-fingered.]

" **dyeri**—Meek, 1872. Proceedings. Acad. Nat. Sci. Middle part Hud. Riv. Gr. [Ety. proper name.]

" **dyeri** *var.* **subglobosus**—Meek, 1873. Ohio Pal. Vol. 1. Middle part Hud. Riv. Gr. [Sig. subglobose.]

" **dyeri** *var.* **sublævis**—S. A. Miller, 1878. Jour. Cin. Soc. Nat. Hist. Middle part Hud. Riv. Gr. [Sig. somewhat smooth.]

" **fornshelli**—S. A. Miller, 1874. Cin. Quar. Jour. Sci., Vol. 1. Upper part Hud. Riv. Gr. [Ety. proper name.]

" **nealli**—Hall, 1866. Pamphlet. Upper part Hud. Riv. Gr. [Ety. proper name.]

" **parvus**—Hall, 1866. Pamphlet. Lower part Hud. Riv. Gr. [Sig. little.]

" **shafferi**—S. A. Miller, 1875. Cin. Quar. Jour. Sci., Vol. 2. Middle part Hud. Riv. Gr. [Ety. proper name.]

Hemicystites—Hall, 1852. Pal. N. Y., Vol. 2. [Ety. *hemi*, half; *kustis*, a bladder.]

" **granulatus**—Hall, 1852. Pal. N. Y., Vol. 2. Middle part Hud. Riv. Gr. [Sig. granulated.]

" **stellatus**—Hall, 1866. Pamphlet. Middle part Hud. Riv. Gr. [Sig. star-shaped.]

Heterocrinus—Hall, 1847. Pal. N. Y., Vol. 1. [Ety. *heteros*, irregular; *krinon*, a lily.]

" **constrictus**—Hall, 1866. Pamphlet. Middle part Hud. Riv. Gr. [Sig. constricted.]

" **constrictus** *var.* **compactus**—Meek, 1873. Ohio Pal., Vol. 1. Lower part Hud. Riv. Gr. [Sig. compact.]

Heterocrinus exilis—Hall, 1866. Pamphlet. Upper part Hud. Riv. Gr. [Sig. slender.]

" **exiguus**—Meek. Syn. for H. exilis.

" **heterodactylus**—Hall, 1847. Pal. N. Y., Vol. 1. Utica Slate and Hud. Riv. Gr. [Sig. irregular-fingered.]

" **isodactylus**—Syn. for H. constrictus *var* compactus.

" **juvenis**—Hall, 1866. Pamphlet. Hud. Riv. Gr. [Sig. young.]

" **laxus**—Hall, 1866. Pamphlet. Hud. Riv. Gr. [Sig. loose.]

" **simplex**—Hall, 1847. Pal. N. Y., Vol. 1. Utica Slate and Hud. Riv. Gr. [Sig. simple.]

" **simplex** *var.* **grandis**—Meek, 1873. Ohio Pal., Vol. 1. Hud. Riv. Gr. [Sig. grand.]

" **subcrassus**—Meek & Worthen, 1865. Proc. Acad. Nat. Sci. Upper half of Hudson Riv. Gr. [Sig. somewhat like *H. crassus.*

Lepadocrinus—Conrad, 1840. Ann. Rep. N. Y. [Ety. *lepas* the Barnacle *Anatifa; krinon*, a lily.]

" **moorei**—Meek, 1871. Am. Jour. Sci. and Arts, 3d Ser. Vol. 2. Upper part Hud. Riv. Gr. [Ety. proper name.]

Lichenocrinus—Hall, 1866. Pamphlet. [Ety. *lichen*, a moss; *krinon*, a lily.]

" **crateriformis**—Hall, 1866. Pamphlet. Utica Slate and lower part of Hud. Riv. Gr. [Sig. having the form of a cup.]

" **dyeri**—Hall, 1866. Pamphlet. Middle part Hud. Riv. Gr. [Ety. proper name.]

" **tuberculatus**—S. A. Miller, 1874. Cin. Quar. Jour. Sci., Vol. 1. Upper part Hud. Riv. Gr. [Sig. tuberculated.]

Palæaster—Hall, 1852. Pal. N. Y., Vol. 2. [Ety. *palaios*, ancient; *aster*, a star.]

" **antiquatus**—Locke, 1846. (Asterias antiquata) Proc. Acad. Nat. Sci., Phil. Hud. Riv. Gr. [Sig. ancient.]

" **clarkei**—S. A. Miller, 1878. Jour. Cin. Soc. Nat. Hist. Hud. Riv. Gr. [Ety. proper name.]

" **dubius**—Miller & Dyer, 1878. Contribution to Palæontology, No. 2. Hud. Riv. Gr. [Sig. doubtful.]

Palæaster dyeri—Meek, 1872. Am. Jour. Sci. and Arts, 3d Ser., Vol. 3. Hud. Riv. Gr. [Ety. proper name.]

" **granulosus**—Hall, 1868. 20th Reg. Rep. N. Y. Hud. Riv. Gr. [Sig. granular.]

" **incomptus**—Meek, 1872. Am. Jour. Sci. and Arts, 3d Ser., Vol. 3. Hud. Riv. Gr. [Sig. unadorned.]

" **jamesi**—Dana, 1863. (Palæasterina (?) jamesi.) Am. Jour. Sci. and Arts, 2d Ser., Vol. 35. Hud. Riv. Gr. [Ety. proper name.]

" **longibrachiatus**—S. A. Miller, 1878. Jour. Cin. Soc. Nat. Hist. Upper part Hud. Riv. Gr. [Sig. long-armed.]

" **shafferi**—Hall, 1868. 20th Reg. Rep. N. Y. Utica Slate, and possibly lower part Hud. Riv. Gr. [Ety. proper name.]

" **simplex**—S. A. Miller, 1878. Jour. Cin. Soc. Nat. Hist. Upper part Hud. Riv. Gr. [Sig. simple.]

" **spinulosus**—Miller and Dyer, 1878. Jour. Cin. Soc. Nat. Hist. Hud. Riv. Gr. [Sig. full of spines.]

Palæasterina—McCoy, 1851. Brit. Pal. Foss., but first defined by Salter, 1857. Ann. Mag. Nat. Hist. [Ety. *palaios*; ancient; *aster*, a star; *inus*, resemblance.]

" **approximata**—Miller & Dyer, 1878. Jour. Cin. Soc. Nat. Hist. Upper part Hud. Riv. Gr. [Sig. approximate; from its resemblance to *P. speciosa*.]

" **speciosa**—Miller & Dyer, 1878. Jour. Cin. Soc. Nat. Hist. Upper part Hud. Riv. Gr. [Sig. beautiful.]

Protaster—Forbes, 1849. Mem. Geo. Sur. Great Britain. [Ety. *protos*, first; *aster*, star.]

" **flexuosus**—Miller & Dyer, 1878. Jour. Cin. Soc. Nat. Hist. Lower part of Hud. Riv. Gr. [Sig. full of turnings.]

" **granuliferus**—Meek, 1872. Am. Jour. Sci. and Arts, 3d Ser., Vol. 3. Hud. Riv. Gr. [Sig. granule-bearing.]

Protasterina fimbriata—Syn. for Protaster flexuosus.

Stenaster—Billings, 1858. Can. Org. Rem. Decade 3. [Ety. *stenos*, narrow; *aster*, a star.]

" **grandis**—Meek, 1872. Am. Jour. Sci. and Arts, 3rd Ser., Vol. 3. Upper part Hud. Riv. Gr. [Sig. grand.]

SUB-KINGDOM MOLLUSCA.

CLASS BRYOZOA.

Alecto—Lamouroux, 1821. Expos. Method. [Ety. mythological name.]
" **auloporoides**—Nicholson, 1875. Ohio Pal., Vol. 2. Hud. Riv. Gr. [Sig. like *Aulopora*.]
" **confusa**—Nicholson, 1875. Ohio Pal., Vol. 2. Utica Slate and lower part Hud. Riv. Gr. [Sig. confused.]
" **frondosa**—Nicholson, 1875. Ohio Pal., Vol. 2. Hud. Riv. Gr. [Sig. branchy.]
" **inflata**—Hall, 1847. Pal. N. Y., Vol. 1. Hud. Riv. Gr. [Sig. inflated.]
" **nexilis**—James, 1875. Catalogue, Cin. Foss. Hud. Riv. Gr. [Sig. wreathed together.]

Bythopora—Miller & Dyer, 1878. Cont. to Pal., No. 2. [Ety. *buthos*, the depths of the sea; *poros*, a pore.]
" **arctipora**—Nicholson, 1875. (Ptilodictya (?) arctipora.) Ohio Pal., Vol. 2. Hud. Riv. Gr. [Sig. having narrow pores.]
" **fruticosa**—Miller & Dyer, 1878. Cont. to Pal. No. 2. Hud. Riv. Gr. [Sig. shrubby.]

Callopora—Hall, 1852. Pal. N. Y., Vol. 2. [Ety. *kallos*, beautiful; *poros*, a pore.]
" **cincinnatensis**—Ulrich. Jour. Cin. Soc. Nat. Hist. Hud. Riv. Gr. [Ety. proper name.] I am by no means certain that this species belongs to the genus Callopora.

Ceramopora--Hall, 1852. Pal. N. Y., Vol. 2. [Ety. *keramis*, imbricated; like roof tile; *poros*, a pore.]
" **nicholsoni**—James, 1875. Catalogue Cin. Foss. Hud. Riv. Gr. [Ety. proper name.]
" **ohioensis**—Nicholson, 1875. Ohio Pal., Vol. 2. Hud. Riv. Gr. [Ety. proper name.]

Cyclopora—Prout, 1860. Trans. St. Louis Acad. Sci. [Ety. *kuklos*, a circle; *poros*, a pore.]
" **jamesi**—Prout, 1860. Trans. St. Louis Acad. Sci. Hud. Riv. Gr. [Ety. proper name.]
" **pavonia**—D'Orbigny, 1850. (Ptilodictya (?) pavonia.) Prodr. de Palaeont, Hud. Riv. Gr. [Ety. *Pavonia*, a genus of polyps.]

Intricaria—Defrance, 1823. Dict. des Sci. Nat. [Ety. *intrico*, to entangle.]

" **clathrata**—Miller & Dyer, 1878. Cont. to Pal., No. 2. Hud. Riv. Gr. [Sig. latticed, cross-barred.]

" **reticulata**—Hall, 1847. Pal. N. Y., Vol. 1. Hud. Riv. Gr. [Sig. reticulated.]

Ptilodictya—Lonsdale, 1839. Murch. Sil. Syst. [Ety. *ptilon*, a wing; *dictyon*, a net.] All the species referred to this genus belong to Stictopora, which is regarded, generally, as only a subgenus.

" **emacerata**—Nicholson, 1875. Ohio Pal., Vol. 2. Hud. Riv. Gr. [Sig. thin, lean.]

" **falciformis**—Nicholson, 1875. Ohio Pal., Vol. 2. Hud. Gr. [Sig. sword-shaped.]

" **fenestelliformis**—Nicholson, 1875. Ohio Pal., Vol. 2. Upper part Hud. Riv. Gr. [Sig. like the genus *Fenestella*.]

" **flagellum**—Nicholson, 1875. Ohio Pal., Vol. 2. Hud. Riv. Gr. [Sig. a small whip.]

" **hilli**—James, 1878. Palæontologist. Supposed to be from the Trenton Gr. [Ety. proper name.]

" **internodia**—Miller & Dyer, 1878. Cont. to Pal., No. 2. Hud. Riv. Gr. [Sig. between knots.]

" **maculata**—Ulrich, 1878. Jour. Cin. Soc. Nat. Hist. Hud. Riv. Gr. [Sig. spotted.]

" **magnifica**—S. A. Miller, 1878. Jour. Cin. Soc. Nat. Hist. Upper part Hud. Riv. Gr. [Sig. magnificent.]

" **perelegans**—Ulrich, 1878. Jour. Cin. Soc. Nat. Hist. Hud. Riv. Gr. [Sig. very elegant.]

" **shafferi**—Meek, 1872. Proc. Acad. Nat. Sci. Hud. Riv. Gr. [Ety. proper name.]

CLASS BRACHIOPODA.

Crania—Retzius, 1781. Schrift. Berl. Gesell. Natur. [Ety. *kranion*, the upper part of the skull.]

" **dyeri**—S. A. Miller, 1875. Cin. Quar. Jour. Sci., Vol. 2. Hud. Riv. (?) Gr. [Ety. proper name.]

" **lælia**—Hall, 1866. Pamphlet. Hud. Riv. Gr. [Ety. proper name.]

" **multipunctata**—S. A. Miller. Hud. Riv. Gr. [Sig. many dotted.]

" **reticularis**—S. A. Miller, 1875. Cin. Quar. Jour. Sci., Vol. 2. Upper part Hud. Riv. Gr. [Sig. reticulated.]

Crania scabiosa—Hall, 1866. Pamphlet. Hud. Riv. Gr. [Sig. scabby.]
" **socialis**—Syn. for C. scabiosa.

Discina sublamellosa and **D. tenuistriata** are, as I think, founded upon very poor specimens of Trematis dyeri.

Leptæna—Dalman, 1827. Kongl. Vet. Acad. Handl. [Ety. *leptos*, thin.]
" **sericea**—Sowerby, 1839. Murch. Sil. Syst. Trenton, Utica Slate and Hud. Riv. Gr. [Sig. silky.]
Leptobolus—Hall, 1871. Pamphlet. [Sig. minute *obolus*.]
" **lepis** — Hall, 1871. Pamphlet. Utica Slate Gr. [Sig. a scale.]

Lingula—Bruguire, 1792. Encyc. Meth. [Ety. *lingula*, a little tongue.] All the species referred to this genus belong to *Lingulella*.

Lingulella—Salter, 1861. Mem. Geo. North Wales. [Ety. diminutive of *lingula*.]
" **cincinnatensis**—Hall & Whitfield, 1875. Ohio Pal., Vol. 2. Hud. Riv. Gr. [Ety. proper name.]
" **covingtonensis**—Hall & Whitfield, 1875. Ohio Pal., Vol. 2. Utica Slate Gr. [Ety. proper name.]
" **norwoodi**—James, 1875. Cin. Quar. Jour. Sci., Vol. 2. Hud. Riv. Gr. [Ety. proper name.]
" **vanhornei**—S. A. Miller, 1875. Cin. Quar. Jour. Sci., Vol. 2. Hud. Riv. Gr. [Ety. proper name.]

Orthis—Dalman, 1827. Kongl. Vet. Acad. Handl. [Sig. straight—straight hinge line.]
" **acutilirata**—Conrad, 1842. Jour. Acad. Nat. Sci., Vol. 8. Upper part Hud. Riv. Gr. [Sig. sharp-ridged.]
" **bellula**—Meek, 1873. Ohio. Pal., Vol. 1. Hud. Riv. Gr. [Sig. pretty.]
" **borealis**—Billings, 1859. Can. Nat. and Geo., Vol. 4. Trenton Gr. of Ky. [Sig. northern.]
" **clytie**—Hall, 1861. Fourteenth Reg. Rep. N. Y. Trenton Gr. of Ky. [Ety. mythological name.]
" **ella**—Hall, 1860. Thirteenth Reg. Rep. N. Y. Hud. Riv. Gr. [Ety. proper name.]
" **emacerata**—Hall, 1860. Thirteenth Reg. Rep. N. Y. Utica Slate and lower part of Hud. Riv. Gr. [Sig. made lean.]
" **fissicosta**—Hall, 1847. Pal. N. Y., Vol. 1. Hud. Riv. Gr. [Sig. having divided costae.]

Orthis insculpta—Hall, 1847. Pal. N. Y., Vol. 1. Upper part of Hud. Riv. Gr. [Sig. engraved.]

" **jamesi**—Hall, 1861. Fourteenth Reg. Rep. N. Y. Hud. Riv. Gr. [Ety. proper name.]

" **lynx**—Eichwald, 1830. Nat. Kizze von Podol. Trenton and Hud. Riv. Gr. [Sig. the name of a quadruped of the genus *Felis.*]

" **lynx** *var.* **crassa**—James, 1874. Cin. Quar. Jour. Sci., Vol. 1. Hud. Riv. Gr. [Sig. thick.]

" **lynx** *var.* **laticostata**—Meek, 1873. Ohio Pal., Vol. 1. Hud. Riv. Gr. [Sig. broad-ribbed.]

" **occidentalis**—Hall, 1847. Pal. N. Y., Vol. 1. Hud. Riv. Gr. [Sig. western.]

" **pectinella**—Conrad 1840. Ann. Rep. N. Y. Trenton Gr. of Ky. [Sig. a little comb.]

" **plicatella**—Hall, 1847. Pal. N. Y., Vol. 1. Hud. Riv. Gr. [Sig. a little fold.]

" **plicatella** *var.* **triplicatella**—Meek, 1873. Ohio Pal. Vol. 1. Hud. Riv. Gr. [Sig. having three plications.]

" **retrorsa**—Salter, 1858. Geo. Sur. of Great Britain. Hud. Riv. Gr. [Sig. turned backward.]

" **sinuata**—Hall, 1847. Pal. N. Y., Vol. 1. Hud. Riv. Gr. [Sig. waved.]

" **subquadrata**—Hall, 1847. Pal. N. Y., Vol. 1. Upper part Hud. Riv. Gr. [Sig. somewhat quadrate.]

" **testudinaria**—Dalman, 1827. Vet. Acad. Handl. Trenton, Utica Slate and Hud. Riv. Gr. [Sig. arched like a tortoise shell.]

" **testudinaria** *var.* **meeki**—S. A. Miller, 1875. Cin. Quar. Jour. Sci., Vol. 2. Hud. Riv. Gr. [Ety. proper name.]

" **testudinaria** *var.* **multisecta**—Meek, 1873. Ohio Pal., Vol. 1. Utica Slate and lower part of Hud. Riv. Gr. [Sig. having many paths.]

" **tricenaria**—Conrad, 1843. Proceedings Acad. Nat. Sci., Vol. 1. Trenton Gr. of Ky. [Sig. of or belonging to thirty.]

Pholidops—Hall, 1859. Pal. N. Y., Vol. 3. [Ety. *Pholidos* a scale.]

" **cincinnatensis**—Hall, 1872. Pamphlet. Lower part of Hud. Riv. Gr. [Ety. proper name.]

Rhynchonella—Fischer, 1809. Mem. Soc. Imp. Moscow. [Ety. *rhynchos*, a beak; *ella*, diminutive.]

Rhynchonella capax—Conrad, 1842. (Atrypa capax.) Jour. Acad. Nat. Sci., Vol. 8. Upper part Hud. Riv. Gr. [Sig. large.]

" **dentata**—Hall, 1847. (Atrypa dentata.) Pal. N. Y., Vol. 1. Upper part Hud. Riv. Gr. [Sig. having teeth.]

Schizocrania—Hall & Whitfield, 1875. Ohio Pal., Vol. 2. [Ety. *schiza*, a cleft; *Crania*, a genus of shells.]

" **filosa**—Hall, 1847. (Orbicula filosa.) Pal. N. Y., Vol. 1. Hud. Riv. Gr. [Sig. thready.]

Streptorhynchus—King, 1850. Monograph Permian Fossils. [Ety. *streptos*, twisted; *rhynchos*, beak.]

" **filitextum**—Hall, 1847. (Strophomena filitexta.) Pal. N. Y., Vol. 1. Upper part Hud. Riv. Gr. [Sig. woven like thread.]

" **hallianum**—S. A. Miller, 1874. Cin. Quar. Jour. Sci., Vol. 1. Lower part Hud. Riv. Gr. [Ety. proper name.]

" **nutans**—Meek, 1873. (Hemipronites nutans.) Ohio Pal., Vol. 1. Upper part Hud. Riv. Gr. [Sig. bent over.]

" **planoconvexum**—Hall, 1847. (Leptæna planoconvexa.) Pal. N. Y., Vol. 1. Middle part Hud. Riv. Gr. [Sig. level-convex.]

" **planumbonum**—Hall, 1847. (Leptæna planumbona.) Pal. N. Y., Vol. 1. Upper part of Hud. Riv. Gr. [Sig. flat on the umbo.]

" **sinuatum**—Emmons, 1855. (Strophomena sinuata.) Am. Geol. Upper part Hud. Riv. Gr. [Sig. waved.]

" **subtentum**—Conrad, 1847. (Strophomena subtenta.) Pal. N. Y., Vol. 1. Upper part Hud. Riv. Gr. [Sig. somewhat bent.]

" **sulcatum**—Verneuil, 1848. (Leptæna sulcata.) Bull. Geol. Soc. France, Vol. 5. Upper part Hud. Riv. Gr. [Sig. furrowed.]

Strophomena—Rafinesque, 1825. Manuel de Malacologie. [Ety. *strophos*, bent; *mene*, a crescent.]

" **alternata**—Conrad, 1838. (Leptæna alternata.) Ann. Rep. N. Y. Trenton, Utica Slate and Hud. Riv. Gr. [Sig. alternating.]

Strophomena alternata *var.* **alternistriata**—Hall, 1847. Pal. N. Y., Vol. 1. Utica Slate and Hud. Riv. Gr. [Sig. alternately striated.]

" **alternata** *var.* **fracta**—Meek, 1873. Ohio Pal., Vol. 1. Hud. Riv. Gr. [Sig. broken.]

" **alternata** *var.* **loxorhytis**—Meek, 1873. Ohio Pal., Vol. 1. Upper part Hud. Riv. Gr. [Sig. oblique-wrinkled.]

" **alternata** *var.* **nasuta**—Conrad, 1842. Jour. Acad. Nat. Sci., Vol. 8. Trenton and Hud. Riv. Gr. [Sig. having a prominent nose.]

" **squamula**—James, 1874. Cin. Quar. Jour. Sci., Vol. 1. Hud. Riv. Gr. [Sig. a little scale.]

" **tenuistriata**—Sowerby, 1839. (Leptæna tenuistriata.) Murch. Sil. Syst. Utica Slate and Hud. Riv. Gr. [Sig. fine-lined.]

Trematis—Sharpe, 1847. Quar. Jour. Geo. Soc., Vol. 13. [Ety. *trema*, an opening.]

" **dyeri**—S. A. Miller, 1874. Cin. Quar. Jour. Sci., Vol. 1. Lower part Hud. Riv. Gr. [Ety. proper name.]

" **millepunctata**—Hall, 1866. Pamphlet. Hud. Riv. Gr. [Sig. many-dotted.]

" **punctostriata**—Hall, 1873. Twenty-third Reg. Rep. N. Y. Hud. Riv. Gr. [Sig. punctured and striated.]

" **quincuncialis**—Miller & Dyer, 1878. Cont. to Pal. No. 2. Upper part Hud. Riv. Gr. [Sig. in the form of a quincunx.]

Trematospira—Hall, 1859. 12th Reg. Rep. N. Y. [Ety. *trema*, an opening; *spira*, a spire.]

" (?) **granulifera**—Meek, 1872. Proceedings Acad. Nat. Sci. Hud. Riv. Gr. [Sig. bearing granules.]

" (?) **quadriplicata**—S. A. Miller, 1875. Cin. Quar. Jour. Sci., Vol. 2. Trenton Gr. of Ky. This species does not belong to the genus *Trematospira*. It belongs to an undefined genus of which *Rhynchonella cuneata* should be made the type.

Zygospira—Hall, 1862. 15th Reg. Rep. N. Y. [Ety. *zygos*, a yoke; *spira*, a spire.]

Zygospira headi—Billings, 1862. (Athyris headi.) Pal. Foss., Vol. 1. Upper part Hud. Riv. Gr. The fossil referred to this species by Prof. Meek is quite distinct from it, and should bear a separate specific name.

" **modesta**—Say, 1847. (Atrypa modesta.) Pal. N. Y., Vol. 1. Trenton, Utica Slate and Hud. Riv. Gr. [Sig. not large.)

" **modesta** *var.* **cincinnatensis**—Meek, 1873. Ohio Pal.,Vol. 1. Hud. Riv. Gr. This variety is founded on no other distinction than its large size.

CLASS PTEROPODA.

Conularia—Miller, 1818. Sow. Min. Conch., Vol. 3. [Ety. *conulus*, a little cone.]

" **formosa**—Miller & Dyer, 1878. Jour. Cin. Soc. Nat. Hist. Hud. Riv. Gr. [Sig. beautiful.]

" **trentonensis**—Hall, 1847. Pal. N. Y., Vol. 1. Trenton and Hud. Riv. Gr. [Ety. proper name.]

Tentaculites—Schlotheim, 1820. Petref. [Ety. *tentaculum*, a feeler; *lithos*, stone.]

" **richmondensis**—S. A. Miller, 1874. Cin. Quar. Jour. Sci., Vol. 1. Upper part Hud. Riv. Gr. [Ety. proper name.]

" **tenuistriatus**—Meek & Worthen, 1865. Proceedings Acad. Nat. Sci. Hud. Riv. Gr. [Sig. fine-striated.]

CLASS GASTEROPODA.

Bellerophon—Montfort, 1808. Conch. Syst., Vol. 1. [Ety. mythological name.]

" **bilobatus**—Sowerby, 1839. Murch. Sil. Syst. Trenton, Utica Slate and Hud. Riv. Gr. [Sig. two-lobed.]

" **mohri**—S. A. Miller, 1874. Cin. Quar. Jour. Sci., Vol. 1. Upper part Hud. Riv Gr. [Ety. proper name.]

" **morrowensis**—Miller & Dyer, 1878. Cont. to Pal., No. 2. Upper part Hud. Riv. Gr. [Ety. proper name.]

Bucania—Hall, 1847. Pal. N. Y., Vol. 1. [Ety. *bukane*, a trumpet.]

" **costata**—James, 1872. (Cyrtolites costatus.) Am. Jour. Sci. and Arts, 3rd Ser., Vol. 3. Hud. Riv. Gr. [Sig. ribbed.]

" **expansa**—Hall, 1847. Pal. N. Y., Vol. 1. Upper part Hud. Riv. Gr. [Sig. expanded.]

Carinaropsis—Hall, 1847. Pal. N. Y., Vol. 1. [Ety. *Carinaria*, a genus of shells; *opsis*, appearance.]

" **patelliformis**—Hall, 1847. Pal. N. Y., Vol. 1. Utica Slate Gr. [Sig. like *Patella*, limpet-shaped.]

Cyclonema—Hall, 1852. Pal. N. Y., Vol 2. [Ety. *kuklos* a circle; *nema* a thread.]

" **bilix**—Conrad, 1842. (Pleurotomaria bilix.) Jour. Acad. Nat. Sci., Vol. 8. Hud. Riv. Gr. [Sig. woven like a thread.]

" **bilix** *var.* **fluctuatum**—James 1874. Cin. Quar. Jour. Sci., Vol. 1. Hud. Riv. Gr. [Sig. waved.]

" **conicum**—S. A. Miller, 1874. Cin. Quar. Jour. Sci., Vol. 1. Upper part Hud. Riv. Gr. [Sig. conical.]

" **percarinatum**—Hall, 1847. (Pleurotomaria percarinata.) Pal. N. Y., Vol. 1. Utica Slate and lower part Hud. Riv. Gr. [Sig. very much carinated.]

" **pyramidatum**—James, 1874. Cin. Quar. Jour. Sci., Vol. 1. Hud. Riv. Gr. [Sig. pyramidal.]

" **varicosum**—Hall, 1870. 24th Reg. Rep. N. Y. Hud. Riv. Gr. [Sig. varicose.]

Cyclora—Hall, 1845. Am. Jour. Sci. and Arts, Vol. 48. [Ety. *kuklos*, a circle.]

" **hoffmani**—S. A. Miller, 1874. Cin. Quar. Jour. Sci., Vol. 1. Lower part Hud. Riv. Gr. [Ety. proper name.]

" **minuta**—Hall, 1845. Am. Jour. Sci. and Arts, Vol. 48. Utica Slate and Hud. Riv. Gr. [Sig. minute.]

" **parvula**—Hall, 1845. Am. Jour. Sci. and Arts, Vol. 48. Hud. Riv. Gr. [Sig. very small.]

Cyrtolites—Conrad, 1838. Ann. Rep. N. Y. [Ety. *kurtos*, curved; *lithos*, stone.]

" **carinatus**—S. A. Miller, 1874. Cin. Quar. Jour. Sci., Vol. 1. Utica Slate and lower part Hud. Riv. Gr. [Sig. keeled.]

" **dyeri**—Hall, 1871. Pamphlet. Upper part Hud. Riv. Gr. [Ety. proper name.]

" **elegans**—S. A. Miller, 1874. Cin. Quar. Jour. Sci., Vol. 1. Middle part Hud. Riv. Gr. [Sig. elegant.]

" **magnus**—S. A. Miller, 1878. Jour. Cin. Soc. Nat. Hist. Upper part Hud. Riv. Gr. [Sig. great.]

" **ornatus**—Conrad, 1838. Ann. Rep. N. Y. Hud. Riv. Gr. [Sig. ornamented.]

Fusispira Hall, 1871. Pamphlet. [Ety. *fusus*, a spindle; *spira*, a spire.]
" **subfusiformis**—Hall, 1847. (Murchisonia subfusiformis.) Pal. N. Y., Vol. 1. Trenton Gr. [Sig. somewhat spindle-shaped.]
" **terebriformis**—Hall, 1871. Pamphlet. Lower part Hud. Riv. Gr. [Sig. auger-shaped.]

Microceras — Hall, 1845. Am. Jour. Sci. and Arts, Vol. 48. [Ety. *mikros*, small; *keras*, a horn.]
" **inornatus**—Hall, 1845. Am. Jour. Sci. and Arts., Vol. 48. Utica Slate and Hud. Riv. Gr. [Sig. not ornamented.]

Murchisonia—D'Archiac & Verneuil, 1841. Bull. Soc. Geo. France, Vol. 12. [Ety. proper name.]
" **bellicincta**—Hall, 1847. Pal. N. Y., Vol. 1. Hud. Riv. Gr. [Sig. beautifully banded.]
" **gracilis**—Hall, 1847. Pal. N. Y., Vol. 1. Lower part Hud. Riv. Gr. [Sig. slender.]
" **milleri**—Hall, 1877. Am. Pal. Foss. Hud. Riv. Gr. [Ety. proper name.]
" **multigruma**—S. A. Miller, 1878. Jour. Cin. Soc. Nat. Hist. Upper part Hud. Riv. Gr. [Sig. much heaped up.]
" **uniangulata**—Hall, 1847. Pal. N. Y., Vol. 1. Trenton, Utica Slate and lower part Hud. Riv. Gr. [Sig. having one angular line.]

Pleurotomaria—Defrance, 1826. Dict. Sci. Nat., Vol. 41. [Ety. *pleura*, side; *tome*, notch.]
" **halli**—S. A. Miller, 1874. Cin. Quar. Jour. Sci., Vol. 1. Lower part Hud. Riv. Gr. [Ety. proper name.]
" **subconica**—Hall, 1847. Pal. N. Y., Vol. 1. Upper part Hud. Riv. Gr. [Sig. somewhat conical.]
" **tropidophora**—Meek, 1872. Am. Jour. Sci. and Arts, 3d Ser., Vol. 4. Upper part Hud. Riv. Gr. [Sig. keel bearing.]

Raphistoma—Hall, 1847. Pal. N. Y., Vol. 1. [Ety. *raphe*, a seam or suture; *stoma*, mouth.]
" **lenticulare**—Emmons, 1842. (Pleurotomaria lenticularis.) Geo. Rep. N. Y. Trenton, Utica Slate and Hud. Riv. Gr. [Sig. lens-shaped.]

CLASS CEPHALOPODA.

Crytoceras—Goldfuss, 1832. Handbuch der Geog. [Ety. *kurtos*, curved; *keras*, horn.]

" **amœnum**—S. A. Miller, 1878. Jour. Cin. Soc. Nat. Hist. Upper part Hud. Riv. Gr. [Sig. pleasant, welcome.]

" **magister**—S. A. Miller, 1875. Cin. Quar. Jour. Sci., Vol. 2. Lower part Hud. Riv. Gr. [Sig. the chief.]

" **vallandighami**—S. A. Miller, 1874. Cin. Quar. Jour. Sci., Vol. 1. Middle part Hud. Riv. Gr. [Ety. proper name.]

" **ventricosum**—S. A. Miller, 1875. Cin. Quar. Jour. Sci., Vol. 2. Lower part Hud. Riv. Gr. [Sig. ventricose.]

Endoceras—Hall, 1847. Pal. N. Y., Vol. 1. [Ety. *endos*, within; *keras*, horn.]

" **proteiforme**—Hall, 1847. Pal. N. Y., Vol. 1. Trenton and Hud. Riv. Gr. [Sig. having many shapes.]

Gomphoceras—Sowerby, 1839. Murch. Sil. Syst. [Ety. *gomphos*, a club; *keras*, a horn.]

" **eos**—Hall & Whitfield, 1875. Pal. Ohio, Vol. 2. Upper part Hud. Riv. Gr. [Sig. the dawn.]

Orthoceras—Breynius, 1732. Dissert. Polyth. [Ety. *orthos*, straight; *keras*, horn.]

" **byrnesi**—S. A. Miller, 1875. Cin. Quar. Jour. Sci., Vol. 2. Hud. Riv. Gr. [Ety. proper name.]

" **carleyi**—Hall & Whitfield, 1875. Ohio Pal., Vol. 2. Hud. Riv. Gr. [Ety. proper name.]

" **cincinnatense**—S. A. Miller, 1875. Cin. Quar. Jour. Sci., Vol. 2. Hud. Riv. Gr. [Ety. proper name.]

" **duseri**—Hall & Whitfield, 1875. Ohio Pal., Vol. 2. Upper part Hud. Riv. Gr. [Ety. proper name.] Probably a syn. for *O. fosteri*.

" **dyeri**—S. A. Miller, 1875. Cin. Quar. Jour. Sci., Vol. 2. Hud. Riv. Gr. [Ety. proper name.]

" **fosteri**—S. A. Miller, 1875. Cin. Quar. Jour. Sci., Vol. 2. Upper part Hud. Riv. Gr. [Ety. proper name.]

" **hallanum**—S. A. Miller, 1877. American Palæozoic Fossils. Upper part Hud. Riv. Gr. [Ety. proper name.]

" **harperi**—S. A. Miller, 1875. Cin. Quar. Jour. Sci., Vol. 2. Hud. Riv. Gr. [Ety. proper name.]

Orthoceras meeki—S. A. Miller, 1875. Cin. Quar. Jour. Sci., Vol. 2. Hud. Riv. Gr. [Ety. proper name.]

" **mohri**—S. A. Miller, 1875. Cin. Quar. Jour. Sci., Vol. 2. Upper part Hud. Riv. Gr. [Ety. proper name.]

" **ortoni**—Meek, 1872. Proceedings Acad. Nat. Sci. Hud. Riv. Gr. [Ety. proper name.]

" **transversum**—S. A. Miller, 1875. Cin. Quar. Jour. Sci., Vol. 2. Lower part Hud. Riv. Gr. [Sig. transverse.]

" **turbidum**—Hall & Whitfield, 1875. Ohio Pal., Vol. 2. Hud. Riv. Gr. [Sig. disordered.]

Trochoceras—Hall, 1852. Pal. N. Y., Vol. 2. [Ety. *trochos*, a hoop; *keras*, a horn.]

" **baeri**—Meek & Worthen, 1865. Proceedings Acad. Nat. Sci. Upper part Hud. Riv. Gr. [Ety. proper name.]

Trocholites—Conrad, 1838. Ann. Geo. Rep. N. Y. [Ety. *trochos*, a hoop; *lithos*, stone.]

" **ammonius**—Conrad, 1838. Ann. Geo. Rep. N. Y. Trenton Gr. [Ety. mythological name.]

" **circularis**—Miller & Dyer, 1878. Cont. to Pal. No. 2. Upper part Hud. Riv. Gr. [Sig. round.]

" **minusculus**—Miller & Dyer, 1878. Cont. to Pal. No. 2. Utica Slate Gr. [Sig. rather small.]

CLASS LAMELLIBRANCHIATA.

Ambonychia—Hall, 1847. Pal. N. Y. Vol. 1. [Ety. *ambon*, the boss of a shield; *onyx*, a claw.]

" **bellistriata**—Hall, 1847. Pal. N. Y., Vol. 1. Utica Slate and Hud. Riv. Gr. [Sig. beautifully striated.]

" **carinata**—Goldfuss, 1826. (Pterina carinata.) Petref. Germ. Hud. Riv. Gr. [Sig. heeled.]

" **casei**—Meek & Worthen, 1866. Proceedings Acad. Nat. Sci. Upper part Hud. Riv. Gr. [Ety. proper name.]

" **costata**—Meek, 1873. Ohio Pal., Vol. 1. Hud. Riv. Gr. [Sig. ribbed.]

" **radiata**—Hall, 1847. Pal. N. Y., Vol. 1. Hud. Riv. Gr. [Sig. radiated.] This may be a syn. for A. carinata.

" **retrorsa**—S. A. Miller, 1878. Jour. Cin. Soc. Nat. Hist. Hud. Riv. Gr. [Sig. turned back.]

Angellum—S. A. Miller, 1878. Jour. Cin. Soc. Nat. Hist. [Ety. *angos*, a pail; *ellus*, diminutive.]
" **cuneatum**—S. A. Miller, 1878. Jour. Cin. Soc. Nat. Hist. Upper part Hud. Riv. Gr. [Sig. wedge-shaped.]

Anodontopsis—McCoy, 1851. Ann. and Mag. Nat. Hist., 2d Ser., Vol. 7. [Ety. *Anodonta*, a genus of shells; *opsis*, appearance.]
" **milleri**—Meek, 1871. Am. Jour. Sci., 3d Ser., Vol 2. Upper part Hud. Riv. Gr. [Ety. proper name.]
" **unionoides**—Meek, 1871. Am. Jour. Sci. and Arts, 3rd Ser., Vol. 2. Hud. Riv. Gr. [Sig. like a *Unio*.]

Anomalodonta—S. A. Miller, 1874. Cin. Quar. Jour. Sci., Vol. 1. [Sig. anomalous toothed.]
" **alata**—Meek, 1872. (Ambonychia alata.) Proceedings Acad. Nat. Sci. Upper part Hud. Riv. Gr. [Sig. winged.]
" **gigantea**—S. A. Miller, 1874. Cin. Quar. Jour. Sci., Vol. 1. Upper part Hud. Riv. Gr. [Sig. very large.]

Avicula—See Pterinea.

Cardiomorpha—DeKoninck, 1844. Anim. Foss. Carb. Belg. [Ety. *kardia*, heart; *morphe*, form.]
" (?)**obliquata**—Meek, 1872. Proceedings Acad. Nat. Sci. Lower part Hud. Riv. Gr. [Sig. oblique.]

Cleidophorus—Hall, 1847. Pal. N. Y., Vol. 1. [Ety. *kleidos*, a clavicle; *phoros*, bearing.]
" **fabula**—Hall, 1845. (Nucula fabula.) Am. Jour. Sci. and Arts, Vol. 48. Hud. Riv. Gr. [Sig. a little bean.]

Cuneamya—Hall & Whitfield, 1875. Ohio Pal., Vol. 2. [Ety. *cuneus*, a wedge; *Mya*, a genus of shells.]
" **curta**—Whitfield, 1878. Jour. Cin. Soc. Nat. Hist. Upper part Hud. Riv. Gr. [Sig. cut off.]
" **miamiensis**—Hall & Whitfield, 1875. Ohio Pal., Vol. 2. Upper part Hud. Riv. Gr. [Ety. proper name.]
" **neglecta**—Meek, 1872. (Sedgwickia (?) neglecta.) Proceedings Acad. Nat. Sci. Upper part Hud. Riv. Gr. [Sig. neglected.]
" **scapha**—Hall & Whitfield, 1875. Ohio Pal., Vol. 2. Upper part Hud. Riv. Gr. [Sig. skiff or boat.]

Cycloconcha—S. A. Miller, 1874. Cin. Quar. Jour. Sci., Vol. 1. [Ety. *kuklos*, a circle; *concha*, a shell.]

" **mediocardinalis**—S. A. Miller, 1874. Cin. Quar. Jour. Sci., Vol. 1. Lower part Hud. Riv. Gr. [Sig. in allusion to the position of the teeth near the middle of the hinge line.]

Cypricardites—Conrad, 1841. Ann. Rep. N. Y. [Ety. from its resemblance to *Cypricardia*.]

" **carinatus**—Meek, 1872. (Dolabra carinata.) Proceedings Acad. Nat. Sci. Lower part Hud. Riv. Gr. [Sig. carinated.]

" **hainesi**—S. A. Miller, 1874. Cin. Quar. Jour. Sci. Upper part Hud. Riv. Gr. [Ety. proper name.]

" **hindi**—Billings, 1862. (Cyrtodonta hindi.) Pal. Foss., Vol. 1. Upper part Hud. Riv. Gr. [Ety. proper name.]

" **quadrangularis**—Whitfield, 1878. Jour. Cin. Soc. Nat. Hist. Hud. Riv. Gr. [Sig. quadrangular.]

" **sterlingensis**—Meek & Worthen, 1866. (Dolabra sterlingensis.) Proceedings Acad. Nat. Sci. Upper part Hud. Riv. Gr. [Ety. proper name.]

Lyrodesma—Conrad, 1841. Ann. Rep. N. Y. [Ety. *lyra*, a harp; *desma*, a ligament.]

" **cincinnatense**—Hall, 1871. Pamphlet. Utica Slate and lower part Hud. Riv. Gr. [Ety. proper name.]

" **planum**—Conrad, 1841. Ann. Rep. N. Y. Hud. Riv. Gr. [Sig. flat.]

Megambonia—Hall, 1859. Pal. N. Y., Vol. 3. [Ety. *mega*, great; *ambon*, the boss of a shield.]

" **jamesi**—Meek, 1872. Proceedings Acad. Nat. Sci. Hud. Riv. Gr. [Ety. proper name.]

Modiolopsis—Hall, 1847. Pal. N. Y., vol. 1. [Ety. *Modiola*, a genus of shells; *opsis*, appearance.]

" **cincinnatensis**—Hall & Whitfield, 1875. Ohio Pal., Vol. 2. Utica Slate Gr. [Ety. proper name.]

" **concentrica**—Hall & Whitfield, 1875. Ohio. Pal., Vol. 2. Hud. Riv. Gr. [Sig. concentric.]

" **modiolaris**—Conrad, 1838. (Pterinea modiolaris.) Ann. Rep. N. Y. Hud. Riv. Gr. [Sig. like a *Modiola*.]

Modiolopsis pholadiformis—Hall, 1857. Lake Sup. Land Dist., Vol. 2. Upper part Hud. Riv. Gr. [Sig. like the *Pholas.*]

" **terminalis**—Hall, 1847. Pal. N. Y., Vol. 1. Hud. Riv Gr. [Sig. terminating.]

" **truncata**—Hall, 1847. Pal. N. Y., Vol. 1. Hud. Riv. Gr. [Sig. cut short.]

" **versaillesensis**—S. A. Miller, 1874. Cin. Quar. Jour. Sci., Vol. 1. Upper part Hud. Riv. Gr. [Ety. proper name.]

Orthodesma—Hall & Whitfield, 1875. Ohio. Pal., Vol. 2. [Ety. *orthos*, straight; *desma*, a ligament.]

" **contractum**—Hall, 1847. (Orthonota contracta.) Pal. N. Y., Vol. 1. Upper part Hud. Riv. Gr. [Sig. contracted.]

" **curvatum**—Hall & Whitfield, 1875. Ohio Pal., Vol. 2. Upper part Hud. Riv. Gr. [Sig. curved.]

" **mickelboroughi**—Whitfield, 1878. Jour. Cin. Soc. Nat. Hist. Hud. Riv. Gr. [Ety. proper name.]

" **parallelum**—Hall, 1847. (Orthonota parallela.) Pal. N. Y., Vol. 1. Hud. Riv. Gr. [Sig. parallel.]

" **rectum**—Hall & Whitfield, 1875. Ohio Pal., Vol. 2. Upper part Hud. River Gr. [Sig. straight.]

Orthonota—Conrad, 1841. Ann. Rep. N. Y. [Ety. *orthos*, straight; *notos*, back.]

" **pholadis**—Conrad, 1838. Ann. Rep. N. Y. Hud. Riv. Gr. [Sig. like a *Pholas.*]

Pterinea—Goldfuss, 1826. Germ. Petref. [Ety. *pteron*, a wing.]

" **corrugata**—James, 1874. Cin. Quar. Jour. Sci., Vol. 1. Upper part Hud. Riv. Gr. [Sig. corrugated.]

" **demissa**—Conrad, 1842. Jour. Acad. Nat. Sci., Vol. 8. Hud. Riv. Gr. [Sig. hanging down.]

" **insueta**—Emmons, 1842. Geo. Rep. N. Y. Hud. Riv. Gr. [Sig. unusual.]

" **welchi**—James, 1874. Cin. Quar. Jour. Sci., Vol. 1. Upper part Hud. Riv. Gr. [Ety. proper name.]

Sedgwickia—McCoy, 1844. Synop. Carb. Foss., Ireland. [Ety. proper name.]

" **compressa**—Meek, 1872. Proceedings Acad. Nat. Sci. Upper part Hud. Riv. Gr. [Sig. compressed.]

Sedgwickia divaricata--Hall & Whitfield, 1875. Ohio Pal., Vol. . Upper part Hud. Riv. Gr. [Sig. divaricated.]

" **fragilis**—Meek, 1872. Proceedings Acad. Nat. Sci. Hud. Riv. Gr. [Sig. frail.]

" **lunulata**—Whitfield, 1878. Jour. Cin. Soc. Nat. Hist. Hud. Riv. Gr. [Sig. a small moon.]

Tellinomya—Hall, 1847. Pal. N. Y., Vol. 1. [Ety. from a resemblance to *Tellina* and *Mya*.]

" **hilli**—S. A. Miller, 1874. Cin. Quar. Jour. Sci., Vol. 1. Upper part Hud. Riv. Gr. [Ety. proper name.]

" **levata**—Hall, 1847. (Nucula levata.) Pal. N. Y., Vol. 1. Hud. Riv. Gr. [Sig. smoothed.]

" **obliqua**—Hall, 1848. (Nucula obliqua.) Am. Jour. Sci. and Arts, Vol. 48. Hud. Riv. Gr. [Sig. oblique.]

" **pectunculoides**—Hall, 1871. Pamphlet. Hud. Riv. Gr. [Sig. like *Pectunculus*.]

SUB-KINGDOM ARTICULATA.

CLASS ANNELIDA.

Cornulites—Schlotheim, 1820. (Petrefactenkunde.) [Ety. *cornu*, horn; *lithos*, stone.]

" **corrugatus**—Nicholson, 1872. (Conchicolites corrugatus.) Lond. Geo. Mag., Vol. 9. Hud. Riv. Gr. [Sig. corrugated.]

" **flexuosus**—Hall, 1847. (Tentaculites flexuosus.) Pal. N. Y., Vol. 1. Trenton, Utica Slate and Hud. Riv. Gr. [Sig. flexuous.]

" **intermedius**—Nicholson, 1874. (Ortonia intermedia.) Lon. Geo. Mag., N. S., Vol. 1. Hud. Riv. Gr. [Sig. intermediate.]

" **minor**—Nicholson, 1873. (Ortonia minor.) Lond. Geo. Mag., Vol. 10. Hud. Riv. Gr. [Sig. less.]

Nereidavus—Grinnell, 1877. Am. Jour. Sci. and Arts, 3d Ser., Vol. 14. [Ety. *Nereidæ*, a family of annelids; *avus*, grandfather.]

Nereidavus varians—Grinnell, 1877. Am. Jour. Sci. and Arts, 3d Ser., Vol. 14. Hud. Riv. Gr. [Sig. variable.] I regard this species as representing part of the masticatory apparatus of a Crustacean, since it so closely resembles the masticatory organs of the carboniferous genera, Dithyrocaris and Ceratiocaris. Prof. Grinnell refers it to similar organs of an Annelid, notwithstanding that we have no knowledge of an Annelid, in the Palaeozoic rocks, capable of bearing such organs.

Scolithus—Haldeman, 1840. Supp. to Monograph of Limniades. [Ety. *scolex*, a worm; *lithos*, stone.]

" **tuberosus**—Miller & Dyer, 1878. Jour. Cin. Soc. Nat. Hist. Hud. Riv. Gr. [Sig. bumping out.]

Spirorbis—Lamarck, 1801. Syst. An. Sans. Vert. [Sig. spiral whorl.]

" **cincinnatensis**—Miller & Dyer, 1878. Jour. Cin. Soc. Nat. Hist. Hud. Riv. Gr. [Ety. proper name.]

Walcottia—Miller & Dyer, 1878. Jour. Cin. Soc. Nat. Hist. [Ety. proper name.]

" **cookana**—Miller & Dyer, 1878. Cont. to Pal., No. 2. Hud. Riv. Gr. [Ety. proper name.]

" **rugosa**—Miller & Dyer, 1878. Jour. Cin. Soc. Nat. Hist. Hud. Riv. Gr. [Sig. rugose.] In addition to these, Mr. Ulrich has described some fossils under the names of *Eotrophonia setigera, Protoscolex covingtonensis, P. ornatus, P. tenuis*, and *P. simplex;* the latter of which is a synonym for *Walcottia cookana.*

CLASS CRUSTACEA.

Acidaspis—Murchison, 1839. Sil. Syst. [Ety. *akis*, a spear-point; *aspis*, a shield.]

" **anchoralis**—S. A. Miller, 1875. Cin. Quar. Jour. Sci., Vol. 2. Below the middle of the Hud. Riv. Gr. [Sig. anchor-like.]

" **cincinnatensis**—Meek, 1873. Ohio, Pal., Vol. 1. Middle part Hud. Riv. Gr. [Ety. proper name.]

" **crossota**—Locke, 1843. Am. Jour. Sci. and Arts, Vol. 44. Utica Slate and lower part of Hud. Riv. Gr. [Ety. *crossotus*, fringed.] Usually misspelled *crosotus.*

" **onealli**—S. A. Miller, 1875. Cin. Quar. Jour. Sci., Vol. 2. Upper part Hud. Riv. Gr. [Ety. proper name.]

Asaphus—Brongniart, 1822. Hist. Nat. Crust. [Ety. *asaphus*, obscure.]

" **gigas**—DeKay, 1825. Ann. Lyc. Nat. Hist. N. Y. Trenton, Utica Slate and Hud. Riv. Gr. [Sig. a giant.]

" **megistos**—Locke, 1841. Proceedings Am. Ass. Geol. Trenton, Utica Slate and Hud. Riv. Gr. [Sig. very large.]

Beyrichia—McCoy, 1850. Synop. Sil. Foss. Ireland. [Ety. proper name.]

" **chambersi**—S. A. Miller, 1874. Cin. Quar. Jour. Sci., Vol. 1. Throughout Hud. Riv. Gr. [Ety. proper name.]

" **ciliata**—Emmons, 1855. Am. Geol. Utica Slate and lower part of Hud. Riv. Gr. [Sig. haired on the margin.]

" **cincinnatensis**—S. A. Miller, 1875. Cin. Quar. Jour. Sci., Vol. 2. Upper part of Hud. Riv. Gr. [Ety. proper name.]

" **duryi**—S. A. Miller, 1874. Cin. Quar. Jour. Sci., Vol. 1. Middle part of Hud. Riv. Gr. [Ety. proper name.]

" **oculifera**—Hall, 1871. Pamphlet. Middle part Hud. Riv. Gr. [Sig. eye-bearing.]

" **quadrilirata**—Syn. for Beyrichia regularis.

" **regularis**—Emmons, 1855. Am. Geol. Upper part Hud. Riv. Gr. [Sig. formed in bars.]

" **richardsoni**—S. A. Miller, 1874. Cin. Quar. Jour. Sci., Vol. 1. Upper part Hud. Riv. Gr. [Ety. proper name.]

" **striato-marginata**—S. A. Miller, 1874. Cin. Quar. Jour. Sci., Vol. 1. Upper part Hud. Riv. Gr. [Sig. having a striated margin.]

" **tumifrons**—Syn. for Beyrichia ciliata.

Calymene—Brongniart, 1822. Hist. Nat. Crust. [Ety. *kekalymenos*, concealed.]

" **callicephala**—Green, 1832. Monograph of Trilobites. Trenton, Utica Slate and Hud. Riv. Gr. [Sig. having a beautiful head.]

" **christyi**—Hall, 1860. Thirteenth Reg. Rep. N. Y. Upper part Hud. Riv. Gr. [Ety. proper name.]

" **senaria**—Conrad. Syn. for C. callicephala.

Ceraurus—Green, 1832. Monograph of Trilobites. [Ety. *keras*, a horn; *oura*, a tail.]

" **icarus**—Billings, 1850. Can. Nat. and Geol., Vol. 5. Upper part of Hud. Riv. Gr. [Ety. mythological name.] I regard the identification of this species with the Canadian as doubtful.

Ceraurus pleurexanthemus—Green, 1832. Monograph of Trilobites. Hud. Riv. Gr. [Ety. *pleura*, side; *exanthemata*, breaking out.]

Cythere—Müller, 1785. Entomostraca sue Insecta, etc. [Ety. proper name.]

" **cincinnatensis**—Meek, 1872. Proceedings Acad. Nat. Sci. Middle part Hud. Riv. Gr. [Ety. proper name.]

" **irregularis**—S. A. Miller, 1878. Jour. Cin. Soc. Nat. Hist. Hud. Riv. Gr. [Sig. irregular.]

Dalmanites—Emmrich, 1845. (Dalmania.) Barrande, 1852. Sil. Syst. Boh. [Ety. proper name.]

" **breviceps**—Hall, 1866. Pamphlet. Upper part of Hud. Riv. Gr. [Sig. short-headed.]

" **carleyi**—Meek, 1872. Am. Jour. Sci. and Arts, 3rd Ser., Vol. 3. Middle part Hud. Riv. Gr. [Ety. proper name.]

Enoploura—Wetherby, 1879. Jour. Cin. Soc. Nat. Hist. [Ety. *enoplos*, armed; *oura*, tail.] Proposed for Anomalocystites balanoides.

" **balanoides**—Meek, 1872. (Anomalocystites balanoides.) Am. Jour. Sci. and Arts, 3rd Ser., Vol. 3. Hud. Riv. Gr. [Sig. resembling *Balanuis.*]

Leperditia—Rouault, 1851. Bull. Soc. Geo. France. [Ety. *lepis*, a scale; *dittos*, double.]

" **byrnesi**—S. A. Miller, 1874. Cin. Quar. Jour. Sci., Vol. 1. Utica Slate Gr. [Ety. proper name.]

" **cylindrica**—Hall, 1871. Pamphlet. Trenton, Utica Slate and Hud. Riv. Gr. [Sig. cylindrical.]

" **minutissima**—Hall, 1871. Pamphlet. Utica Slate and Hud. Riv. Gr. [Sig. very small.]

Lichas—Dalman, 1826. Monograph of Trilobites. [Ety. mythological name.]

" **harrisi**—S. A. Miller, 1878. Jour. Cin. Soc. Nat. Hist. Upper part Hud. Riv. Gr. [Ety. proper name.]

" **trentonensis**—Conrad, 1842. Jour. Acad. Nat. Sci., Vol. 8. Hud. Riv. Gr. [Ety. proper name.]

Plumulites—Barrande. [Ety. *plumula*, a feather.]

" **jamesi**—Hall & Whitfield, 1875. Ohio Pal., Vol. 2. Hud. Riv. Gr. [Ety. proper name.]

Prœtus—Steininger, 1830. Versteinerungen, etc. [Ety. mythological name.]

" **parviusculus**—Hall, 1866. Pamphlet. Hud. Riv. Gr. [Sig. very small.]

" **spurlocki**—Meek, 1872. Am. Jour. Sci. and Arts, 3d Ser., Vol. 3. Hud. Riv. Gr. [Ety. proper name.] C. D. Walcott has suggested that this is the young of *Asaphus megistos*.

Triarthrus—Green, 1832. Monograph of Trilobites. [Ety. *triarthrus*, three-jointed.]

" **becki**—Green, 1832. Monograph of Trilobites. Utica Slate. [Ety. proper name.] J. G. Anthony in 1846 [Quar. Jour. Geo. Soc., Vol. 3,) said he found *Triarthrus becki* below the Cincinnati Observatory at an elevation of 200 feet above low water mark in the Ohio. I have never found this species more than 125 feet above low water mark; but it is quite likely that the Utica Slate will include a thickness of 200 feet, and that some of the fossils referred to the lower part of the Hudson River Group will be found to be confined to the Utica Slate.

Trinucleus—Lhwyd, 1698. Phil. Trans., Vol. 20. [Ety. *trinucleus*, three-kerneled.]

" **concentricus**—Eaton, 1832. Geo. Text Book. Utica Slate and lower part Hud. Riv. Gr. Probably Trenton, also [Sig. concentric.]

" **bellulus**—Synonym for T. concentricus.

Rocks of Upper Silurian age may be traced from Clarke county, Indiana, through all the river border counties to Butler county, Ohio, where, according to Dr. Locke, they are six hundred and one feet above the Ohio river at Cincinnati, or one thousand and forty-one feet above the ocean. Over this entire distance the Niagara presents great uniformity of lithological features and rests upon strata of Lower Silurian age that are alike marked in their lithological characteristics, while at the same time the two horizons are so distinct that they may be readily recognized without the aid of fossils. The only exception to this uniformity of lithological character is that mentioned in the Banded rock at Madison, and this may only be from a more compact crystallization of the marl-like shale, which at other localities occupies the same horizon.

The upper members of the Hudson River group, or Cincinnati beds, may prove to be locally somewhat thicker in Indiana than at the immediate neighborhood of Cincinnati; but this is not of sufficient importance to warrant one in establishing a different epoch for the beds at Richmond or Madison, as I have endeavored to prove by the above stratigraphical deductions.

The Niagara rocks in Indiana for the most part, especially in the southeastern part of the State, have lost none of the characters by which they are distinguished in New York. There they form the mural face of Niagara Falls, Genesee Falls, as well as a multitude of smaller falls and precipitous bluffs. The scenery in Indiana is alike marked by this epoch, and hence the name given to it in Ohio by Dr. Locke of "Cliff Rock." It caps the hills over a large portion of Jefferson county, and all the streams that cut their way through it have more rapidly removed the soft, marly Hudson River beds from beneath, and the superincumbent, massive Niagara breaks loose and tumbles to the foot of the ravine, where it is often seen in large blocks.

In this way cliffs are formed over which the streams pour their waters in beautiful cascades. Indeed, it is impossible to find any scenery in the State more beautiful and grand than is to be found in the vicinity of Madison and Hanover College. As we follow the crop of the Niagara limestone to the northeast, we find the character of some of the beds changed to a light, grayish buff, close-grained, magnesian limestone, forming flagstone and building stone of great value. Extensive quarries are opened in the vicinity of Greensburg, at St. Paul on Flat Rock creek; and, in fact, the stone is of excellent quality for a great distance both up and down the creek. Near Waldron, on Conns creek, there is, close to the top of the beds and over the flagstone, four or five feet of bluish shale and thin bands of limestone that abound in fossils. The bed is not persistent, and becomes thinner and disappears as you go either north or south of this place. It is very near to the corniferous limestone which crops further up the creek. Prof. James Hall, State Geologist of New York, has made a special study of the fossils of this locality and St. Paul, commencing as far back as 1862, and the results have been publised, so far as accurate drawings of the specimens are concerned, in the Twenty-eighth Regent's Report. No less than one hundred and twenty-six species have been recognized, and the locality has become one of the most noted in the world for the variety and beauty of its fossils. I am under obligations to Dr. R. R. Washburn, who lives at Waldron, for a number of very fine crinoid and brachiopod shells which he took from his large collection, all of which he obtained from the fossiliferous shales of Conns creek, one mile to the west of Waldron. The doctor is an enthusiast in the study of paleontology, and an intelligent, generous-hearted gentleman. His gratuitous labors in the cause of science are alike creditable to himself and an honor to the State. Among the most interesting objects found on Conns creek are the roots of Eucalyptocrinus. Some specimens are seen which preserve the base of the column, and show the ramification of the rootlets through the calcareous shale in every direction, and in such a manner as to indicate that they were imbedded in it during their growth at the bottom of the ocean. Numerous forms of Bryozoa cover some of the layers of stone with their netlike markings, and have even found lodgment upon the shells of mollusca. There could have been no want of life in palæozoic times. Then, as now, it would appear as though every available space was occupied by living matter.

Passing northwest, the Niagara rocks may be traced through portions of Rush, Hancock, Henry, Madison, Hamilton and Howard to Cass county on the upper Wabash river. To the east of Cass the Niagara is seen along the Wabash and Salamonie rivers in Miami, Wabash, Huntington, Blackford and Wells counties. There are crops along the Mississinewa river in Grant county, and in the bed of White river in Delaware county. In all the above counties the Niagara beds are quarried for flagging stone and architectural purposes. The layers are for the most part thin, and the stone refractory, variable in color and wanting in durability. The average composition may be seen from the following analyses of specimens from Randolph county, taken at the localities named:

	Macksville.	Ridgeville.
Water at 212° F	1.18	0.90
Silicic acid	1.20	0.70
Ferric oxide	1.30	2.70
Alumina	4.40	3.75
Lime	45.45	45.08
Magnesia	4.01	4.36
Carbonic anhydride	40.12	39.21
Sulphuric acid	0.27	0.44
Combined water and loss	2.07	2.86
	100.00	100.00

These stones are porous, open-grained, light buff colored. They make excellent lime. The specimens were collected and analyzed by Dr. Levette. It will be seen by the subjoined analysis of Huntington stone, which is celebrated for the quality of lime which it yields, that the Randolph county beds are not only equivalent in geological time, but are almost identical in chemical composition.

HUNTINGTON STONE, BEST FOR LIME.

Water at 212°	0.50
Silicic acid	1.50
Lime	31.92
Magnesia	7.58
Alumina and ferric oxide	8.25
Carbonic anhydride	49.52
Sulphuric acid	0.34
Loss	0.39
	100.00

The Niagara rocks in this part of the State carry locally a thin bed of sandstone which belongs to the Corniferous epoch. In Huntington county it forms the upper fifteen inches, is pure white, coarse-grained and loosely coherent.

In Madison county, at Pendleton, we have the following section extending from the bed of Fall creek to the top of the drift, all belonging to the Corniferous epoch:*

Drift with large bowlders of granite and other crystalline rocks strewed over the surface	50 feet.
Ash colored, rough weathering, cherty, magnesian limestone, alternating with soft, sandy, greenish colored, pyritiferous layers, in all, about	4 feet.
Buff, sandy, magnesian limestone, Pleurotomaria and coral bed	4 feet.
Heavy bedded and soft, white sandstone, upper part fossiliferous	15 feet.
Bed of Fall creek	

*A letter received from Prof. James Hall, State Geologist of New York, since this report was written, informs me that after a study of the Pendleton fossils he refers the sandstone to the "Schoharie Grit." He says: "My own convictions are that it is the equivalent of our own Schoharie Grit, being the western prolongation of beds that are generally well developed in Canada West, but making no conspicuous figure in the geology. Several of the fossils are identical with those of our own Schoharie Grit, and lately I had placed in my hands, for drawing, by Mr. Rogers, of Pendleton, a specimen of *Cyrtoceras eugeniana*, which is a common and characteristic fossil of the grit, and is the first specimen I have seen from beyond Central New York."

The sandstones may be had in blocks five feet thick; it is soft when first quarried, but hardens on exposure to the weather, and has a good reputation as a building stone, both for beauty and durability. This stone furnished the sand for the Indianapolis Glass Works, when they first started, and proved to be well adapted for this branch of manufacture. The fossils found at this locality are *Spirifer fimbriata*, *S. subumbonata*, *Conocardium trigonale*, *Zaphrentis gigantea*, *Pleurotomaria?*, *Diphyphyllum cæspitosum?*, *Cladopora fibrosa?*, and *Tentaculites scalariformis*.

These arenaceous beds have, so far, only been noticed in Huntington and Madison counties; at the former locality the thickness of the stratum is only a few inches, without organic remains, and its area quite limited. At Pendleton the exposure is, in all, about twenty-three feet, of which fifteen feet is sandstone. The layers all contain fossils, many of which correspond specifically with those found in the rocks at the Falls of the Ohio; I have, therefore, concluded to place them in the same epoch. I do this for the same reasons that I have placed all the rocks lying between the Corniferous and the Hudson River group, in Indiana, in the Niagara. The deposits are too thin and without well-defined characters, either lithological or fossiliferous, that will serve for lines of undisputed subdivisions. Of course every deposit has its top, middle and bottom parts, and at each locality these may be marked by the prevalence of specific forms of life or lithological variations; but I maintain that the absence of these forms, and a change in lithological features at another locality, is not unmistakable evidence of a difference in geological time. It is the duty of the geologist to make careful sections of all exposures of the rocks, to note the character of each stratum, and give with great minuteness the record of the fossils; but he will find himself involved in inextricable difficulties if he under-takes to make its features the standard by which to measure the age of other outcrops. Sandstone beds may be traced along the exposed face until the sand is replaced by lime, and the bed actually becomes a limestone. It may be without fossils at one part of the exposure and fossiliferous at another; so it is with the forms of life—they will vary in a remarkable degree along the same horizon in different parts of the stratum. I do not wish to be understood as ignoring the study and use of organic remains in determining geological sequence, but I simply deny their infallibility for the identity of minute subdivisions of strata over widely separated districts of country.

The Pendleton sandstone rests immediately on magnesian limestone belonging to the Niagara, which crops in considerable force on property owned by Hon. William Crim, one and a half miles west of the court house, in Anderson, and close to the bank of White river. It is opened up for quarrying, and presents a face several hundred feet in length, and contains as many as eleven workable layers of stone, varying from four to twelve inches in thickness. The section at the west end of the quarry is:

	Ft.	In.
Earth stripping	4	00
Buff argillaceous, magnesian limestone in uneven layers	4	06
Bluish colored layer, good stone	0	08
Bluish colored layer, good stone	0	06
Bluish colored layer, good stone	1	00
Bluish colored layer, good stone	0	08
Bluish colored layer, good stone	0	04
Bluish colored layer, good stone	0	06
Bluish colored layer, good stone	0	04
Bluish colored layer, good stone	0	04
Bluish colored layer, good stone	0	06
Bluish colored layer, good stone	0	06
Bluish colored layer, good stone	0	09
	14	07

At the east end of the quarry the stripping averages from two to four and a half feet. The thickness of the layers here is about the same as at the west end. The stone from Crim's quarry meets with a very ready sale and bears a good reputation for durability. Quarries have been opened in the vicinity of Marion, in Grant county, at a number of localities to the northwest of the city and along the Mississinewa river. The character of the stone is the same as at Crim's, near Anderson, and, like the latter, belongs to the Niagara epoch. It is a magnesian limestone; has an exposure of twelve feet and upwards, and is in layers varying from two to eighteen inches in thickness.

The city of Marion is situated in the valley of the Mississinewa river, at a point where the stone has been removed by denudation, or, mostly, by glaciation.

With a view to supply the city with water a well was dug on the east side of the river. It was commenced twenty-five feet in diameter, and carried to a depth of twenty-seven feet and walled with brick. It started in swampy ground, and passed through:

	Ft.
Black muck	1
Blue clay	2
Gravel and sand	9
Blue clay	15
	27

No water was found in this part of the well after passing below the seeps from the clay which formed the bed of the old swamp. A bore was started in the bottom of the digging, and, after passing through forty-one feet of gravel and clay, reached a stream of water which flowed to the surface with considerable force, and in twelve hours filled the body of the great well and flowed over the top. Here was an abundant supply of good potable water. Dean Bro.'s, of

Indianapolis, had been engaged to put up water works for distributing the water over the city, and at the time of my visit their admirable pump was at work emptying the main well, so that an additional and larger bore could be made for the purpose of increasing the flow of water, and thus insure an ample supply for all possible wants of the city. The people of Marion were very anxious to know the quality of the water for drinking and other household uses, and some bottles were filled and taken to the laboratory for chemical examination. The result of this analysis was reported to Mr. D. S. Hogan for publication in the local papers, but as a matter of general information it is repeated here:

ANALYSIS OF MARION ARTESIAN WELL WATER.

This water comes from a depth of sixty-eight feet, and has a temperature of 51½° F. It is colorless and odorless, has a slight chalybeate taste, and a small deposit of ferric oxide settled to the bottom of one of the bottles after standing a few days.

An imperial gallon (10 pounds) contains 28.2 grains of solid mineral matter, composed of:

	Grains.
Silica, insoluble in acids	1.610
Alumina	0.350
Magnesia	3.705
Lime	9.319
Ferrous oxide	0.849
Soda	0.154
Potash	0.022
Carbonic acid, combined	9.314
Sulphuric acid	2.298
Chlorine	0.236
Loss	0.343
	28.200

These substances are probably combined as follows:

	Grains.
Silica	1.610
Alumina	0.350
Sulphate of magnesia (Epsom salts)	4.061
Proto sulphate of iron	1.790
Carbonate of lime	16.800
Carbonate of magnesia	2.814
Carbonate of potash	0.042
Chloride of sodium (common salt)	0.390
	27.857

The free carbonic acid, which exists in considerable quantity, together with nitrogen and oxygen, was not determined. It is a sulphate, chalybeate and carbonated water, and may be said to have tonic and alterative properties, though 28.2 grains in 70,000 grains (10 pounds) of water must be looked upon as a homœopathic dilution, and an excessive drinker would scarcely receive into his system more than three grains of solid mineral matter from the water, by its free use, in twenty-four hours.

The total mineral constituents of the Marion artesian water corresponds very closely in quantity with what is found in most natural spring and well waters that are obtained from the drift deposit of Indiana.

The water analyzed from the spring at the "Mound," in Madison county, contained 24.101 grains of solid mineral matter in an imperial gallon, as follows:

	Grains.
Silica	1.658
Alumina	trace
Magnesia	trace
Lime	8.161
Ferrous oxide	1.041
Sulphuric acid	2.750
Carbonic acid	6.411
Undetermined and loss	4.080
	24.101

The Hawkins chalybeate spring, situated in the edge of Richmond, Wayne county, contains 32.2 grains of solid matter in an imperial gallon.

The chalybeate spring at Rochester, Fulton county, 24.5 grains.

Indianapolis well water, upper seam, 36 to 40, and the lower seams 23 to 28 grains per gallon.

So far as tested, all the water in the State which is obtained from the drift contains a considerable amount of iron, and in many localities the quantity is sufficiently large to give it decided tonic and alterative properties.

The Niagara beds in Delaware and Randolph counties have been quarried for building stone and for lime. Indeed, this stone is noted for the excellent quality of lime which it makes, and the operation of burning lime forms a large industry wherever the layers beneath the cherty beds which belong at the top of this formation can be reached. In Randolph county the stone is cream colored, porous and coarse-grained, which renders it inferior for masonry where durability is a matter to be considered, but the following analyses show that it is in no way inferior to the celebrated Huntington stone for the manufacture of lime. For comparison, the analysis is also given of the Huntington stone, which has given the best results in making quicklime for masonry.

No. 1 is quarried in White river bottom, near Macksville, seven miles west of Winchester, Randolph county.

No. 2 is found near Ridgeville, in the north part of Randolph county, and crops out in the bed of Mississinewa river for some miles east and west of that town.

No. 3 is from Hawleys Brothers' quarry at Huntington, Huntington county.

ANALYSES.

	No. 1.	No. 2.	No. 3.
Water expelled at 212° F	1.18	0.90	0.50
Silicic acid	1.20	0.70	0.50
Ferric oxide	1.30	2.70	8.25
Alumina	4.40	3.75	
Lime	45.45	45.08	31.92
Magnesia	4.01	4.36	9.58
Carbonic acid	40.11	40.21	49.52
Sulphuric acid	0.27	0.44	0.54
Loss and undetermined	2.08	1.86	
	100.00	100.00	100.81

After passing north of a line reaching from Huntington, on the upper Wabash river, and following a little north of this stream at Logansport, and thence through the northern part of White and the southern part of Newton counties, no beds of stone are found in the State exposed to view, but lie buried beneath the glacial drift, which varies, in this part of the State, from fifty to two hundred feet and upward in thickness.

By penetrating through this drift deposit at any point in the State north of the line designated, the Niagara rocks will be found, and as these beds of stone occupy a horizon many hundreds of feet below the coal measure rocks, it will be readily seen how futile must be the efforts of those who seek to find seams of coal in this part of the State.

Underlying the buff, magnesian limestone of the Niagara, so extensively used for making quick-lime in Wabash, Huntington and other counties bordering the upper Wabash river, there is a gray, argillaceous limestone that possesses dydraulic properties to a considerable degree. This stone has not yet been able to make its way into market against other cements which, if we should judge from their chemical constituents as usually rendered in analyses of cement stones, one would be puzzled to understand wherein lay the superiority of the latter. For the purpose of illustrating this subject I will here give the analyses of some of these rocks, together with that of well known cements from this and other States:

HYDRAULIC STONE ON THE DAVIESS FARM, NEAR SOMERSET, WABASH COUNTY.

Moisture		1.000
Silicic acid		30.600
Alumina		16.720
Carbonate of lime	(CaO., 14.336)	25.600
Carbonate of magnesia	(MgO., 6.052)	12.713
Ferric oxide		2.480
Organic matter, alkalies, undetermined and loss		10.887
Ratio: Silica 100 to 130 Base.		100.000

ANALYSIS OF THE CELEBRATED ROSENDALE CEMENT STONE, NEW YORK.*

Carbonate of lime	(CaO., 25.76)	46.00
Silica, clay and insoluble silicates		27.70
Carbonate of magnesia	(MgO., 8.46)	17.76
Alumina		2.34
Protoxide of iron		1.26
Sulphuric acid		0.26
Chlorides of potassium and sodium		4.02
Hygrometric water		0.22
Loss		0.44
Ratio: Silica, 100; Bases, 181.		100.00

CUMBERLAND CEMENT STONE, MARYLAND.

Carbonate of lime	(CaO., 23.408)	41.80
Silica, clay and insoluble silicates		24.74
Carbonate of magnesia	(MgO., 1.952)	4.10
Alumina		16.74
Peroxide of iron		6.30
Soda		4.64
Sulphuric acid		2.22
Hygrometric water		0.60
Ratio: Silica, 100; Base, 213.		101.14

* This and the three following analyses are taken from "Coignet-Breton and other artificial stone" by Gen. Q. A. Gillmore, p. 13.

BALCONY FALLS STONE, VIRGINIA.

Carbonate of lime	(CaO., 17.376)	31.03
Silica		34.22
Carbonate of magnesia	(MgO., 9.507)	19.97
Alumina		7.80
Water and loss		0.69
Free carbonic acid		6.29
		100.00

Ratio: Silica, 100; Base, 100.

VASSY CEMENT STONE, FRANCE.

Carbonate of lime	(CaO., 35.728)	63.8
Silica		14.0
Carbonate of magnesia	(MgO. 714)	1.5
Alumina		5.7
Carbonate of iron		11.6
Water and loss		3.4
		100.0

Ratio: Silica, 100; Base, 383.

The amount of alumina in the Cumberland and Balcony Falls cement stones shows that they must have contained a considerable amount of combined water, the former not less than five or six per cent., and the latter not less than three or four per cent.; therefore there is likely to be an excess of carbonates of lime and magnesia, to that extent, at least, in the reported analyses. I look for the error in these salts because it requires time and patience to thoroughly wash their bulky precipitates. There is no self-evident error in the analysis of the Vassy cement stone, the 5.7 per cent. of alumina would indicate that it carried from three to four per cent. of water. The excellence of this cement was for a time thought to be due to the large per cent. of ferric oxide which it contains. But it is well known that there are many equally good cements which have but a comparatively small amount of ferric oxide, and, indeed, M. Vicate, who devoted many years of study to the subject, and is recognized as eminent authority on cements, is of the opinion that ferric oxide exerts an injurious influence upon hydraulic mixtures. The Vassy cement stone contains a small amount of silica as compared to the bases. Assuming the silica, or, rather, silicic acid to be 100, the ratio is, silicic acid, 100; bases, 383.

The Rosendale cement, which is one of the best natural cements in America, has a ratio of silicic acid, 100; bases, 181. Cumberland cement, silicic acid, 100; bases, 213. Balcony Falls cement, Va., silicic acid, 100; bases, 100. Wabash county, Ind., cement, silicic acid, 100; bases, 130.

For hydraulic purposes the essential constituents of a cement stone are carbonate of lime and silica. By calcination the carbonate of lime converts the silica into silicic acid, which forms a gelatinous mass with acids. Carbonate of magnesia acts in a similar manner to carbonate of lime, and when the two are present in the proper proportions, hydraulic energy is uninterrupted, and a stone is formed, of great strength and durability, which consists of a double silicate of lime and magnesia. A portion of alumina is not objectionable in a cement stone in the presence of plenty of carbonate of lime and silica; it enters into combination as a hydrated silicate of lime and alumina. Sulphuric acid, or sulphate of lime, does not promote hardening or setting of the cement, and the same may be said of the oxide of iron. Large quantities of these substances are therefore objectionable, and they may be looked upon as adulterations.

Since carbonates of lime or magnesia, aided by alkalies, when present, are the active agents during the calcining of the cement stone in bringing about the decomposition of the silicates, and forming a silicate that is soluble in acids, it will be interesting to present a tabular arrangement of the ratio of silica to the carbonates of lime and magnesia in the above, and some additional analyses of cement stones that are in common use:

ANALYSIS.

	Silicates.	Carbonates.
Balcony Falls, Va	100	149
Rosendale, N. Y	100	248
Wabash county, Ind	100	124
Cumberland, Md	100	186
Beache's, Clark county, Ind	100	262
Vassy, France	100	465
English	100	341
Bologne	100	311

Between the silicates and carbonates, including the carbonates of lime, magnesia and alkalies, when present, there is a wide variation in cement stones of good repute for hydraulic energy.

It has already been stated that for hydraulic properties the essential constituents of a cement are silicic acid and caustic lime. The hardening under water is mainly due to the chemical combination of these two constituents through the agency of water, producing hydrated silicate of lime; where other bases are present, such as alumina and magnesia, double silicates are formed that become very hard and strong. In order to bring about this chemical change the silica must be brought to that condition which will enable it to form a gelatinous paste with acids. A portion of the silica may be in this condition naturally, but by far the larger portion remains unacted upon by acids until brought to a white heat in the presence of carbonate of lime.

If the bases are in excess of the silicic acid they are constantly being removed by the soluble action of water, and the strength of the cement is thereby improved. Rainwater standing for twelve months in a cement cistern made for the use of the geological laboratory was found to contain as much as eleven grains of carbonate of lime in an imperial gallon, and this solvent power of rainwater on the cement continued up to the time of our leaving the office at the old State House, a period extending over seven years.

In the following analyses of hydraulic stones collected by Prof. John Collett from the sub-carboniferous formation in Harrison and Crawford counties, Ind., and Rock Haven, Meade county, Ky., the investigation was conducted by Dr. G. M. Levette, under instructions to make the analyses in such a manner as to ascertain the effect produced upon the insoluble silicates, by calcining the stones at a full white heat. Each specimen was, therefore, analyzed three or four times. A moderate sized lump that fully represented the stone was crushed and pulverized to an impalpable powder in an agate mortar, and from this separate portions were taken.

First—A weighed portion of the powder was digested with hydrochloric acid and the filtrate treated in the usual way for the determination of the soluble salts. The insoluble silicates remaining on the filter were ignited and weighed, the result of which is given in the first column of the following table.

Second—Another weighed portion of the same powder was calcined at a white heat and then treated as the first; results shown in the second column of the table.

Third—Another weighed portion of the same was fused with four times its weight of carbonate of potash and soda, in a platinum crucible, and treated as the first; results shown in third column.

Fourth—In some instances the insoluble silicates found by the first process were fused with carbonates of potash and soda, and the composition placed in the fourth column.

Fifth—The amount of silica soluble in water, from the calcined stone, is also given as a matter of interest.

The sample first analysed is a specimen taken from the lower part of the quarry at Rock Haven, Ky. The cement made at this place, though the works have only been in operation for a few years, has already gained a high reputation for hydraulic energy, and is said by the manufacturers to be greatly preferred to the Louisville cement. However this may be, I wish it understood that I do not believe that this point is at all established beyond question. The same strata of stone are found in Indiana, and we will now direct attention to the analyses:

ROCK HAVEN CEMENT STONE, MEADE COUNTY, KY.—BOTTOM OF BED.

	No. 1. Not Calcined.	No. 2. Calcined.	No. 3. Fused in Alkalies.
Water expelled at 212° F.	0.75	0.75	0.75
Insoluble silicates	34.30	27.10	25.90
Soluble silica	0.20	1.10	1.10
Ferric oxide	1.90	6.75	7.45
Alumina		2.40	3.00
Lime	30.80	31.00	31.12
Magnesia	0.66	0.66	0.66
Carbonic acid	24.20	24.35	24.45
Sulphuric acid	1.80	1.80	1.80
Combined water, organic matter, traces of alkalies and loss	5.39	4.09	3.77
	100.00	100.00	100.00

Silicic acid, soluble in water, 1.2.

It is common to render the lime and magnesia as carbonates, but I have thought best to separate the carbonic acid, since in the practical preparation of cement the stone is calcined, and nearly or quite all the carbonic acid is expelled by the heat.

In order to compare these results with the analyses of cements made by other analysts, I have taken the figures given in the second column, which shows the composition of the calcined stone. I will also add for the better understanding of those who may wish to repeat or extend this analytical research, that the carbonic acid was determined by fusing the powdered stone with borax glass.

To show the relation of the silicic acid to the bases, the former is taken to be 100.

ROCK HAVEN CEMENT STONE—TOP PART OF BED.

	No. 1. Not Calcined.	No. 2. Calcined.	No. 3. Fused.	No. 4. Insoluble Matter of No. 1 fused.
Water expelled at 212° F.	1.00	1.00	1.00	
Insoluble silicates	36.90	31.00	27.85	28.15
Soluble silica	0.30	0.35	0.35	
Ferric oxide	} 1.25	6.67	} 4.20	4.55
Alumina			4.40	4.45
Lime	28.42	28.60	28.83	
Magnesia	0.43	0.43	0.43	
Carbonic acid	22.33	22.47	22.65	
Sulphuric acid	1.20	1.20	1.20	
Combined water, organic matter, traces of alkalies and loss	8.17	8.23	8.09	
	100.00	100.00	100.00	

Silicic acid, 100; Soluble bases, 114.

JOHN KINTNER'S HYDRAULIC CEMENT, CEDAR GROVE, HARRISON COUNTY, INDIANA.

	No. 1. Not Calcined.	No. 2. Calcined.	No. 3. Fused.	No. 4. Insoluble matter of No. 1 fused.
Water expelled at 212° F.	0.80	0.80	0.80	
Insoluble silicates	29.75	26.20	9.70	9.20
Soluble silica	0.60	1.00	0.90	
Ferric oxide	} 5.00	7.10	{ 3.25	1.80
Alumina			5.45	2.50
Lime	34.84	35.14	41.61	8.26
Magnesia	....	....	1.67	
Carbonic acid	27.37	28.06	32.70	6.49
Sulphuric acid	0.80	0.80	0.80	
Combined water, organic matter, traces of alkalies and loss	0.84	.90	3.12	
	100.00	100.00	100.00	28.25

Silicic acid, 100; Soluble bases, 131.

CEDAR GROVE CEMENT ROCK, BRIGGS' FARM, HARRISON COUNTY, IND.

	No. 1. Not Calcined.	No. 2. Calcined.	No. 3. Fused.	No. 4.
Water expelled at 212° F	1.00	1.00	1.00	
Insoluble silicates	27.70	25.40	23.65	22.50
Soluble silica	0.10	0.10	0.15	
Ferric oxide	} 4.00	4.90	{ 2.50	2.50
Alumina			2.80	1.65
Lime	35.00	36.46	36.80	0.60
Magnesia	trace	trace	0.63	
Carbonic acid	27.50	28.64	29.27	0.47
Sulphuric acid	trace	trace	0.20	
Organic matter, undetermined and loss	4.70	3.50	3.00	
	100.00	100.00	100.00	27.72

Silicic acid, 100; Soluble bases, 144.

SHACKLEFORD'S CEMENT ROCK.

	Top.	Middle.	Bottom.
Moisture expelled at 212° F	0.20	0.25	0.18
Insoluble silicates	11.00	10.25	12.80
Soluble silica	1.18	1.13	1.10
Ferric oxide	2.35	1.95	3.10
Alumina	2.70	2.00	1.30
Lime	43.37	46.65	43.37
Magnesia	0.18	0.50	0.27
Carbonic acid	34.86	36.55	34.07
Sulphuric acid	0.27	0.14	0.26
Combined water, organic matter, undetermined and loss	3.89	0.58	3.55
	100.00	100.00	100.00

Silicic acid, 100; Soluble bases, 468.

One could hardly look upon this as a hydraulic lime, and the analysis would place it with the fat limes.

NATURAL CEMENT—HARRISON AND CRAWFORD COUNTIES.

	Not Calcined.	Calcined.
Water expelled at 212° F.	0.60	0.60
Insoluble silicates	29.50	27.45
Soluble silica	....	1.40
Ferric oxide, Alumina	4.10	4.75
Lime	23.52	23.50
Magnesia	2.98	2.98
Carbonic acid	21.77	21.76
Sulphuric acid	none	none
Chloride of alkalies	2.80	2.80
Combined water, organic matter and loss	14.73	14.76
	100.00	100.00

Silicic acid, 100; Soluble bases, 113.

This stone is said to make a good cement when ground without being calcined, but its analysis does not show it to be possessed of much hydraulic energy under such circumstances.

In order to make a further comparison, samples of English Portland cement and Louisville cement were obtained from the commission house of R. S. Foster; Milwaukee cement from Andrew Wallace's store, and Fayetteville, N. Y.; Buffalo-Portland, manufactured by the Union Cement Co., Buffalo, N. Y., from the office of the Indiana State House Commissioners. The latter were sent to the Commissioners as samples to compete with others in supplying the demand for building the State House. The specimens taken from the stores are of cements that are sold to meet the general wants of our market.

ANALYSIS OF ENGLISH PORTLAND CEMENT.

Water expelled at 212° F	1.20
Insoluble silica	20.60
Soluble silica	3.80
Ferric oxide	2.00
Alumina	8.40
Lime	44.07
Magnesia	0.86
Carbonic acid	4.00
Sulphuric acid	5.58
Chloride of alkalies	2.60
Combined water	5.02
Loss and undetermined	1.87
	100.00

Four per cent. of carbonic acid represents 9.09 per cent. of carbonate of lime.

It is possible that the sulphuric acid exists in combination with lime, $CaO,SO_4 = 9.50$, and so far from this being a benefit, competent authorities consider that even 3.5 per cent. of sulphate of lime is detrimental to the strength and durability of hydraulic cement. In determining the ratio of silicic acid to bases I have, therefore, deducted from the lime 3.92 as combined with the sulphuric acid and rendered inert. We have, then, silicic acid, 23.40, and bases, 54.01.

Ratio: Silicic acid, 100; Bases, 280.

This cement effervesced, and the silica was gelatinous when treated with acid. The 4.00 per cent. of carbonic acid found will represent 9.09 per cent. of carbonate of lime. The 3.8 per cent. of silica soluble in chlorohydric acid and thrown down by evaporating the acid solution to dryness is much in excess of what was found in any other cement. The amount of silica soluble in water is 1.4 per cent. By recalcining the cement at a bright white heat the water which could not be expelled at 212° was estimated after deducting the carbonic acid from the loss.

LOUISVILLE CEMENT--MANUFACTURED IN CLARKE COUNTY, INDIANA.

Water expelled at 212° F	1.40
Gelatinous silica	15.70
Soluble silica	2.10
Ferric oxide	3.40
Alumina	20.60
Lime	38.38
Magnesia	1.30
Carbonic acid	5.90
Sulphuric acid	2.67
Chloride of alkalies	5.50
Combined water and loss	3.05
	100.00

This cement contains a large amount of alkalies, and differs mainly from the English-Portland in having less silicic acid and an excess of alumina. It contains a less quantity of sulphuric acid, 2.67 per cent., which, if combined with lime, will be equivalent to 4.54 per cent. of gypsum.

The ratio of silicic acid to bases is 100 to 411.

MILWAUKEE CEMENT.

Water expelled at 212° F	0.60
Gelatinous silica	22.60
Soluble silicic acid	1.20
Ferric oxide	2.20
Alumina	22.20
Lime	29.89
Magnesia	5.70
Carbonic acid	10.40
Sulphuric acid	1.18
Chloride of alkalies	2.10
Combined water and loss	1.93
	100.00

The 1.18 of sulphuric acid represents 2.02 per cent. of calcic sulphate
The ratio of silicic acid to bases is as 100 to 265.

This cement contains too much alumina and not enough lime. The ratio of silica to bases is very fair, but alumina is not as good a base as lime for the formation of hard and durable stone.

FAYETTEVILLE CEMEMT, ONONDAGA COUNTY, NEW YORK.

Water expelled at 212° F	0.80
Gelatinous silica	14.30
Soluble silicic acid	1.40
Ferric oxide	trace
Alumina	21.00
Lime	40.80
Magnesia	2.37
Carbonic acid	5.15
Sulphuric acid	1.84
Chloride of alkalies	5.20
Combined water and loss	7.14
	100.00

Silicic acid, soluble in water, 2.10 per cent.

Ratio of silica to bases, as 100 to 453.

The 1.84 per cent. of sulphuric acid represents 3.14 per cent. of calcic sulphate.

This cement contains too much alumina and not enough silica.

BUFFALO CEMENT COMPANY, LIMITED.

This company manufacture two brands of cement. A barrel of each was sent to the State House Commissioners as samples of what they would be able to furnish for use in constructing the state house. These barrels are marked respectively, "Buffalo-Portland Cement," which is here called No. 1, and "Buffalo Cement," No. 2, of the following analyses, made of samples taken from the barrels by boring into them with an auger:

ANALYSIS.

	No. 1.	No. 2.
Water expelled at 212° F	0.60	0.75
Silicic acid	24.80	24.30
Ferric oxide	1.65	2.61
Alumina	7.85	6.20
Lime	38.58	37.29
Magnesia	7.60	6.16
Carbonic acid	2.10	3.55
Sulphuric acid	1.00	2.16
Chloride of alkalies	4.95	5.30
Combined water and loss	10.87	11.68
	100.00	100.00

No. 1.—Ratio of silicic acid to bases as 100 to 218.

No. 2.—Ratio of silicic acid to bases as 100 to 205.

The analyses show no material difference in the chemical composition of these two cements, and, indeed, I was informed by one of the company that they are both made from the same cement stone, but they claim that there is a physical difference, and give decided preference to the Buffalo-Portland cement, which is made in this way: When the calcined stone is ground as fine as possible between the mill stones it forms the ordinary quality branded "Buffalo Cement." To the feel this cement contains some hard grains, which are still more apparent when the powder is placed under the microscope. These hard grains are the hard-burned, or vitreous part of the stone, which the manufacturers call "slag." This slag is separated by a fine bolting-cloth and re-ground, to make what they term "Buffalo-Portland Cement." A bushel of the latter cement is much heavier than the common (120 lbs. per bu.), and the manufacturers claim that it makes an infinitely harder and more durable concrete. This mode of manufacturing cement has been patented by the company. Of this I have no personal knowledge, but I may add that it had already been conjectured in my report of 1873, p. 157, that the cinder, or rejected, over-burned stone, would, if ground up with the other stone, improve the quality of the cement.

CUMBERLAND HYDRAULIC CEMENT, CUMBERLAND, MARYLAND.

Sample taken from a keg that was sent by the manufacturers to the State House Commissioners:

Water expelled at 212° F	1.00
Silicic acid	27.75
Ferric oxide	4.00
Alumina	11.00
Lime	40.75
Magnesia	0.72
Carbonic acid	6.50
Sulphuric acid	2.80
Chloride of alkalies	3.10
Combined water and loss	2.38
	100.00

Ratio of silicic acid to bases as 100 to 189.

WESTERN CEMENT ASSOCIATION, 98 MARKET STREET, CHICAGO, ILL.

Sample sent by express through the kindness of P. H. Decker, of Chicago. Manufactured at Utica, Ill. Light buff colored powder, meagre feel.

Water expelled at 212° F	1.20
Silicic acid	27.60
Ferric oxide	0.80
Alumina	10.60
Lime	33.04
Magnesia	9.26
Carbonic acid	2.70
Sulphuric acid	2.40
Chloride of alkalies	7.42
Combined water and loss	4.98
	100.00

Ratio of silicic acid to bases as 100 to 191.

This cement has a very good reputation, and differs but little in composition from the preceding. The main difference being in the large amount of alkalies which it contains. Estimating the sulphuric acid to combine with the lime to form an inert salt, or rather a combination that is an injury to the cement, and the carbonic acid combined with lime, we have 5.75 per cent. of the base that is of no value, so that the ratio of silicic acid to effective bases is 100 to 170.

Having now gone through with a large number of analyses, for convenience and comparison, the results will be presented in tabular form:

ANALYSIS OF CEMENT STONES AND CEMENTS.

NAME OF BRAND, OWNER OR QUARRY.	Silicates—Insoluble.	Soluble Silica.	Ferric Oxide.	Alumina.	Lime.	Magnesia.	Carbonic Acid.	Sulphuric Acid.	Chloride of Alkalies.	Moisture at 212° F.	Combined Water and Loss.	Ratio of Bases to 100 of Silica.
Balcony Falls, Virginia	34.22	......	....	7.80	17.37	9.51	30.41	......	......	......	0.69	100.
Buffalo Cement	24.30	......	2.61	6.20	37.29	6.16	3.55	2.16	5.30	0.75	11.68	205.
Buffalo-Portland Cement	24.80	......	1.65	7.85	38.58	7.60	2.10	1.00	4.95	0.60	10.87	218.
Briggs, Harrison county, Indiana	25.40	0.10	2.50	2.80	36.46	*	28.64	*	......	1.00	3.10	144.
Cumberland Cement Stone, Maryland	24.74	......	6.30	16.74	23.40	1.95	30.55	2.22	4.64	0.60	....	213.
Cumberland Cement, Maryland	27.75	......	4.00	11.00	40.75	0.72	6.50	2.80	3.10	1.00	2.38	189.
Fayetteville, New York	14.30	1.40	*	21.00	40.80	2.37	5.15	1.84	5.20	0.80	7.14	453.
Kintners, Harrison county, Indiana	26.20	1.00	3.25	5.45	35.14	1.67	28.06	0.80	......	0.80	....	131.
Louisville Cement, Indiana	15.70	2.10	3.40	20.60	38.38	1.30	5.90	2.67	5.50	1.40	3.05	411.
Milwaukee, Wisconsin	22.60	1.20	2.20	22.20	29.89	5.70	10.40	1.18	2.10	0.60	1.93	265.
Natural Cement	27.45	1.40	*	4.75	23.50	2.98	21.76	......	2.80	0.60	14.76	113.
Portland Cement, England	20.60	3.80	2.00	8.40	44.07	0.86	4.00	5.58	2.60	1.20	6.89	280.
Rockhaven, Kentucky, Top	31.00	0.35	4.20	4.40	28.60	0.43	22.47	1.20	......	1.00	6.30	114.
Rockhaven, Kentucky, Bottom	27.10	1.10	6.75	2.40	31.00	0.66	24.35	1.80	......	0.75	4.09	151.
Rosendale, New York	27.70	......	1.26	2.34	25.76	8.45	29.55	0.26	4.02	0.22	0.44	181.
Shacklefords, Harrison county, Indiana	10.25	1.13	1.95	2.00	46.65	0.50	36.55	0.14	......	0.25	0.58	468.
Somerset, Wabash county, Indiana	30.60	......	2.48	16.72	14.33	6.05	17.93	......	......	1.00	10.88	130.
Vassy, France	14.00	......	11.60	5.70	35.72	0.71	28.87	......	......	......	3.40	383.
Western Cement Company, Utica, Illinois	27.60	......	0.80	10.60	33.04	9.26	2.70	2.40	7.42	1.20	4.98	191.
Roman Cement Stone	16.89	......	8.67	4.71	37.52	1.16	30.35	......	......	......	....	257.

* A trace.

There is a very wide difference noticeable in the relation of the silicic acid and the earth bases with which it combines; lime, magnesia, and alumina. I mention only these earths since they alone are serviceable in connection with the silicic acid to form a good hydraulic mortar. If these substances are present in combining proportions, the ratio of silicic acid to bases may be 100 of the former to 366 of the latter. If lime and magnesia form the base, the ratio should be about 100 to 277. If lime alone constitutes the base, the silicic acid should be 100 to 200; and when of lime and alumina 100 to 398. When foreign substances are present, which we find always to be the case, then these ratios will of course have to be varied.

Take for example the cement made in Clarke county, Ind., and sold in the market as Louisville cement, calculated for 100 parts of effective substances, or silicic acid, lime and alumina, and leaving out the other constituents, will be:

Silicic acid	20.89
Alumina	32.10
Lime*	47.01
	100.00

The ratio of silicic acid to bases is 100 to 337, which falls but little short of the true combining ratio for silicate of alumina and lime, 398.

The English-Portland cement, calculated for 100 parts of active constituents, contains:

Silicic acid	31.43
Alumina	10.80
Lime and magnesia	57.77
	100.00

Ratio of silicic acid to bases, 100 to 218.

*This also includes the small quantity of magnesia which the cement contains.

The true combining ratio lies between that of the silicates of lime and alumina, as in the case of the Louisville cement. To form a silicate of lime and alumina, the proportion of each substance is:

Silicic acid	20.00
Lime	41.40
Alumina	38.60

It appears from actual tests, that while the Louisville cement makes a strong and durable concrete, comparing favorably with any other American cement, it will not make as strong and hard hydraulic stone as the English-Portland cement. To render it equal to the latter cement, to every 100 pounds of the former should be added 100 pounds of silicic acid, calcined with 100 pounds of carbonate of lime. This would add about ten per cent. to the silicic acid, ten per cent. to the lime, and reduce the alumina twenty per cent.

The large consumption of English-Portland cement in the United States renders it a matter of very great importance that we should be able to manufacture a cement that will take its place and prove its equal in every respect. For sub-aqueous masonry ordinary mortar is worthless; when placed under water it becomes gradually softened and disintegrated from the loss of lime, which is gradually dissolved away. The hydraulic cements, on the other hand, possess the valuable property of hardening under water. Cements of this kind have long been known to the world. At Puzzuoli, near Naples, a porous volcanic substance is found called Puzzuolano, which forms an excellent hydraulic cement when powdered and mixed with lime. It was employed by the Romans in many buildings, which are still in good preservation, having resisted the ravages of time more perfectly than the bricks it was used to cement. Vicat, one of the first to manufacture hydraulic cement on sound principles, used four parts of chalk (carbonate of lime) ground and levigated in water with one part of clay; when allowed to subside, is moulded into blocks, dried and calcined at a carefully regulated heat. The calcined blocks are then ground to a fine powder.

Portland (English) cement is also artificially prepared from clay, obtained from the valley of Medway, and chalk. The name is derived from the circumstance that when dry it resembles the Portland stone in color. In the preparation the clay and chalk are ground with water, the mixture is allowed to subside, then dried and burnt until slightly vitrified. The calcined material is again ground, and the resulting powder, when mixed with a proper proportion of water, forms a mortar that will harden under water into a strong and durable stone.

The rapidity with which hydraulic cement sets varies according to its composition. It is stated that if clay (clay is rather an indefinite term, since it may contain a large or small quantity of silica) does not exceed ten or twelve per cent. of the weight of the original limestone the mortar requires several weeks to harden; if the clay amounts to fifteen to twenty-five per cent. it sets in two or three days, and if twenty-five to thirty-five per cent. of clay be present it will solidify in a few hours.

Roman cement is prepared from nodules of septaria, which are found in the valley of the Thames. Cement made from these nodules will set in a few hours. The composition of these nodules, according to Meyer's analysis, is:

ROMAN CEMENT.

Soluble in acid 76.000	Carbonate of lime	66.990
	Carbonate of magnesia	1.670
	Carbonate of iron	6.950
	Alumina	0.390
Insoluble in acid 23.305	Silica	16 890
	Alumina	4.320
	Oxide of iron	1.720
	Lime	0.005
	Magnesia	0.370
		99.305

Bologne cement is made of similar material obtained in the neighborhood of Bologne, and has an almost identical composition.

I have in previous reports called attention to the occurrence of large beds of fresh-water chalk—carbonate of lime—found on the borders of many of the small lakes in Fulton, Kosciusko, Steuben and Noble counties, in the northern part of the State. This chalk exists in the form of a fine powder, which is almost a pure carbonate of lime. The composition of a sample taken from the farm of G. W. Slocum, on Sec. 30, T. 37, R. 13, in Steuben county, Ind., is:

Moisture expelled at 212°	8.00
Insoluble silicates	0.30
Alumina with trace of iron	1.50
Lime	45.36
Magnesia	3.42
Carbonic acid	41.50
Sulphuric acid	0.10
Phosphoric acid	0.38
	100.56

I am satisfied that a superior quality of hydraulic cement can be made by intimately mixing 100 parts of this chalk with 30 parts of clay that contains but little alumina, grind them together in water, form the sediment into cakes, dry and calcine as in the process of making Portland cement.

The economy of using this chalk over the common limestone, is the facility with which it my be reduced to powder and mixed with the clay before burning.

One of the largest deposits of this chalk in the State is at Rome City, in Noble county, but it may be had in any desirable quantity at many other localities in the above-named counties.

BUILDING STONE.

The preparation for building a State House has awakened a deep interest in the subject of building stone, from the fact that the structure will require nearly a million cubic feet of stone, and that no State in the Union can boast of more extended quarries of this essential mineral.

The beds of heavy, close-grained, compact, magnesian limestone, so extensively quarried on Flat Rock creek, near St. Paul, and by the Greensburg Stone Company, on Sand creek, near Greensburg, Decatur county, the blue limestone at North Vernon and Deputy, and other localities in Jennings and Jefferson counties, have long held an enviable reputation for massive masonry, such as foundations for public buildings, bridge abutments, etc., etc., where great strength and durability are essential elements. The Deputy and North Vernon building stone is blueish gray, commonly called blue, moderately close-grained, slightly conchoidal fracture, and lies in seams from one to two feet thick. The total exposure of the "North Vernon Blue Stone" is from twenty-five to thirty-three feet thick, and the bed covers an extended area in Jennings and Jefferson counties. It occupies a position almost immediately under the "Black Shale" and in the Hamilton division of the Devonian. Of the entire exposure only two or three layers are considered of first quality, and as we follow the crop to the south and southwest the character of the stone is materially changed, being charged with a large percentage of clay, which gives the stone hydraulic properties and supplies the material for the manufacture of the "Louisville Hydraulic Cement," so long and favorably known as a cement for submarine masonry, and to which allusion has already been made.

The analysis of the so-called "North Vernon Blue Stone" shows it to be almost a pure carbonate of lime. The tests for strength made by General Q. A. Gilmore, for the

State House Commissioners, indicates that it requires 15,750 pounds to the square inch to crush it. A cubic foot will weigh 165.43 pounds, and the ratio of absorption is 1 to 156; that is, a cubic foot will absorb less than a pint of water.

The specimen used in this test was furnished by F. H. Wrape & Co., of Deputy.

ANALYSIS OF WRAPE & CO.'S BUILDING STONE, DEPUTY, JEFFERSON COUNTY, INDIANA.

	Per Cent.
Water, dried at 212° F	0.85
Insoluble silicates	1.75
Ferric oxide	1.00
Alumina	2.20
Lime	50.06
Magnesia	0.85
Carbonic acid	40.27
Sulphuric acid	1.21
Chloride of alkalies	trace
Organic matter and loss	1.81
	100.00

The carbonate of lime in the above equals 89.4 per cent.

This is a homogeneous stone, and hard and difficult to work for a free stone.

The building stone sold in the market as Greensburg or Flat Rock stone belongs to a geological age known as the Niagara, which, in this State, immediately underlies the Hamilton.

At North Vernon we can see the two formations in conjunction, but at the latter locality the Niagara beds are of a deeper buff color, and too porous to be used for building material. In Dearborn county, in the vicinity of Greensburg on Sand Creek, and St. Paul on Flat Rock creek and some of its tributaries, the Niagara beds furnish a light gray, close-grained, magnesian limestone that is of very uniform structure and is strong and durable. The crop is from twenty to thirty feet thick, composed of a number of layers from four inches to two feet thick. Flagging may be obtained of this stone in flags fifty by two hundred feet, and four, six or seven inches thick, and without break or flaw, that will not vary one inch in thickness over the entire surface. Stone twenty-two inches thick may be had in like dimensions and evenly bedded, if it were possible to handle such masses.

The chemical composition of this stone is shown by the following analysis of samples taken from the Greensburg Stone Company's quarries, and from Eck & Son's quarry at St. Paul.

GREENSBURG STONE COMPANY.

According to General Gilmore, a cubic foot will weigh 169.98 pounds; crushing strength of a cubic inch, 16875 pounds; ratio of absorption, 1 to 117.

ANALYSIS.

	Per Cent.
Moisture dried at 212° F	0.85
Insoluble silicates	5.90
Ferric oxide	2.50
Alumina	3.70
Lime*	41.55
Magnesia	4.93
Sulphuric acid	0.90
Carbonic acid	38.07
Chloride of alkalies	1.60
	100.00

W. W. LOWE'S STONE, ON FLAT ROCK CREEK, NEAR ST. PAUL, DECATUR COUNTY.

Whitish gray, close-grained.

According to General Gilmore, one cubic foot will weigh 168.09 pounds; crushing strength of a cubic inch, 16000 pounds; ratio of absorption, 1 to 336.

* Equal 74.2 per cent. carbonate of lime.

ANALYSIS.

	Per Cent.
Water, dried at 212° F	0.60
Insoluble silicates	5.10
Ferric oxide	1.00
Alumina	2.40
Lime	46.42
Magnesia	3.00
Carbonic acid	39.78
Sulphuric acid	0.80
Chloride of alkalies	0.50
Loss and undetermined	0.40
	100.00

Lime 46.42 equals carbonate of lime 82.71.

SCANLAN'S STONE, ST. PAUL, ON FLAT ROCK CREEK, DECATUR COUNTY.

Whitish gray, close-grained.

ANALYSIS.

	Per Cent.
Moisture dried at 212° F	1.20
Insoluble silicates	5.30
Ferric oxide	1.20
Alumina	1.30
Lime	46.48
Magnesia	3.00
Carbonic acid	39.82
Sulphuric acid	1.00
Chloride of alkalies	1.40
	100.00

Lime 46.48 equals carbonate of lime 83.00.

The three last stones are magnesian limestones, and, chemically tested, there is but little difference, and they represent a large class of building stones, not only in Indiana, but in the adjoining states of Ohio and Illinois, such as the Dayton stone of the former and the Joliet and Lamont of the latter. Perhaps no building stones in the west have been more thoroughly tested or are better known to the architects and builders. Being more costly to dress than the oolitic limestones, it has been chiefly used in this State for foundations and bridge abutments, for which purpose it is admirably adapted. In Chicago the Lamont stone has not only been used for basements, but in the form of facings forms one of the chief building materials. As shown by the following analysis, made from a sample which I obtained from a stone to be used in the Cook county, Ill., court house, it is less homogeneous than the Indiana magnesian stones, and contains a far greater per cent. of clay, magnesia and alkalies.

ANALYSIS OF LAMONT STONE.

	Per Cent.
Water, dried at 212° F	0.85
Silica	15.90
Ferric oxide	2.30
Alumina	7.00
Lime	25.65
Magnesia	9.94
Carbonic acid	31.08
Sulphuric acid	0.38
Chloride of alkalies	2.85
Combined water and loss	4.05
	100.00

Lime 25.65 equals carbonate of lime 45.80; magnesia 9.94 equals carbonate of magnesia 20.87.

In large cities, where bituminous coals are used, the atmosphere becomes charged with sulphurous acid gas, and this is changed to sulphuric acid, which exerts a very marked action upon magnesian stones by converting the carbonate into sulphate of magnesia (Epsom salts) which is readily soluble in water, and is washed out by the rains to stain, disfigure, and finally destroy the cohesion of the stone.

Magnesian limestones are of very variable composition as regards the clay, carbonate of lime and carbonate of magnesia, which enter into their composition.

Magnesian limestone covers an extensive area in the northeastern part of England, and was used in the construction of York Minster and the Houses of Parliament in London, which are among the finest architectural works in the country. In remote places, where the atmosphere is free from the sulphurous effusions derived from the extensive consumption of coal, the stone appears to be durable, but under the influence of the atmosphere of London its destruction was so rapid in the Houses of Parliament that it has become necessary to coat the surface, from time to time, with a coat of silicate of soda to stop the decay. According tô Henry Law, "Civil Engineering, Weales' Series," the average weight of a cubic foot of the magnesian limestone employed in the construction of the Houses of Parliament is 144 pounds. Weight in pounds required to crush a cubic inch, 5,219 pounds; this multiplied by 144 will give the weight that will crush a square foot, 751,536, and this divided by eight will give the practical weight which a square foot of this stone is able to support.

In estimating the crushing weight of the stones tested for the State House Commissioners, by General Q. A. Gilmore, they will all be found greatly in excess of what is required; but in this connection it must be remembered that these results are for the ultimate crushing of the stone, while many will commence to yield to somewhat less than half the weight required for their total destruction.

We come now to consider a class of building stones that belong to the sub-carboniferous age. The quarries that have been worked for supplying the general market in this geological formation, with one exception, furnish almost a pure limestone. The most noted building stone here is supplied from strata that are supposed to be the equivalent of the rocks which crop at St. Louis, Missouri, and are called St. Louis limestone in the geological reports of Illinois. The crop of this stone may be followed from Montgomery county on the north, to Harrison county on the south. The workable beds are from ten to upwards of one hundred feet thick. The color ranges from grayish white and bluish gray to chalk white. The structure is oolitic, so named from its resemblance to the roe of a fish (egg-stone.) These segregated particles are sometimes so small that it is difficult to recognize them with the naked eye; at other times they are so large as to be quite conspicuous. It may be quarried in blocks of any thickness and size. At Matthews & Son's quarry I saw blocks cut out by the steam "channeler," six and a half by nine and a half and forty-two feet long. At the Chicago & Bedford Stone Company's quarry, at Bedford, Indiana, a block of the same width and thickness was sixty-six feet long, cut out by a channeling machine. At most of the localities where this stone is quarried, blocks of much greater length, thickness and width can be obtained if required, and Cleopatra's needle might be duplicated, should a market be opened for monoliths of that character.

A number of tests of this stone were made by General Gilmore, for the State House Commissioners, to determine its resistance to crushing, density and ratio of absorption.

A specimen of oolitic limestone from Simpson & Archer's quarry, four miles east of Spencer, on the Indianapolis & Vincennes railroad, gave the following result:

A cubic foot weighs 140.03 pounds, and it required 7,500 pounds to crush a cubic inch; ratio of absorption, 1 to 30.

ANALYSIS OF SIMPSON & ARCHER'S STONE.

	Per Cent.
Water at 212° F.	0.41
Insoluble silicates	0.70
Ferric oxide and alumina	0.91
Lime	54.20
Magnesia	0.11
Carbonic acid	42.64
Sulphuric acid	0.20
Chloride of alkalies	0.32
Combined water and loss	0.51
Lime, 54.20 equals carbonate of lime 96.80.	100.00

A sample of stone from the quarry of Dunn & Company, near Bloomington, Ind., gave for crushing strength per square inch 13,750 pounds; weight of a cubic foot, 137.24 pounds; ratio of absorption, 1 to 43.

ANALYSIS OF DUNN & COMPANY'S STONE.

	Per Cent.
Water, dried at 212° F.	0.25
Insoluble silica	0.65
Ferric oxide and alumina	1.00
Lime	53.50
Magnesia	0.19
Carbonic acid	42.20
Sulphuric acid	0.40
Chloride of alkalies	0.55
Combined water and loss	1.26
	100.00

Lime 53.50 equals carbonate of lime 95.54.

Sample of stone from Chicago & Bedford Stone Company's quarry, Bedford, Indiana, gave crushing strength 11,750 pounds; weight of cubic foot, 146.56 pounds; ratio of absorption, 1 to 28.

ANALYSIS OF CHICAGO & BEDFORD STONE COMPANY'S STONE.

	Per Cent.
Water, dried at 212° F.	0.35
Insoluble silicates	0.50
Ferric oxide and alumina	0.98
Lime	54.10
Magnesia	0.13
Carbonic acid	42.62
Sulphuric acid	0.31
Chloride of alkalies	0.40
Combined water and loss	0.61
	100.00

Lime 54.10 equals carbonate of lime 96.60.

A sample of stone from S. M. Stockslager's quarry, Harrison county, Indiana, gave crushing strength, 10,250; a cubic foot weighs 149.59 pounds; ratio of absorption, 1 to 27.

ANALYSIS OF STOCKSLAGER'S STONE.

	Per Cent.
Water, dried at 212° F	0.50
Insoluble silicates	0.31
Ferric oxide	0.18
Alumina	0.14
Lime	54.93
Magnesia	none
Carbonic acid	43.17
Sulphuric acid	0.25
Chloride of alkalies	0.40
Combined water and loss	0.12
	100.00

Lime 54.93 equals carbonate of lime 98.10.

This is a chalk-white stone, soft when first taken from the quarry, but hardens with age.

Specimens from Matthews & Son's oolitic limestone, Ellettsville, Monroe county, Indiana, show a crushing strength of 13,500 pounds; a cubic foot weighs 142.23 pounds; ratio of absorption, 1 to 28.

Perry Brothers' oolitic limestone, Ellettsville; crushing strength, 12,628 pounds to the square inch; a cubic foot weighs 152.39 pounds; ratio of absorption, 1 to 41.

Dunn & Company, of Bedford, Indiana, oolitic stone; crushing strength, 6,500 pounds; weight of a cubic foot, 147.03 pounds; ratio of absorption, 1 to 24.

John Glover, Bedford, Indiana, oolitic limestone; crushing strength, 10,125 pounds; weight of a cubic foot, 152.39 pounds; ratio of absorption, 1 to 32.

Hege & Jackson, near Spencer, Indiana, oolitic limestone; crushing strength per cubic inch, 8,750 pounds; weight of one cubic foot, 145.16 pounds; ratio of absorption, 1 to 23.

E. Zink & Son, Salem, Indiana, oolitic limestone; crushing strength per square inch, 8,625 pounds; weight of one cubic foot, 144.28 pounds; ratio of absorption, 1 to 22.

Dunn & Company, Dark Hollow, Bedford, Indiana, oolitic limestone; crushing strength per square inch, 6,750 pounds; weight of one cubic foot, 140.3 pounds; ratio of absorption, 1 to 18.

The chemical composition of the Indiana oolitic limestones is remarkably uniform throughout the State; it is almost a pure carbonate of lime; its average density may be put at 150 pounds per cubic foot, and the ratio of absorption at 1 to 30.

Examined along the crop this stone shows a wonderful resistance to weathering, and presents a bold and well defined face along the valleys. As a durable building stone it has withstood the ravages of time in buildings for upwards of fifty years and still retains the hammer and chisel marks almost as sharp as when first cut. The density as shown above exceeds that of the celebrated English Portland oolite. It likewise possesses greater strength. The ratio of absorption of the English stone is 1 to 20, while the Indiana stone is 1 to 30. The reliable sustaining weight of a square foot of English Portland stone is 82,000 pounds, while that of the Indiana stone is not less than 135,000 pounds to the square foot. For the purpose of showing the weight which building material may have to support, I will state that the piers that support the dome of St. Paul, London, sustain a weight of 39,000 pounds to the square foot, and the piers at St. Peters, Rome, support a weight of 33,000 pounds to the square foot.

At Putnamville, in Putnam county, Mr. James E. Lee has a quarry of close-grained, hard, silicious limestone, which is strong and durable. The face exhibits twelve layers, ranging from five to twenty-two inches in thickness. General Gilmore found the crushing strength to be 11,750 pounds to the square inch; weight of a cubic foot 166.36 pounds, and ratio of absorption 1 to 170.

ANALYSIS OF PUTNAMVILLE STONE.

	Per cent.
Water, dried at 212° F	0.30
Insoluble silicates	27.50
Ferric oxide	2.00
Alumina	1.70
Lime	35.23
Magnesia	0.33
Carbonic acid	28.03
Sulphuric acid	2.60
Chloride of alkalies	0.75
Undetermined and loss	1.56
	100.00

The small amount of water which this stone absorbs is much in its favor. It differs from the oolitic limestone in carrying a large per cent. of silica, and in its greater density.

There are other excellent building stones in the State, of which mention is not made in this connection; some having received attention in former reports, and others are reserved for future investigation and notice.

GLACIAL DRIFT.

No phenomena encountered in the study of geological history has proven more perplexing to students than those which brought about the destruction of vast beds of rock, and left their fragmentary remains scattered over immense areas of country far from their native locality. Various theories have been, from time to time, propounded to reconcile observed facts with natural forces now in action. The most prominent of these are known as the Glacial theory, Iceberg theory, and water and atmospheric or denudation theory.

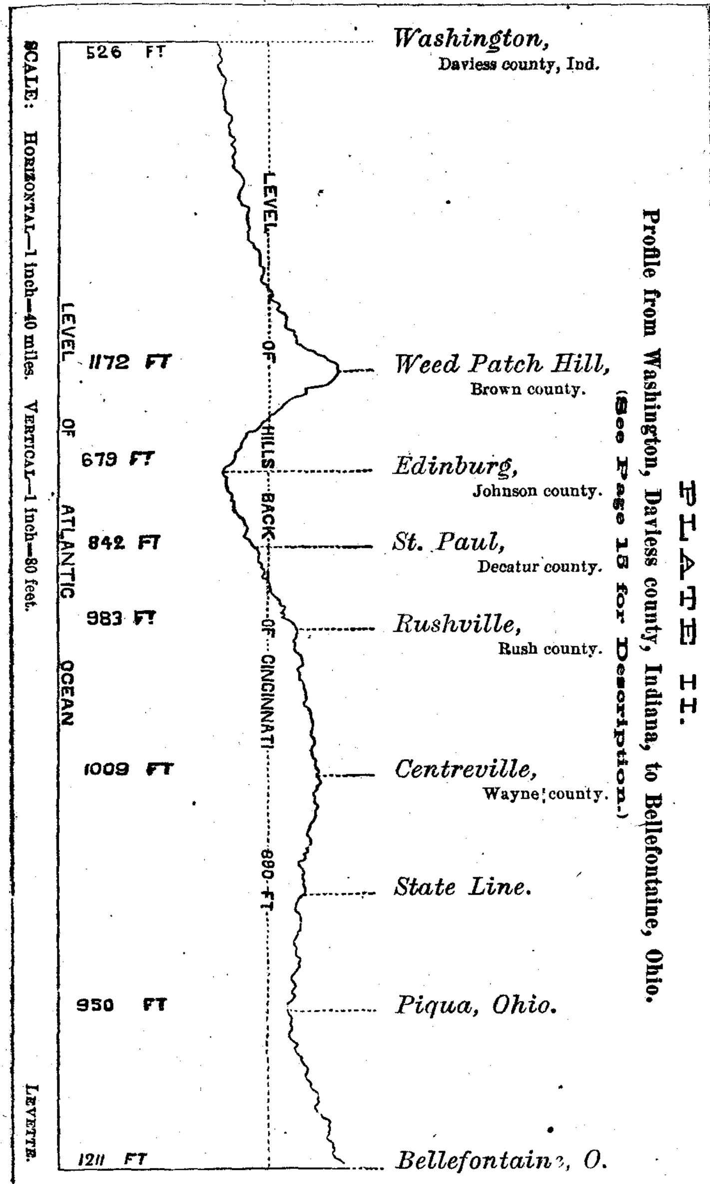


PLATE II.

Profile from Washington, Daviess county, Indiana, to Bellefontaine, Ohio.

(See Page 15 for Description.)

Every working geologist must admit the immense influence which the action of running water, aided by the corroding force of the air, has had in modifying the surface configuration of the land. Every drop of rain that falls upon elevated ground, over and above that which is absorbed by or permeates the strata, forces its way to a lower level, loaded with suspended and dissolved matter which it has removed from above to be deposited at lower levels. This force, continued over indefinite time, must of itself cut down mountain chains and leave plains in their stead, which are composed, in their upper part, of fragments of rock, gravel, clay, and sand, the debris of superior strata.

This leveling and transferring power of moving water exerts a very marked influence in modifying the configuration of continents and the ocean's bed. The sediment carried down by large rivers, like the Mississippi, and poured into the Gulf of Mexico, has pushed the shore lines many miles beyond its ancient boundary. The dashing of the waves of the ocean on other parts of the continent are wearing and forcing the shore line farther back, so that the contour of a continent is in this way perceptibly changed in a remarkable short time, when compared with most geological phenomena. As the relative proportion of land and water must ever remain the same, the mechanical action of water would alone, if uninterrupted by other forces of nature, depress continents and islands, and extend their surface area.

A proper regard must also be had for the active part which icebergs play in the transportation of rocks and sediment; but no matter with what ingenuity the advocates of these theories construct their arguments, they totally fail to satisfy the most casual observer of their adequacy to accomplish the work of building up the Drift deposit of Indiana, Illinois and Ohio.

The most visionary admirer of the force which running water exerts in moving forward, especially if the track be inclined, as a mountain valley, great masses of rock, and, by abrasion, round them into boulders, can not go so far as to believe that the crystalline and metamorphic boulders found over all parts of Indiana, from the northern to the southern limits, and in some places still further south, could have reached their present places of rest, hundreds of miles from their northern home, through the force exerted by currents of water, however great the flood. Nor can they be so unreasonable as to suppose for a moment that the fragments of crystalline and metamorphic rocks comprising the drift could have been derived from the cutting down of mountains that reared their granite crests far above the present plains. The geologist can here find no fractures or dykes through which eruptive rocks could be forced to overtop the palæozoic beds.

Again, to admit that these erratic masses were distributed by icebergs is to suppose that the drift was formed under the waters of the ocean, in which event we should be able to find in some parts of the formation the remains of marine organisms. No such discovery has yet been made, and there is but little to encourage the search. The remains so far discovered in the drift are trunks and limbs of trees and the bones of animals that lived upon the land.

Turning now to glaciation, we find it all-sufficient to account for the moving of rocks, as well as finer debris, from one region of country to another, and scatter them over lands far distant from their parent beds, and this without calling to our aid any causes not seen in action on existing glaciers. It is not necessary to bring to our assistance as a means to account for the frigidity of the glacial epoch the unnatural problem of a change in the polar axis of the earth. Rather let us conclude that it was due to the then relative position of land and water, and a change in the deflection of the warm currents of water that flow from the equatorial region to the northward. A change in the course of the Gulf Stream would materially alter the meteorological conditions of Great Britain, and the present mild climate of California and Oregon is greatly due to warm currents that flow north along the eastern shores of Asia being deflected in their direction. A change, then, in the direction of these currents of warm water, and the elevation of the mountain chains of Laurentian and Huronian rocks in British America until their crests were clothed in perpetual snow and ice, would be all that is needed to usher in the glacial period. An upward movement of the northern part of the American continent had, in my opinion, been in progress, with possibly some intermission, since the close of the coal epoch. Up to glacial times the great lakes were a part of the ocean, but, cut off by the rise of the land, and having an outlet but no influx from the ocean, the immense drainage of fresh water and small amount of evaporation in time deprived them of salinity. All marine life that could not adapt itself to this change sought the way out or perished. The late Dr. William Stimpson found a species of marine crustacea, *Mysis*, in deep dredgings in Lake Michigan, and similar discoveries of marine forms of life have been found in fresh water lakes in Europe, which point to their ocean parentage.

Then, again, I do not believe that it is possible for glaciers to make erosions to so great a depth as the beds of some of these lakes, and to the extent required by their area, nor is such a history demanded for a solution of the problem of their existence.

I can see no evidence of a subsidence of the land to terminate the glacial period, nor can we find in Ohio, Indiana or Illinois anything to militate against the commencement of the glacial period dating back to tertiary times, and continued until brought to a close by its own erosive force, aided by atmospheric and meteorological influences. By these combined agencies, acting through time, the mountain home of the glacier was cut down, and a general leveling of the land took place all along its course.

The glacial period was the result of high elevations in the northern regions, and its force was expended in eroding and cutting down, and in removing mineral matter from a higher to a lower level. This grinding and equalizing work of the glaciers was bound in time to effect a material change in the topography and in the meteorological condition of the continent; not only were elevated mountain peaks worn down and the general leveling of the land brought about, but vast quantities of mud and sand were carried forward by the streams of water which flowed beneath the glaciers, and these streams, swelled during the summer time to floods by the melting of the ice, would carry the sediment forward until deposited in the ocean. In this way the shores of the continent were pushed from year to year, and from century to century, and the superficial area of the land would in this way be materially augmented.

The changes to be wrought in the physiognomy of a continent by the combined glacier, atmospheric decomposition, and running water, are marvelous; but so slow do they appear to act, when measured by man's brief opportunity to observe, that we are prone to under-estimate their value, and seek for some grand power to lift up or dash down the earth's crust at all times, and in just such manner as may be satisfactory to the mind of the cataclysmic philosopher.

The configuration of the earth's surface in North America, as well as its climatic laws, gave direction to the glaciers and caused them to move from the north in a southerly course. There are some exceptions to this general bearing of the ice-flow, but they do not militate against the above generalization and may be referred to local causes, such as influence the course of the tributaries that flow into the valley of the Mississippi River. Though they move in various directions, all bend to the southward and are but feeders to the great river which flows from north to south, and forms the principal outlet for the drainage of a vast portion of the continent. Again, it is evident to me that the main channels of drainage were formed by glaciation; but, in many respects, they have been subsequently modified by atmospheric erosion and the abrading force of running water.

The valley of the Ohio River was the southern terminus of the glacier, and its channel was formed by the melting of the ice, and the flow of water which always underlies the ice-bed. As the glacier became less and less powerful, by the dying out of the cause which created and sustained it, the terminal margin withdrew to the north; and where-ever there remained undestroyed rock barriers or dams, they gave direction to the waters of the terminal moraines. The course of the Wabash river and its principal tributaries, East and West Forks of White river, as well as the Ohio, owe their main direction to this cause. The undestroyed rock barriers which crop in Adams, Wells, Huntington, Union, and Cass counties, in the northern part of Indiana, turned the waters from the glacial moraine in a course a little south of west nearly across the State. The barrier being more completely removed in Tippecanoe county, the direction trends more to the south until, in Fountain and Warren counties, a more formidable barrier of massive, pebbly sandstone, belonging to the Millstone Grit epoch, which has a north and south trend, turned the river channel from thence to its confluence with the Ohio almost directly south.

It is not my purpose to go into great detail in tracing out the effects of glaciation in modifying the topography of

Indiana and determining its system of drainage, but to throw out these general views on phenomena which elicit so much general interest among the uninformed as well as those who are skilled in geological lore.

While in operation, the glacier was capable of cutingt down mountains and strewing their fragments over its track. It tore up ledges of gold and copper bearing rocks from the Archæan and the Laurentian and Huronian beds, ground them into dust, that was carried forward to the moraines where the glacier terminated. In like manner it transported fragments of palæolozic rocks and fossils, coal from the carboniferous beds of Michigan, trunks and limbs of trees that grew along its shores, and left them in strange places and in inharmonious order in so far as relates to the sequence of the respective objects in geological time.

The large boulders found in all parts of Indiana are mostly granitoid rocks belonging to beds that are nowhere represented in the State, and must have come from beyond her borders.

The greatest deposits of these erratic rocks are to be found in the northern part of the State, but they are not uncommon in all the counties bordering on the Ohio river. In Dearborn and Ohio counties in the southeastern corner, and Gibson county in the southwestern part of the State, there are a great many notable granite boulders. In the latter county the drift material has a variable depth of ten to twenty-five feet or more, mostly sand, clay and small pebbles; but near the line of Posey county, and in what is called the Barrens, there are a number of very large granite boulders, which attracted the attention of William Maclure, one of the very earliest geological explorers in this country, us well as that of his associates and co-laborers in science, Thomas Say and C. A. LeSueur. These able observers made a trip from their home in New Harmony to this locality as early as 1828, in order to study the character of the phenomena. They lie on a level, sandy plain, and there is no crop of any kind of rock for miles around. About fifty miles almost due west of this locality, in Illinois, I found a number of granitic boulders, one of which I estimated to weigh ten to fifteen tons. I also saw a few boulders in Gallatin county, in the same State, by the roadside, going from Shawneetown to Equality. There is a single granite boulder that will weigh several hundred weight lying on the hillside just above the town of Carrsville, in Livingston county, Kentucky, about latitude 37.2. This is the most southerly point I have been able to find granite boulders above reach of river currents.

The most remarkable prolongation of glacial drift southward is seen in Dearborn and Ohio counties, Indiana, and Boone county, Kentucky. In the two first named counties the drift is found in greatest force along the hillsides bordering Laughery creek, resting upon the bluish clay shale beds of the Hudson River group, and one hundred and fifty feet above the bed of the stream. The entire drift deposit is fully fifty feet thick, and is made up of the usual material, stratified clays, sand and gravel, above which there are numbers of massive granitoid boulders. One of these boulders I estimated to contain over one hundred cubic feet.

The lower bed of sand and gravel which rests upon the silurian bluish clay shale contains a portion of gold dust, and gold washing has been carried on here in a small way for some years. When I visited this locality—which is on land once owned by William Gerard, Sr., but now owned by W. H. and J. B. Miller, and situated about one mile a little north of west from Hartford—there was to be seen the ruins of what had been extensive preparations for washing this gold sand in sluice-boxes, but the scheme had fallen through for want of funds and the confidence of those who had at best lent it but a feeble financial support.

Dr. George Sutton, who accompanied me from Aurora, and to whom I am indebted for very many favors, the Hon. Freeman, Dr. J. B. Gerard and several other gentlemen of Hartford, were with me at the time of this examination. While I felt confident that the locality had furnished some gold as represented by the statement of the workmen who were engaged in prospecting, to set all doubts aside, we went to Mr. Miller's house, close by, and had him bring his spade and a tin pan, and try to wash out some gold in our presence. After scraping off a small portion of the surface, a spade full of gravel and sand was thrown into an old pan with coarse holes in the bottom, and the fine material that would pass through the holes was sifted out into the washing-pan. In a few moments Mr. Miller succeeded in separating some particles of gold mixed with a quantity of black, magnetic sand. There is no means of getting water to this place in sufficient quantity and at reasonable cost, but if hydraulic washing could be resorted to it is possible that considerable gold might be washed out. It is not my object, however, in saying this much of the drift gold in the vicinity of Hartford, to excite capitalists to take hold of the property with a view of profitable mining, but to call attention to the fact that gold is found there, and as one of the evidences that the whole deposit has been brought from ancient rock-beds that are not found in places south of the great lakes, and that it is veritable glacial drift. This is not the only spot where gold has been found on this creek. I am told that it has been washed out of the sands on the opposite side of Laughery creek, in Dearborn county, on the farm of Preston Conway. These are important facts, and serve to prepare the minds of those geologists who doubt the extension of glacial drift south of the Ohio river, for the account of its discovery by George Sutton, M. D., in great force in Boone county, Kentucky.

At the Buffalo meeting of the American Association for the Advancement of Science, 1876, Dr. George Sutton, of Aurora, Indiana, read a paper on "Glacial or Ice Deposits in Boone county, Kentucky, of two distinct and widely distant periods."

Dr. Sutton called the attention of the late Dr. John Locke to this drift, and he published an account of it in the *Cincinnati Gazette* in the year 1845. The drift in question is found at two localities and at two elevations—one about seven miles, and nearly east of Hartford, the other from ten to twelve miles and a little south of east. Dr. Sutton is an intelligent observer, whose views are worthy of careful consideration, and I have therefore taken the liberty to reprint this very able paper.

GLACIAL OR ICE DEPOSITS IN BOONE COUNTY, KENTUCKY, OF TWO DISTINCT AND WIDELY DISTANT PERIODS.

[By George Sutton, M. D., of Indiana.]

Upon the most elevated portion of the table-land in Boone county, Kentucky, at an elevation of between 450 and 500 feet above high-water mark of the Ohio river, or about 1,000 feet above the ocean, may be seen extensive accumulations of drift. This drift, in some places, is cemented into firm conglomerate, and caps the highest hills on the north side of Middle creek, and also on each side of Rattling run—a small stream entering Middle creek—presenting perpendicular cliffs, varying from thirty to forty feet in height, making a marked contrast to the general appearance of this section of country, and affording a fine subject for investigation and speculation to the geologist.

Near the mouth of Wolper creek, between five and six miles northwest of this formation, may be seen another deposit of drift, also cemented into conglomerate, which overhangs the creek with perpendicular bluffs. This formation is more than 100 feet in thickness above high-water mark, but between 300 and 400 feet below the deposit of conglomerate on the highlands above Middle creek. The two deposits have received but little attention from geologists. No mention is made of them in the geological reports of Kentucky, and the only notice that I have seen published of the deposits on the highlands above Middle creek, is a brief description by Prof. John Locke in the *Cincinnati Gazette*, in the year 1845. Mr. Robert B. Warder, in the Geological Report of Indiana for 1872, merely directs attention to Split-Rock, opposite the mouth of Laughery creek, as possibly being the terminal moraine of an ancient glacier. Prof. Locke regarded this conglomerate as the evidence of the destruction of a great arch of rocks which united the coal-fields of Ohio with those of Indiana and Kentucky. He says: "The question arises, did this mountain arch ever exist in fact at the place of our city, or, in other words, were the bent layers which are cut off both to the east and to the west, ever complete and continuous? I am of opinion that these layers were continuous, and that causes difficult to be ascertained have swept the upraised layers away, leaving a level country, the surface of which cuts the layers of rocks obliquely and in reverse order both east and west of us." * * * * "What has become of the ruins of these removed layers? I am decidedly of opinion that the conglomerate of Split-Rock exhibits a portion of them, for there we have the layers of blue limestone with its millions of characteristic fossils, forced up, piled chaotically together, and re-cemented in the fantastic heaps in which it was piled by the whirlpools."

We direct attention to these two drift formations, presenting evidence not of the destruction of a great arch of rocks which possibly at one time united the coal-fields of Ohio with those of Indiana, but of the transporting power of ice either by glacial or river action at what appears to me to be two distinct and widely distant periods; both, however, since the formation of the great drainage lines across the continent. The deposits of the one period must have been made prior to the formation of the present Ohio Valley; the other after the river had cut down its channel to nearly its present depth.

It is well known that the surface of the country over all this portion of the *Lower Silurian* formation, was once nearly level, or only slightly undulating, and that the Ohio river and small streams have cut their channels through this table-land to the depth of from 400 to 500 feet.

The altitude above the ocean at the Ohio and Mississippi railroad depot at Aurora is 492 feet. The depot is about ten feet above the high-water mark of the Ohio river, and a few miles to the north of the conglomerate in Kentucky.

The table-land at Milan, about ten miles to the west of Aurora, is 506 feet 10 inches higher, making the highest portion of the country about 1,000 feet above the ocean, and showing the depth of the valleys to be between 400 and 500 feet. The table-land in Kentucky, above Middle creek, is probably the most elevated of any throughout this section of country.

The conglomerate upon the most elevated portion of the table-land may be seen in a retired part of the country about two miles and a half from the mouth of Wolper creek; from this point it may be traced across the country in a southeasterly direction, following the trend of the river hills to Middle creek, where it attains its greatest thickness, varying from 30 to near 100 feet, and at an elevation of about 500 feet above high-water mark in the Ohio river.

On the south side of Middle creek we again find this formation upon the highest portions of the country. It may be traced capping the hills in a southeasterly direction, giving a reddish appearance to the soil, but presenting here more the appearance of uncemented drift, than on the north side of Middle creek. It caps the hills, apparently, along the line of ancient drainage, evidently having been deposited before the river and small streams had worn out their present valleys. But little of this drift is found in the valley of Middle creek; occasionally, on the hill-sides, a piece of conglomerate may be seen that has rolled down from its more elevated position.

The composition of this conglomerate and drift presents a great variety of formations, the silurian, however, predominating. The angles of the fragments are rounded, and every fragment bears the most conclusive evidence of being water-worn. No evidence of stratification can be seen in the perpendicular cliffs; small pebbles and large angular boulders may be seen mingled in confusion and so firmly cemented together that it is difficult, in some places, to break fragments from the main mass.

The conglomerate at the mouth of Wolper creek is about five miles northwest of that seen on the highlands above Middle creek; it presents perpendicular cliffs, and is more than 100 feet in thickness. The perpendicular height in one place that I measured was 73 feet. Above this cliff there was a rise of 20 feet to the highest point, and it probably extended many feet below the soil and rubbish at the bottom, making the deposit at this place at least 100 feet in thickness. Above the mouth of Wolper creek a large mass of this conglomerate has been undermined by the river, and slid off from the main body, making a narrow chasm of several hundred feet in length, and from five to six feet in breadth; this point is known as *Split-Rock.* On one side of this chasm we measured a perpendicular height of 72 feet, and above this conglomerate there is at least 20 feet more of drift and soil. How much below the rubbish at the bottom of this chasm the conglomerate extends, we do not know, but it is below high-water mark.

The conglomerate, like that on the highlands, is composed of a great variety of formations; fragments varying from the finest sand, to several hundred pounds in weight, intermingled in every state of confusion.

Large boulders of granite may be seen imbedded and cemented along the perpendicular wall 60 feet above high-water mark—showing that there must have been a transporting power much greater than water alone to have piled up these masses of stone to such an elevation. They show, also, that when this conglomerate was deposited, the Ohio river must have had a much greater volume of water than it has been known to have during our highest freshets within the last 80 years, or since the country has been settled.

This accumulation of conglomerate is between one and two miles in length, and in some places nearly a mile in breadth. It blends with a stratified and also an undulating terrace formation, which is six or seven miles in length along the river and in some places more than a mile in breadth.

When we stand upon the most elevated portion of the cliff overhanging the mouth of Wolper creek, and look over the undulating cultivated fields back to the river-hills which rise 300 feet above the terrace formation, and bear in mind that on the top of these hills is the conglomerate to which we first directed your attention, the conclusion seems to me to be irresistible that these two deposits of conglomerate were made at widely distant periods. The one dating back to a period *prior* to the formation of our valleys, the *other after* the river had cut down its channel 450 feet below this table-land. The antiquity of the one is seen most clearly where it caps the hills on each side of Middle creek, and, also, on each side of Rattling run, showing that the deposit of the one *must* have preceded that of the other by the length of time which it took to form the Ohio valley and the valleys of its tributaries.

Such, briefly, are some of the facts which may be seen by a visit to this section of country.

The question arises, how came this accumulation of drift at these points? When we look at the map of this part of the country, we see that the Great Miami, and the White Water rivers running from the north, empty into the Ohio valley near this point.

Here, also, we find that the river makes a sudden bend to the southeast, forming the western angle of the great *North Bend* in the Ohio river. A line drawn from the White Water and Miami valleys across this acute angle, intersects the conglomerate at Wolper creek. Along this line behind the hills to the east of Petersburgh, Kentucky, may be seen *an ancient valley* which the Ohio river has long since abandoned. This valley is between three and four miles in length, and from one-fourth to one-half a mile in breadth. It was evidently cut down through the strata of rocks, and shows that at one time here was an extensive island, not formed by the accumulation of drift or sediment, as most of the islands in the Ohio river now are, but an island made by the river eroding out two channels through the strata of the silurian formation. It is now above the highest floods of the Ohio river, is extremely fertile, and is cultivated throughout the whole length. Wells sunk in it pass through loam, sand and gravel similar to what we find in our low bottom-lands.

Along the White Water and Miami valleys we see accumulations of drift. We are told in the Geological Reports of Ohio, that the drift formation is traced across the State of Ohio from Ashtabula to Dayton. It is seen in large quantities near the mouth of White Water, and its outlet to the south and southwest was the mouth of the Miami valley. Now, if we imagine a time when there was a vast accumulation of ice at the junction of these streams—this ice principally brought down from the north through the Miami and White Water valleys—the ancient drainage lines probably valley glaciers—this ice meeting the ice in the Ohio, and forming an enormous ice gorge at this point, grinding along the eastern bank of the Ohio river, and piling up in confusion sand, gravel, and boulders—it seems to me we have an explanation for the accumulation of the drift found near the mouth of Wolper creek.

The sudden bend in the Ohio river and the narrow valley just below the bend probably produced ice obstructions in an ancient day just as we see ice obstructions produced at this portion of the river at the present time. It is also probable that at some remote period the ice obstructions turned a part of the volume of water across this acute angle in the river and formed the cut-off or ancient valley seen beyond the hills east of Petersburgh.

On the Indiana side of the river, we again find the drift near the river hills between two and three miles above Rising Sun, or nearly opposite Laughery Island, and at about the same height as the river terrace formation in Kentucky.

We also find near the mouth of Hogan creek, and extending back from the river along the valley of this creek to the town of Cochran, another terrace formation which is nearly of the same height as the terrace on the opposite side of the river in Kentucky. From an excavation made for a turnpike, and also in excavations made for the O. & M. R. R., we see that this terrace, unlike the terrace in Kentucky, is almost entirely composed of laminated clay and loam; scarcely any gravel can be seen. It is away from the current of the Ohio river and was evidently formed by the deposits of sediment in the back water during ancient floods or freshets of the Ohio river, just as deposits are left after the freshets at the present time on the lowlands back from the river. But it is difficult to account for the thickness of this terrace, rising as it does from a level of the bed of the river to nearly fifty feet above high water mark, unless we adopt the theory that there were at one time floods in the Ohio river far greater than any known since the country has been settled, a view which would be in accordance with the theory of the melting of a great continental glacier.

The accumulation of drift on the highlands above Middle creek were probably produced by causes similar to those that made the deposits in the valley, but at a far more ancient period. We can imagine how ice borne down from the north along the ancient drainage lines of the White Water and Miami rivers, and meeting the ice in the Ohio at this bend, would crowd it on to the south side of the then shallow valley, and leave deposits; the same which we now see, and which have so effectually resisted the decomposing effects of time.

In attempting to account for the formation of these deposits it is not necessary to allude to the changes that may possibly have taken place at different periods in the elevation or depression of portions of the continent. The same great drainage lines now seen in this part of our country must have continued from the time the river first began to erode out its present valley, and in this long series of years changes of climate have taken place, and the conglomerate to which we now direct your attention is evidence, we believe, to sustain the theory that ice has brought down from the north boulders and drift at two distinct and widely distant periods.

Dr. Sutton was kind enough to take me in his carriage to see the drift deposits mentioned in this paper, and after an examination of the locality, I am inclined to agree with him in most of his views regarding their origin. The drift breccia is composed for the most part of large, more or less, rounded boulders of Hudson River rocks, readily recognized by their fossils, and a smaller portion of metamorphic and crystalline rocks. They are cemented together and form a coarse, conglomerate or brecciated mass, one hundred feet or more in thickness. The difference in the elevation of the drift at the mouth of Wolper creek, and that on Rattling run and Middle creek, may be accounted for in this way:

When the glacier pushed its way from the frigid regions at the north to the southward, it moved over the surface of the land, impelled by gravity, and was only stopped by reaching a climate where the ice was melted, and at that point the debris would be dropped, as the sediment of the Mississippi is deposited in the Gulf of Mexico. The direction of the glacier, as indicated by the topography of the country, was from north to south, or nearly so, and the surface over which it moved in Ohio and Indiana was then as high, if not higher, than the point where it terminated.

The drift, then, on Rattling run and Middle creek, in Boone county, Kentucky, represents the terminal moraine of the earliest life of the prolonged glacier. As it cut down its bed and diminished in force—which it may have done rapidly in the soft, shaly beds of silurian rocks over which the main gorge of ice, that formed these beds, was passing in Ohio and Indiana—another moraine, on a lower level, was formed at the mouth of Wolper creek. The glacier, then, which formed these drift beds, when it tore away the silurian rocks, left two long and narrow valleys in Ohio and Indiana, separated from one another by an elevated ridge. This ridge was capped with Niagara limestone, and lay along the boundary line of the two States. The two glacial currents came together at the mouth of the Big Miami river, and the valleys which they eroded are those through which the Big Miami and White Water rivers flow.

These two rivers now unite their waters just before they debouch into the Ohio. Near the present mouth of the Big Miami there is abundant evidence that the Ohio river at one time had its channel to the east of its present bed, and almost in a straight line south to the mouth of Wolper creek. This channel was probably due to the abrading force of the combined waters of Big Miami and White

Water rivers, at a time when their currents were powerful enough to turn the Ohio almost at right angles to its present course; or at a still earlier period, when the glaciers were in action. A deposit of drift near the head of the old river-bed, and the large deposit near its mouth, at Wolper creek, would leave us to refer it to glaciation.

It is not possible to measure, by years, the time that glaciers remained in action over the States south of and bordering on the lakes, but it must have been a period of very great duration. The area, however, which it covered was slowly diminished, as the temperature of the continent became less frigid, and the southern margin was finally withdrawn to the Arctic regions. Strictly speaking then, it would not be amiss to say that the drift on Rattling run was formed before that at Wolper creek; but, in my opinion they can not be referred to distinct glacial epochs any more than the drift in Marion county can be referred to a different epoch from the drift in Laporte county, in the north part of the State.

During this remarkable ice period, though the entire State of Indiana for the greater part of the season was covered by a vast sheet of ice, this ice field was not of uniform depth and force, since the physical features of the State must have been much more strongly marked than at the present time. The prevalent mountain chains would direct it into river-like channels, and it is along the shores of these ancient rivers of ice that we find lines of stranded boulders, like drift wood left by freshets on the banks of streams, and at a greater elevation than the finer sedimentary matter. The boulders and gold bearing drift on Laughery creek, near Hartford, lies about two hundred feet above the drift on Wolper creek, and is about two hundred feet lower than the deposits on Rattling run. There are a number of localities in Indiana, besides these mentioned, where gold is found in glacial drift, but the most noted and best known are in Morgan and Brown counties. In the latter county gold was washed from the drift sands in the valleys of most of the streams flowing into Bean Blossom creek at a very early day, and the county has been the scene of numerous mining excitements within the last forty years. Its geological position was well studied by the first State Geologist, the late Dr. David Dale Owen, and as early as 1837 he cautioned the public against expending large sums of money in mining adventures, since the gold had been brought from the metalliferous veins which have their existence north of the lakes.

The gold bearing quartz torn from these northern lodes by the ice was reduced to fine dust by the grinding motions of the glacier, and in this condition, along with some larger fragments of erratic rocks, it was borne along until finally deposited by the melting of the ice in lower latitudes. In this way also the fine particles of gold were set free from the rock matrix. Under such circumstances the gold must be widely scattered and require a large expenditure of time and money to collect it. According to Prof. Collett (6th Rep. 1874, p. 108,) there had been taken altogether from the drift of Brown county not to exceed ten thousand dollars worth of gold dust.

There has also been found in the drift of Brown county several diamonds, one of which weighed four carats. On Little Indian creek, in Morgan county, Mr. J. J. Maxwell found, some ten years ago, a diamond which weighed three carats. These are interesting facts, and point to the existence of a true diamond field somewhere in the beds of crystalline rocks to the north. I have had no opportunity to examine the diamonds that have been taken from the drift, but learn that they were pronounced upon by competent critics and dealers. Some of the corundum gems approach the diamond so closely in hardness and physical features, when not in perfect crystals, and being usually found in the beds of streams among the debris of crystalline rocks, might, without a direct test, be readily mistaken for diamonds.

From the very nature of things, as already set forth, it will be found an unprofitable business to search for diamonds within the bounds of this State.

Some large pieces and many particles of native copper have been found in the drift, both in the northern and southern part of the State; also fragments of galena, sulphuret of lead. In the northern counties it is not uncommon to find pieces of bituminous coal, and it has been the means of leading many parties to believe that beds of coal could be found in the vicinity of the streams where the samples were picked up.

In Daviess county the drift rests immediately on the carboniferous beds, and contains, locally, fragments of Hudson river limestone and well-preserved fossil shells of the same age. The most abundant fossils are: *Orthis occidentalis; O. lynx; Rhynchonella capax,* and *Strophomena alternata.* There is a bed of block coal not more than ten feet below the drift in which we find these disintegrated and worn fragments of strata that in geological order belong more than two thousand feet below the coal beds. We must expect, then, to encounter in the drift resting upon the rocks of Indiana, no matter what their age, portions of all the formations that lie to the northward of the locality, with their mineral and organic components. So far as we have any knowledge, the drift has furnished in Indiana no rocks or strata newer than the coal. The limbs and trunks of trees that are found imbedded in the blue clay at the base of the drift are of Alpine species, pines and cedars. They were torn from their mountain home by the ice, and drifted with the mud beyond the moraines until quietly deposited in some protected basin. Indeed, the general character of the drift differs but little in its lithological features, or in the order in which the clay, sand and gravel and coarse particles are arranged in alternating beds, either in Indiana, Ohio or Illinois, a feature that is due to a common cause and common origin.

While the drift is not likely to furnish any amount of precious metals it has been invaluable in furnishing gravel for road-making, clay for potteries and brick-makers, and is the source of the principal supply of potable water. At Indianapolis the drift varies from seventy to ninety feet in depth, and is built up of alternate beds of sand, gravel and compact clay, in the following order:

Surface, clay and gravel.

Sand, with water, 1st seam.

Blue compact clay.

Gravel and sand, with water, 2d seam.

Blue compact clay.

Gravel and sand, with water, 3d seam.

Devonian limestone.

The first seam of water is usually found at a depth of 18 to 22 feet; the second seam at 30 to 40 feet; and the third seam at 70 to 90 feet.

These various strata of water have the same fountain source, since they rise to about the same level when tubed.

They are all what is called "hard water." The first seam, reached at 18 to 22 feet below the surface of the city, contains the largest amount of mineral water—principally calcium carbonate, magnesium carbonate, chlorides, and ferrous sulphate. The amount of chlorine is so large that its presence is, in a great measure, due to sewage contaminations. The second seam of water contains but little chlorides, but has about the same amount of calcic and magnesic carbonates as the first. It is a good potable water, when properly protected from contaminations from the upper seam, but is too hard for domestic and steam purposes. The third seam of water is also a hard water—that is, its salts will decompose a portion of soap and form a curd; but it contains less carbonates and more sulphates of the alkaline earths, lime and magnesia. This renders it decidedly preferable for steam-boilers, since the magnesium sulphate is remarkably soluble in water, and the calcium sulphate, in connection with the former, seems to prevent the formation of scales in the boiler. In other words, the scales in boilers is formed by the deposit of calcium and magnesium carbonates, that were previously held in solution by an excess of carbonic acid; the latter is driven off by heat.

CHAMPLAIN PERIOD.

Following the drift there is, in Indiana, a local deposit of lacustril sediment, called Loess. It is a fine-grained, friable, yellowish, buff-colored material, containing a considerable amount of carbonate of lime. In places where it abounds it has also received the name of marl. The Loess is only found along the lower portion of the Wabash, East fork and West fork of White river, and in the counties bordering the Ohio river, and capping the bluffs of that stream, from Crawford county to the mouth of the Wabash river. I have not observed the Loess along the Wabash river farther north than Parke and Vermillion counties—that is, any deposit assuming the physical features of this material, as above described. Usually, it contains a large number of shells, of land and pond mollusca. The land shells are such as live on the borders of ponds and in quite moist places, such as the following named genera and species, found mostly in the Loess along the Wabash river, at New Harmony, in Posey county:

Macrocyclas concava, Say; *Zonites arboreus*, Say; *Hyalina indentata*, Say; *Patula perspectiva*, Say; *Helicodiscus lineatus*, Say; *Pupa armifera*, Say; *P. fallax*, Say; *Strobila labrynthica*, Say; *Stenotrema hirsuta*, Say; *S. monodon*, Rack.; *S. monodon var. fraterna*, Say; *Vallonia pulchella*, Muell.; *Succinea avara*, Say; *Valvata tricarinata*, Say; *Pomatiopsis lapidaria*, Say; *Helicina occulta*, Say.

The last named is extinct in Indiana, and almost so in the United States, being found in limited numbers in a few localities only. All the others are still found living in the State.

The elevation of the Loess in Parke county is about seven hundred feet above the ocean, and in Crawford and Perry counties, on the Ohio, it is about the same, or five hundred feet below the highest table-land in the State, near the head waters of the Wabash river and its main tributaries. From this elevation there is a gradual fall to the mouth of the Wabash, where the deposit is not more than four hundred feet above ocean level. The Loess or "Bluff" formation, as defined above, is not found at any considerable distance inland from the immediate high bluffs bordering the above streams. This fact leads to the conclusion that it is the sedimentary deposit of shallow lakes or ponds that were left along the lateral borders of the glacier after it had cut the deeper channel forming the present beds of the streams. On sandy soils the Loess marl is used advantageously as a fertilizer; it is especially good for wheat and corn.

ANTIQUITIES.

The high bluffs and second bottoms along the Ohio river, and those of its principal tributaries in the southern part of the State, were famous places of resort for the ancient race of people known as Mound-builders.

The following map and diagrams are reduced copies of a most elegantly executed map of Lawrenceburg and its surroundings, made and presented to the Indiana Archæological Society by Mr. Samuel Morrison, C. E., of Indianapolis. Mr. Morrison is one of the oldest and best informed civil engineers in the west, and has stored up a vast amount of useful material in regard to the true boundary lines of streams and the location of errors incidental to the running of the township and section lines.

Plate G* shows the location of two remarkable earthwork enclosures, named on the map, pre-historic forts. One of these works is shown, enlarged, on Plate H.† This fort is situated in Hamilton county, Ohio, a short distance from the Indiana boundary line. It is on the last hill between the Ohio and Great Miami rivers, and on land belonging to the heirs of the late President, General William Henry Harrison. The hill is 200 feet high. The area enclosed contains about twelve acres. It has an open space called a gateway, and two projecting narrow arms called bastions by Mr. Morrison. The table-land within the enclosure is about ten to twenty feet higher than the walls, which appear to be of material scooped from the brow of the hill. The situation of this work is admirably chosen to command a view of the extensive level bottom lands which surround it and render the inmates secure against sudden surprise. The wall is followed by a ditch on the inside.

*See page 123. †See page 125.

Plate I* gives an enlarged plan of the ancient fort on the hill north of Hardensburg, in Dearborn county, Indiana. The wall is four feet high in places, and is partly constructed of loose stones and partly of earth. There are two gateways on the north end, formed by an earthwork that is nearly circular. The hill is nearly 200 feet high, and as at the former fort, commands an extensive view over the country around. On the ridge leading to the northeast and northwest there are eight mounds. There is also a mound on the hill to the south, and two close to the road leading from Lawrenceburg to Hardensburg. There is also a mound northeast of Lawrenceburg, near the track of the Ohio and Mississippi railroad. All these mounds are shown on Plate G, page 123.

There are a number of mounds in the vicinity of Aurora, and quite a large mound was within the city limits, but has been almost entirely removed by cutting a street-way through it. Dr. George Sutton, of Aurora, has a large and interesting collection of ancient stone implements, which he collected from this county and from Kentucky. Dr. Sutton has visited many times the ancient forts mentioned above, and was kind enough to point out their locations to me, as well as that of the mound in the city of Aurora.

J. B. Gerard, M. D., in connection with others, opened a mound near the mouth of Laughery creek, in Ohio county, which was about 100 feet in diameter and 15 feet high; excavations were made at several places, and they found human bones, one whole earthen pot, and a great many fragments of pottery. Mr. Stratton also found a whole pot in this mound, and still another was found by H. C. Miller. Dr. Gerard has noticed from twenty to thirty mounds along the bluffs of Laughery creek, and has opened a number of others, but found nothing of note except ashes, which lay at the base of them all. At Hartford I had the pleasure of

* See page 125.

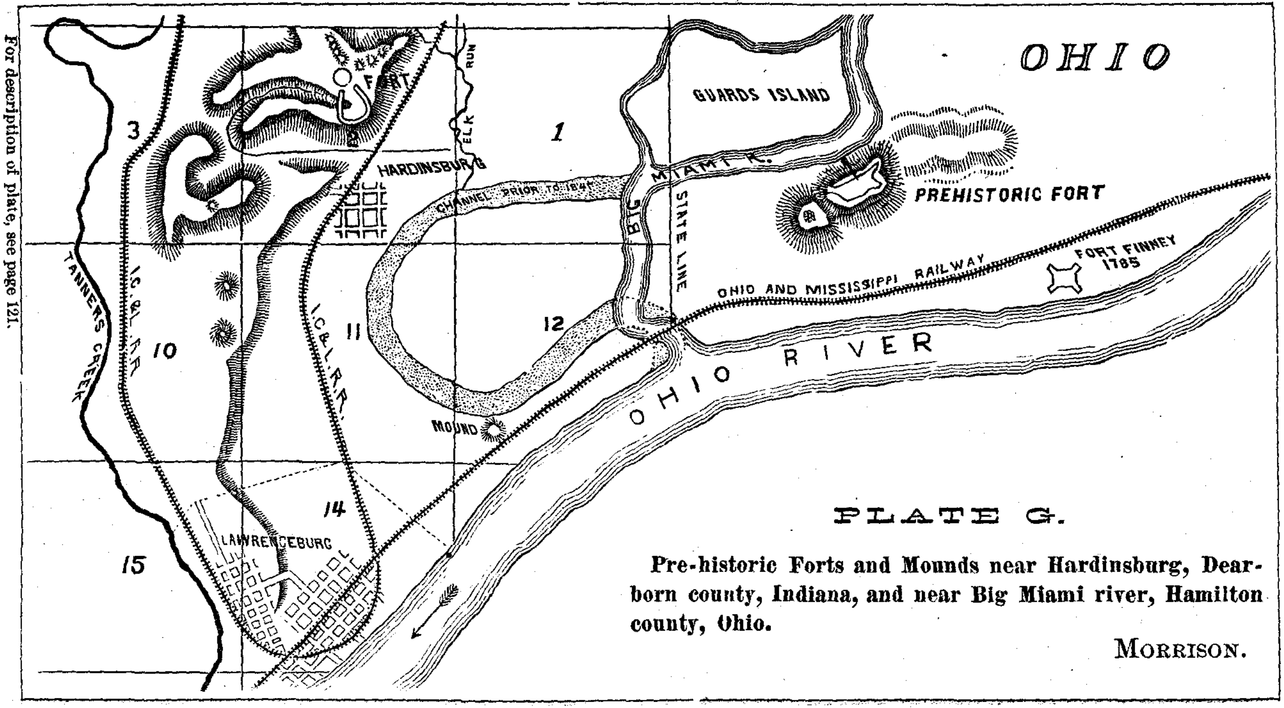


PLATE G.

Pre-historic Forts and Mounds near Hardinsburg, Dearborn county, Indiana, and near Big Miami river, Hamilton county, Ohio.

MORRISON.

For description of plate, see page 121.

seeing the admirable collection of archæological objects, collected principally from this locality by Rev. C. W. Lee. They are well arranged in a case, and among them are several rare and interesting specimens. Mr. Lee is an enthusiastic collector, and, I understand, has added many things to his cabinet since I saw it.

Going down the Ohio river to the mouth of the Wabash river there are a great many mounds and earthworks of small magnitude. One of the most remarkable works south of those mentioned above is called the "Stone Fort;" it is on a hill at the mouth of Fourteen-mile creek, in Clark county, and is figured and described in the Geological Rep. Ind., 1873.

Dr. Blunt, of Mt. Vernon, Ind., has made a very large collection of ancient relics from the mounds of Posey county. He has also a very large collection of pottery from the "Bone Bank," on the east bank of the Wabash river. This famous locality was first mentioned by Arthur Henrie, who surveyed and subdivided into sections that part of Indiana called the "Pocket," which lies between the Ohio and Wabash rivers. In his journal of this survey it is noted that in meandering the Wabash river he discovered in one place, on the left bank of the stream, numerous human bones, indicating the place of a very ancient cemetery*

The "Bone Bank" is figured in the Indiana Geological Report of 1873 from a sketch made by Dr. G. M. Levette. The bluff forming this bank is only a few feet above high water mark, and is the only spot for many miles around that is not submerged in time of very high freshets. Hundreds of earthenware pots, made from a mixture of pulverized mussel shells and common clay, such as may be seen in the river bank, have been found at this locality, washed out

*This information was obtained from Samuel Morrison's historical sketch of Posey county.

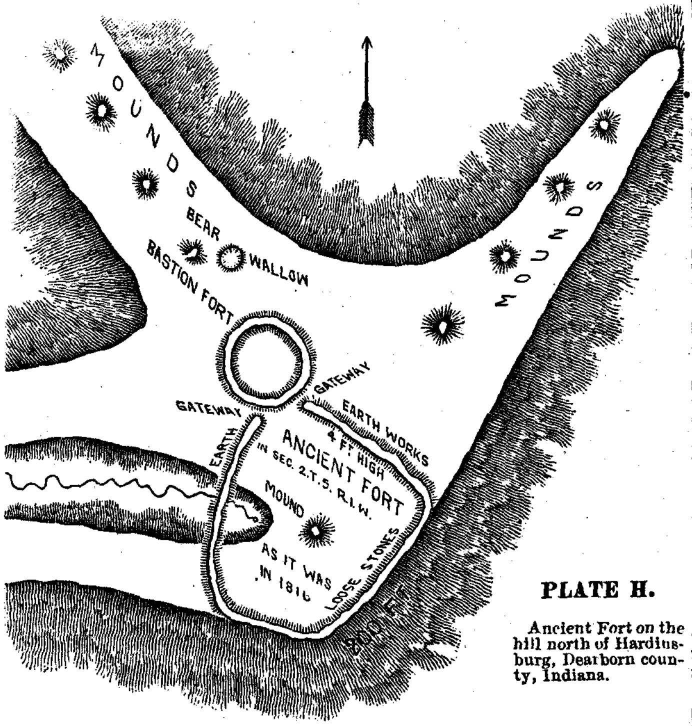


PLATE H.

Ancient Fort on the hill north of Hardinsburg, Dearborn county, Indiana.

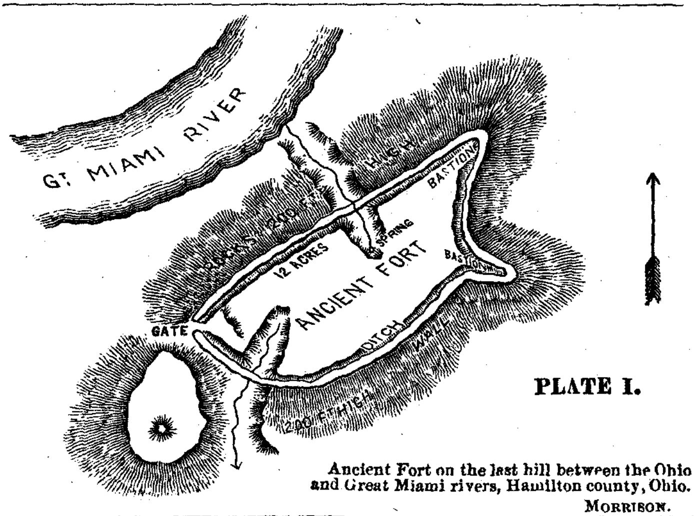


PLATE I.

Ancient Fort on the last hill between the Ohio and Great Miami rivers, Hamilton county, Ohio.

MORRISON.

For description of plates, see pages 121 an l 122.

by the river, which has been cutting away the river bank ever since the occupancy of the country by the whites. Many of the pots from this locality are of unique forms and ornamented with the heads of animals, birds and human beings. I have a jug found at the "Bone Bank" which has a neck supporting an admirably formed human head, and the ears are pierced with holes, indicative of the custom of wearing pendant ornaments of some kind.

Mr. Joseph Reeves, a farmer, whose residence is on the southern and higher end of the "Bone Bank," states that he rarely digs a post hole or makes any other excavation of equal depth without exposing human bones or pottery. Mr. Reeves' kitchen garden is on this bank, and, according to his statement, every spade full of earth turned up in preparing and working it shows fragments of ancient pottery. It is to be regretted that the river floods are cutting this historic spot away so rapidly that the last fragment of pottery may disappear in less than a half century.

Bordering the Wabash river on both sides, from its mouth to Fountain county, mounds are found on all the second bottoms and on all the prominent ridges facing the stream; they are particularly numerous in the vicinity of New Harmony, sixty miles above the mouth of the Wabash. The town, which is situated on the sandy and gravelly, second bottom of the river, occupies the site of an immense group of mounds. A number of small ones are still to be seen in the German burying ground, and a large one still remains in the yard at the residence of the late R. H. Fauntleroy. The eminent naturalist, C. A. LeSueur, of New Harmony, was the first to make mention of mounds in this State. In connection with Thomas Say he opened some mounds on the top of a hill facing the Cut-off, near the town, and described the cists and articles found and the position of the human skeletons which they contained. He also published an account of the large shell heap which is seen on the top of a short ridge near the above mounds. This shell heap ("kitchen midden") is about three hundred yards from the Cut-off, an arm of the Wabash at New Harmony, and covers to the depth of thirty feet, about one-half an acre of the top of one of the highest hills in the county—one hundred and seventy-five feet above the stream. It is composed of the shells of a great many species of mollusca, such as are now living in the river; only a few bones of animals, all belonging to indigenous species, are found, and, judging from the size of the bed, mollusca must have formed an important, if not predominant, part of their food. These mounds and shell heap are mentioned by Prince Maximillian in his travels in North America. Prince Maximillian visited New Harmony in 1835 and 1836, and spent some months there in making collections of birds and mammals. Sir Charles Lyell also visited this locality on his second journey to the United States, and makes mention of it in his "Second Visit to America." Mr. James Sampson, of New Harmony, has a very large collection of antiquities, collected from the mounds in his neighborhood. Mr. Lycurgus Chaffen, of the above place, has also collected a great many interesting relics; among them is a very peculiar shaped plummet, made of native copper, that he presented to the State collection. The next most important locality for mounds along the Wabash, in this State, is in Knox county. In the vicinity of Vincennes there are several of unusual size, being the largest yet found in the State. These mounds were carefully studied and described by Prof. Collett in the Indiana Geological Report of 1873. At Merom, in Sullivan county, there is a broad area of high table-land bordering the Wabash, which appears to have afforded the Mound-builders an admirable site for the display of their peculiar genius in laying out walled enclosures. The works here were all described under the name of Fort Azatlan by Prof. Collett in his report on Sullivan county, Geological Report of Indiana, 1870. Dr. B. F. Harper, of Merom, opened several mounds at "Azatlan." In one he found a number of human skulls, which have been loaned to the State museum. I visited this locality in company with Professors F. W. Putnam, Caleb Cooke and James Emerton, of Salem, Massachusetts, Prof. John Collett and a number of the citizens of Merom, for the purpose of making a careful exploration of the mounds. Though a number were opened here and in the neighborhood, nothing of note was found except one skull, which Prof. Putnam thought to be typical of the mound-building race.

There are a number of mounds in Vigo and Vermillion counties, but no antiquties of any note have been discovered within the State farther up the Wabash.

The second bottoms and bluffs along White river and its East fork are well studded with mounds. When grading for the Indianapolis & Vincennes railroad, at Edwardsport, a large shell heap (kitchen refuse pile) was cut through, but so far it has afforded no relics of interest.

Mounds are abundant in Greene, Owen, and Morgan counties. In the latter county they have furnished a great many interesting relics. A number of mounds at one time existed within the city limits of Indianapolis, but they have given way to the changes required by the growth and development of the city. Mr. Daniel Hough, formerly of Indianapolis, now of Ann Arbor, Mich., has one of the largest archæological collections in the Western States. It comprises implements and relics from all parts of the Union.

Besides mounds, there are a number of circular earthwork enclosures in Hamilton and Tipton counties. The principal works in Tipton county are close to Strawtown, and in a cultivated field. The largest is a circle, with an open gateway on one side. It has been so badly obliterated by the plow that I was unable to make a complete survey of it, especially as the field was covered with a heavy crop of corn at the time of my visit. Enough was left to show that it was several hundred feet in diameter, and had a ditch or fosse on the outside—being singular in this respect, as all other works in the State of which I have any knowledge have the ditch on the inside of the wall. Judge Overman, of Tipton, has made a large collection of Mound-builders' relics, principally from his own and the surrounding counties.

By far the most unique and well preserved earthworks in this State are on the banks of White river, in Madison county, about three miles from Anderson, the county seat. See plates E and F. The principal work in a group of eight, shown on plate E,* is a circular embankment with a deep ditch on the inside. The central area is one hundred and thirty-eight feet in diameter, and contains a mound in the center four feet high and thirty feet in diameter. There is a slight depression between the mound and the ditch. The gateway is thirty feet wide. Carriages may enter at the gateway and drive around the mound, as the ditch terminates on each side of the gateway. The ditch is sixty feet wide and ten and a half feet deep; the embankment is sixty-three feet wide at the base and nine feet high, and the entire diameter of the circle is three hundred and eighty-four feet.

When I first visited these works, which go by the name of the "Mounds," there was growing upon the embankment a great many large forest trees, from one foot to four feet in diameter. Several large walnut trees have since been cut off; with that exception the work still remains covered with a growth in no respect differing from the adjoining forest,

*See page 131.

and the embankment and ditch are in as good a state of preservation as when abandoned by the builders.

Fig. B is 238 feet S. 30° E. of the center of A, is 33 feet across and has two gateways; the bank is two and a half feet high and has no ditch.

Fig. C is 710 feet S. 20° W. from the center of A, is 100 feet in diameter, has a bank which shows in the woods two feet high, and a gate ten feet wide. The public road runs through this circle, and has obliterated the greater part.

Fig. D is 475 feet S. 39° W. from center of A, is 126 feet in diameter, has a bank two and a half feet high, with a slight ditch on the inside; the central area is fifty feet in diameter, and the entrance-way fifteen feet across.

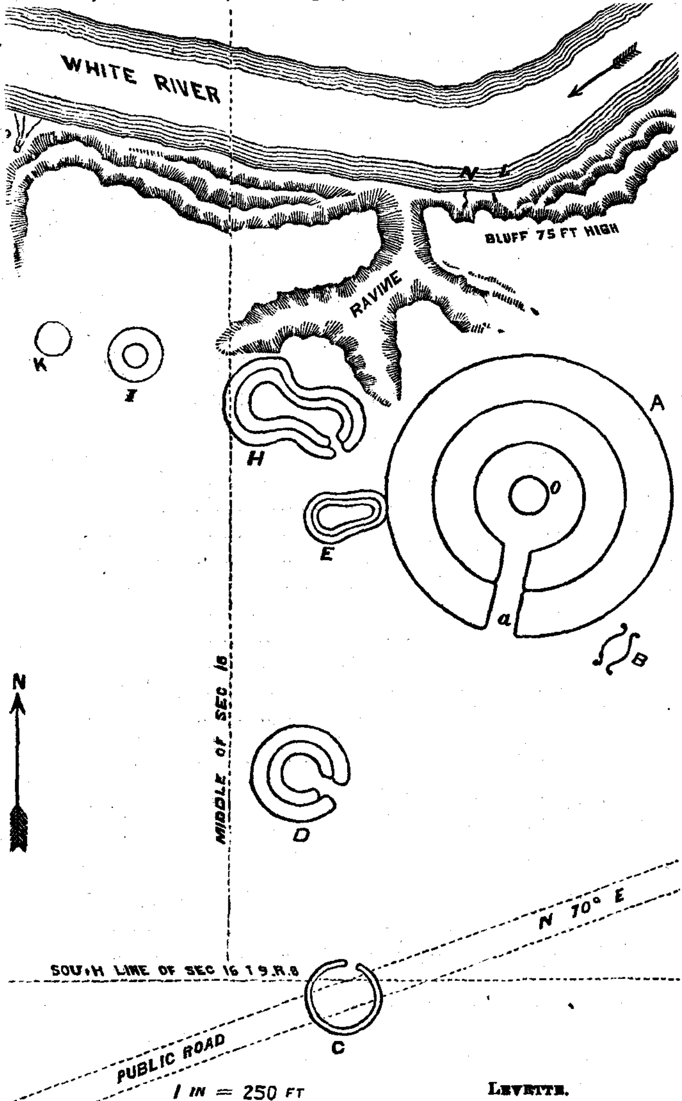
Fig. E is 245 feet S. 84° W. from center of A; extreme length 106 feet; thirty-six feet across the widest part, thirty-three feet across the narrow end, and twenty-seven feet across the constricted part of the figure; has a slight ditch on the inside of the embankment, which is from 0 to 2 feet high; no visible gateway or entrance.

Fig. H is 325 feet N. 70° W. of center of A; has an extreme length of 181 feet; is 122 feet across the wider end, 115 feet across the narrow end, and fifty-seven feet across the constricted part; the central area is ninety-five feet long, and has a varying width of from ten to thirty feet; the wall is from one to six feet high, with a ditch on the inside—now partly filled but still plainly visible; evidences of a small mound on the western end of the central area are still traceable.

Fig. I is 552 feet N. 70° W. from the center of the large circle A; it is a plain circular embankment thirty-six feet in diameter, with a wall two and a half feet high; with no visible ditch or entrance-gate; near the center is a slight mound, thirteen feet in diameter.

PLATE E.

Groupe of ancient earthworks near Anderson, Madison county, Indiana, on section 16, township 9, range 8. 1 inch=250 feet.



For description of plate see page 129.

Fig. K is 662 feet N. 71° W. of the center of A; it is a plain circle, with wall two feet high; no ditch or central mound.

These interesting works are located on the south side of White river, on a bluff seventy-five feet above the water. At the base of this bluff—which is composed of gravel, sand, and clay—there are several bold, running springs of chalybeate water. As this water possesses valuable hygienic properties, the analysis is here given:

ANALYSIS OF WATER FROM SPRING AT THE "MOUNDS," NEAR ANDERSON, INDIANA.

Bold, running spring; cold and clear; strong inky taste; bubbles up through sand; no appearance of escaping gases; decidedly alkaline reaction.

	Grains in an Imperial Galon.
Insoluble silicates	1.6580
Oxide of iron	.7287
Lime	8.1610
Alumina	trace
Magnesia	trace
Sulphuric acid	2.7500
Carbonic acid, combined	7.1070
Iodine	trace
Alkalies	trace
Loss and undetermined	3.5953
Total in one gallon	24.0000

	Per Cent.
Total gas in an imperial gallon	13.580
Free carbonic acid	6.473

The above constitutents are probably combined as follows:

Bicarbonate of lime	10.898
Carbonate of protoxide of iron	1.177
Sulphate of lime	6.672
Insoluble silicates	1.658
Magnesia	trace
Alumina	trace
Alkalies	trace
Iodine	trace
Loss and undetermined	3.595
Total	24.000

This is a very pure calcic chalybeate water, a fine tonic and alterative, and is admirable for persons laboring under general debility and dyspepsia.

The location is all that could be desired for a watering-place and resort for health. The antiquities will furnish a never-ending interest to those who like to study the works of past generations of men.

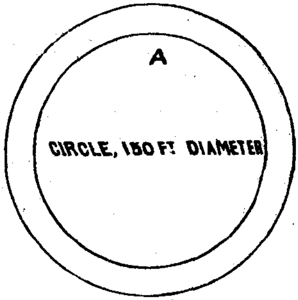
On the same section of land, but half a mile farther up the river, and on the same side of the stream, there is another cluster of earthworks that are of nearly equal interest; in fact, the principal work A, on plate K*, is, in some respects, more remarkable than the large circle on plate E. The outline is of irregular shape—constricted on one end and at the sides; at the other end there is a gate-way (D) nine feet wide, protected by two small mounds (B and C), now about four feet high. The wall is thirty to thirty-five feet wide at the base, and about four feet high; ditch eight feet wide. A central line through the longer way is N. 67° E. and 296 feet long; it is 160 feet across at the widest and 150 feet across at the narrowest part—near the middle. With the exception of the two mounds at the gateway, which lie on the cultivated side of a section fence, and have been cut down by the plow, the remainder of this antiquity is in as good state of preservation as when deserted by its original occupants. Large trees are growing over it, and the underbush is so thick that it was difficult to obtain accurate measurements; in fact, there is hardly a stick of timber amiss over the ruins.

The works represented on plate F† are near that last described. A is a plain circle, 150 feet in diameter; it lies in a cultivated field, and is being fast obliterated. B, on the same plate, is in a tolerable state of preservation; its longer diameter is 106 feet, and forty-eight feet across either end and is slightly constricted at the middle; wall about two

*See page 135. †See page 135.

feet high; ditch on the inside fifteen feet wide; gateway (c) is fifteen wide. The part on the east side of the section line lies in a woods, and is very well preserved. On the west side of the fence the land is cultivated, and the embankment is fast being destroyed. These works, with that on plate K, are close to the bluff of the river, which is here also composed of glacial drift, and is seventy-five feet above the water.

The largest walled enclosure in the State is situated near the town of Winchester, in Randolph county. It is figured in Squier and Davis' Antiquities of the Mississippi Valley, but as that plat was inaccurately made it is reproduced here, page 137, from actual measurements made by Dr. G. M. Levette. It contains thirty-one acres, and a good portion of it lies within the boundary of the Randolph county fair ground, the remaining portion, with the exception of the public roadway on the west end, lies in cultivated fields, so that the whole work is in a fair way to be obliterated. There are two gateways, one on the eastern end, twelve feet wide, and has no defenses, Sugar creek and the intervening bluff probably being deemed sufficient, but at the west end there is an embankment in the shape of a half circle which overlaps the gate and complicates the passage-way. The enclosure is in the shape of a parallelogram with curved angles; the sides are 1,320 feet long, and the ends 1,080 feet. There is a mound in the centre 100 feet in diameter and nine feet high. When the horses are trotting, at fair times, this mound is covered with spectators, as it commands a view of the entire track. I once had the pleasure of witnessing a spirited trot from the top of this mound. The walls of the enclosure are from eight to nine feet high where they have not been disturbed by the plow. A cross-section of the half-circle at the west gate is shown on the plate; it has a slight ditch on the inside, also a cross-section of the main



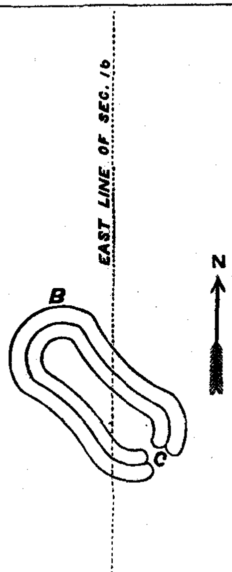


PLATE F.

Ancient earthworks on northeast corner section 16, township 9, range 8, near Anderson, Madison county, Ind.

1 inch=150 feet.

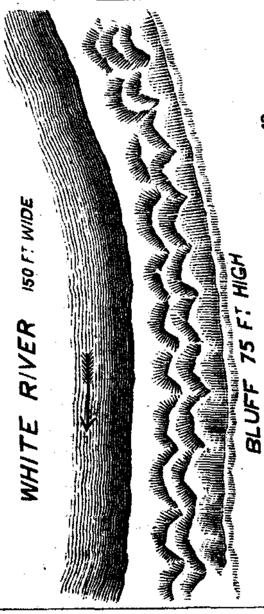
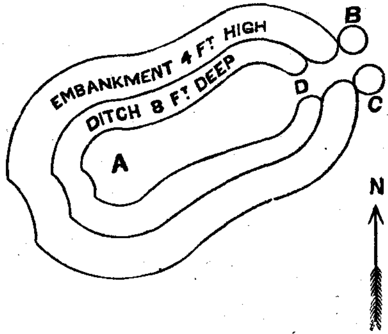


PLATE K.

Ancient earthwork on section 16, township 9, north range 8, near Anderson, Ind.

1 inch=150 feet.



wall which has no fosse. You will perceive that the location for this large and remarkable work was selected with due regard to protection against the sudden attack of an enemy. It is at the junction of Sugar creek and White river, which affords protection on two sides, and the mound in the centre served as a look-out station.

Mounds are found in all the northern counties, along the streams and on the borders of small lakes, and Lake Michigan.

Dr. T. S. Arthur, of Portland, Jay county, has been actively engaged for some years in collecting archæological relics, and his collection is now very large, and comprises many objects of special interest. Colonel R. S. Robertson, of Fort Wayne, is an active member of the State Archæological Society; he has a choice collection of relics and a valuable library of works on pre-historic races. J. Wes. McBride, of Waterloo, and G. C. Glatte, of Kendallville, are also enthusiastic collectors of relics, and each has his well-filled cabinet. Mr. Cheshire, of Lake county, has made a collection of mound relics of his district, and possesses some rare things. The High School at Laporte has also a large collection of objects, mostly taken from mounds in the county.

My reports have always contained some account of the archæology of the State, which, together with the establishment of a State Archæological Society, has given an impetus to this branch of study, so that collectors have sprung up in nearly every county, and they are materially aiding in making known all that remains of its archæology.

The address which I delivered before the State Archæological Society in 1877 has not been published, and I have thought that it would not be out of place to give it to the public in this report.

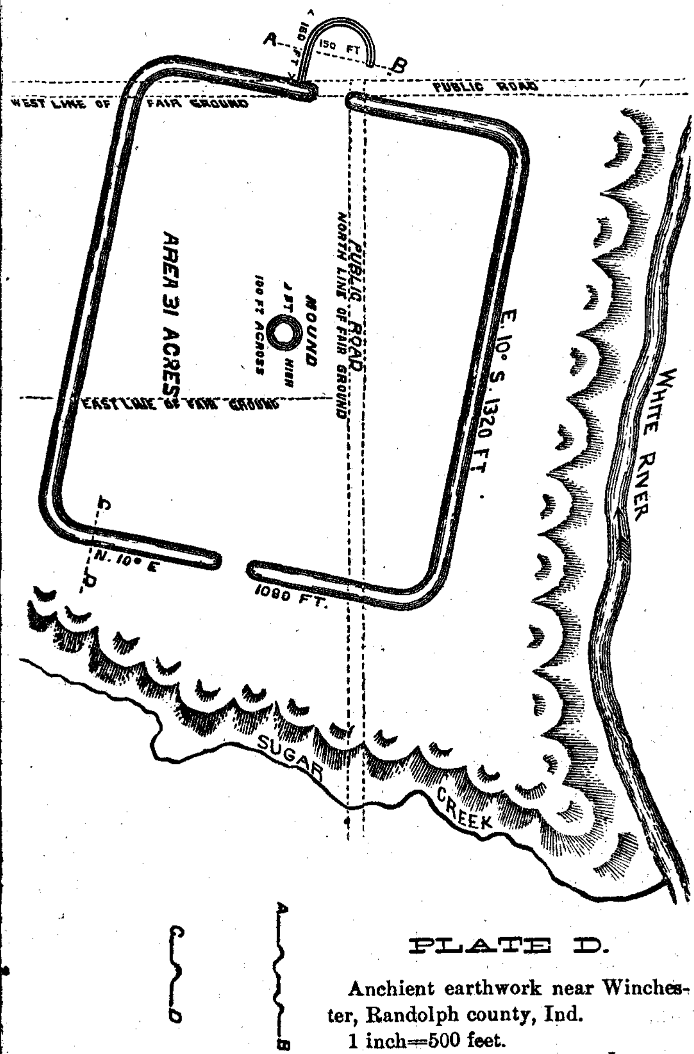


PLATE D.

Anchient earthwork near Winchester, Randolph county, Ind.
1 inch=500 feet.

LEVETTE.

ARCHÆOLOGY.

[Address delivered before the State Archæological Society, at Indianapolis, October 18, 1877, by E. T. Cox.]

Gentlemen of the State Archæological Association of Indiana:

It is the duty of the president of this association to deliver an address at the annual meeting of its members upon such subjects as are prescribed by its organic laws for special study.

I regret exceedingly that my duties have been of such a character that, until within the last three or four days, no time could be spared for the preparation of this address, and I fear that what I have to say will fall far short of your expectations.

No department of natural history is, at this time, receiving more attention from the votaries of science and thoughtful readers than that which pertains to man and his antiquities. Indeed, so familiar are its students with the present status of anthropology that it will be difficult for me to present novel facts in research or new channels of thought worthy of the attention of a body of such able co-laborers. I crave your indulgence, therefore, if some parts of my address should prove to be devoid of special interest.

Matter and life are universal. The solar system, as well as all other heavenly bodies, is the result of simple substances aggregated into compound substances. These complex bodies forming the universe are produced by the affinity or affection which certain elementary and compound substances have for each other, and the process of evolution in the mineral kingdom, as well as in the organic world, is in constant operation.

Organized matter, or life, results from the combination of the fewest number of simple substances, namely: carbon, hydrogen, oxygen and nitrogen. These four elements constitute the chief part of all organized tissues. Woody fibre, sugar, starch, gum, fat, oils and many organic acids contain only three: carbon, hydrogen and oxygen, yet I must not omit to mention that in organized matter a small per cent. of other elements is found; such as phosphorus, sulphur, calcium, potassium, sodium, magnesium, silicon, and some others, but the chief mass of plants and animals are formed of the four elements first mentioned. The fourteen or fifteen elements which constitute the principle mass of the mineral world are almost the same which occur in organized matter, the difference being chiefly this: that in inorganic nature the predominant elements, nearly in the order of their abundance, are oxygen, hydrogen, nitrogen, silicon, chlorine, sodium, aluminum, carbon and iron, after which follow potassium, calcium, magnesium, sulphur, phosphorus, iodine and fluorine;

while in the organic departments the order is nearly as follows: carbon, hydrogen, nitrogen, potassium, calcium, phosphorus, silicon, sulphur, sodium, magnesium, chlorine, iron, iodine and fluorine.

From this it will be apparent that no essential distinction can be made between inorganic and organic bodies founded on the nature of the elements concerned in their production.

Since spectrum analysis has revealed the presence of these elementary substances, common to organized bodies, in the stars, sun and all of its dependent planets, how can we doubt the existence of life in some form throughout the universe. The heavenly bodies which come to us in the shape of meteorites are in many instances found to contain graphite, a form of carbon most likely due to the destruction of organized matter in some form or other.

The law of change pervades all nature, and there appears to be no such thing as stability. The solid crust of our globe and the life evolved upon it when passed in review before the eye of the earnest student of nature presents an ever-changing panorama from old to new forms of life, and though we are not able to assign specific dates in the history of progress from the lowest forms to the earliest traces of man, geology has pointed out the way by which relative records may be established.

If we dig down into the earth beneath our feet, we find that it is composed of layers of many kinds of stone, resting upon unstratified, crystalline rocks—the so-called archean rocks, which form, as it were, the backbone of the earth. The superstructure of stratified rocks were formed by the destruction of older rocks, and once lay at the bottom of the ocean in the condition of mud or ooze. The sedimentary rocks, so formed, are of very great thickness, since we are able to deduce not less than ten miles by measuring from the top of mountain peaks to the bottom of deep sea soundings, while the aggregate thickness of the earth's crust within the reach of the geologist may be set down as twice this amount.

A close study of this crust, composed of stratum upon stratum that enfold the earth like so many successive rings of growth, reveals a most wonderful history, for they are largely made up of the petrified skeletons of the denizens of an ancient ocean. The bottom layers were necessarily formed first, and are therefore the oldest in time; they likewise contain old forms of life, most of which have long since been lost to the world—so that, step by step, as we ascend in the series, new types of life are met with, and by successive epochs we finally pass through eozoic or dawn of life, palæozoic or ancient life, mesozoic or middle life, to cenozoic or recent life. These are simply great divisions of the earth's stony crust, like dividing a column into lower, middle, and upper parts, and will serve our present purposes of pointing out the vast time required for the accumulation of such a mass of sedimentary matter, and the long endurance of life, in one form or another, on the globe.

Lyell, in his Principles of Geology, has undertaken to furnish datum for ascertaining, approximately, the length of time required to form a given amount of strata, by measuring the quantity of sediment annually brought down by the Mississippi river and deposited in the area of 12,300 square miles comprising the delta. "Borings near New Orleans have gone to the depth of 600 feet in these fluviatile deposits, and the average depth was assumed to be 528 feet, or the tenth of a mile. The quantity of solid matter brought down annually by the river is given at 3,702,-758,400 cubic feet, and the accumulations of the whole deposit must have taken 67,000 years." Yet, this deposit made by the Mississippi river represents but a mere fraction of geological history, and belongs to the Quaternary or modern epoch. It will serve, however, to prepare your minds for the reception of a chronology which, though we can not fix the exact date of the beginning, is absolutely demanded at the very threshhold of the earth's history.

In tracing the history of mankind, back or down the stream of time, various systems of classification have been proposed, having for their object the division of the subject into distinct periods.

Sir John Lubbock recommends a division of pre-historic archæology into four great epochs:

1. Palæolithic (ancient stone period), that of the Drift, when man shared the possession of Europe with the cave bear, the woolly haired rhinoceros and other extinct animals.

2. Neolithic (polished stone age), a period characterized by beautiful weapons and instruments made of flint and other kinds of stone, but without a trace of any knowledge of metals except gold, which appears to have been used sometimes for ornaments.

3. Bronze Age, in which bronze was made for arms and cutting instruments of all kinds.

4. Iron Age, in which that metal had superseded bronze for arms, axes, knives, etc., bronze, however, still being in common use for ornaments and frequently for the handles of swords and other arms, though never for blades.*

These divisions are more strictly applicable to European Archæology than to that of America, for during pre-columbian times man on this continent had not advanced beyond the second or neolithic age.

* "Pre-historic Times." Sir John Lubbock.

There can be no doubt that primitive man was a cannibal, scarcely more elevated, in a moral sense, than the beasts which surrounded him, and he was long devoid of a knowledge of all but the simplest forms of art, and was taught by necessity to clutch a stick or unwrought stone as implements of defense or offense, or with which to crush roots or crack nuts for food.

Indeed, this was the condition of the inhabitants of Australia when that continent was first discovered by Europeans. While, therefore, we may justly regard these four ages as natural steps through and by which mankind have progressed from the simplest to the present grand achievements of art, yet the fact can not be overlooked that this progress was not uniform over the entire globe, and that from the present civilization of Europe and the United States we may point to vast regions of country peopled by native races in the lowest stage of savagery, "people who have not conceived the art of fashioning a stone or shaping a bow."

In digging up the bottoms of many of the caves which abound in France, Belgium and Spain, the remains of man, associated with the bones of extinct animals, flint flakes, arrow points and stone knives, have from time to time been found. In some instances these remains were found buried beneath a solid floor of stalagmite of very great thickness, and covered up by many feet of cave-earth (red-ferruginous clay), which is again overlaid by another stalagmitic floor and cave-earth.

Dr. Charles C. Abbott, of Trenton, New Jersey, has for some years past been finding large numbers of palæolithic implements in the glacial drift which forms the lower terrace of the valley on the north side of the Delaware river. The deposit is twenty to thirty feet above the freshets of the river, and extends beneath the bed of the stream. It is composed of large boulders, pebbles and sand, many of which are from archean beds which lie beyond the borders of the State. Though unable to find here any traces of glacial striation on the boulders or pebbles, Dr. Abbott considers the deposit similar to the drift seen in other parts of the State, where striation and grooves are prevalent, and clearly point to glacial origin. The implements are, from their form, called "turtle-back" celts.

Prof. F. W. Putnam also visited the locality where these implements are found, and informed me that he saw numbers of the "turtle-back" celts sticking out of the drift, where they are exposed by cutting away several feet from the face of the cliff, going to prove that they were not brought from near the surface by the sliding of the bank.

Prof. N. S. Shaler, State Geologist of Kentucky, subsequently visited the locality, and while corroborating the testimony of Dr. Abbott and Prof. Putnam that the implements were in place, could not satisfy his mind that the rounded pebbles and boulders belonged to the glacial epoch. This very important discovery of human implements in the drift deposits of New Jersey, by Dr. Abbott, tends to strengthen the evidence in regard to finding a human skull in the glacial deposits of California.

Though there are highly probable accounts of finding the remains of man in the Pliocene deposits of America and Europe, the evidence is not clearly such as will satisfy the strictest demands of science. We may, therefore, look upon the cave-dwellers, who were cotemporaries of the extinct elephant, woolly-haired rhinoceros, hippopotamus, cave-bear, etc., as the most ancient man, and they ante-date the dog and other domestic animals.

The cave-dwellers were probably followed by the mound-builders and the constructors of earth and stone circles; and if, at any period, universal man exhibited but one status, it might justly be claimed for the mound-builders' age—tumuli, or mounds, being found in Egypt, Turkey, Arabia, India, China, Germany, England; indeed, in all countries of Europe, North and South America. Stone circles are reported even in Australia, where the lowest type of man is found, and they are also seen in Japan.

Mr. Shuze Isawa, a native of Japan, who read a paper on the origin of the Japanese people at the Nashville meeting of the A. A. A. S., informed me that the Japanese always built a mound when an Emperor died. Mr. Isawa stated, in his paper, that the Japanese people came from India, and found the island inhabited by a race of savages. These savages were driven to the north part of the island, where a remnant of the race are still to be found.

Notwithstanding this universality of tumuli and stone and earth circles, I think we may justly claim North America as pre-eminently the home of the mound-builder. Here his works are seen in greatest numbers, and culminated in the (so to speak) perfection of his humble but laborious style of architecture, when we consider the simple tools with which the work was accomplished. The step of progress in art, from the cave men to the mound-builders, prevailed only with a branch or offshoot from the primitive stock of men. So it is with regard to all other races who show a decided progress in civilization and arts up to the present time. They are the results of so many developed branches, while the primitive races are still in the lower stages of savagery and barbarism with brains as incapable of ratiocination as their congeners of remote ages. In this stage they will continue until exterminated by the spread of civilization, with which they are unable to cope. In the white race we find the perfection of anatomical and physiological development, and a brain that exceeds that of all other races of men in its size and weight, and immeasurably superior to them in its refined powers of thought. By whatever means we may strive to elevate the Turanian races, and however apt they may be in accumulating ideas and expressing thought, a limit is soon reached, and no amount of training will suffice to surmount the barriers to progress interposed by physiological inabilities. Each race in its respective sphere may continue to achieve triumphs in progressive arts, and grow more and more perfect in knowledge, yet each has its limit, and that limit is determined by organization.

In the prosecution of our investigations of the antiquities of pre-historic man, it is not inappropriate to take a look at the condition and differences which are apparent in his living representatives of to-day.

Ethnologists and naturalists divide mankind into a number of distinct races. Cuvier makes but three, Pritchard seven, Agassiz eight, Pickering has as many as eleven, but the most commonly received classification is that of Blumenbach, who makes five. First is the Caucassian, or white race, including the greater part of the European nations and western Asia; Mongolian, or yellow race, occupying Tartary, China, Japan and India; Ethiopian, or negro race, occupying all Africa south of the Sahara; American, or red race, embracing the Indians of North and South America; Malayan, or brown race, inhabiting the islands of the Indian archipelago and Australia.

There is such a blending of characteristics in some of the lower races that it is by no means easy to establish a boundary line between them, and hence the diversity of opinion in the classification.

Prof. Huxley, with that clearness of thought and profound research that characterizes all his labors, in a paper read before the International Congress of Pre-historic Archæology, which assembled in England in 1868, divides the human family into four races, and I take the liberty of reproducing entire what refers to this point. He says: "By races I mean simply the great distinguishable groups of mankind—such groups as a naturalist would form if all mankind were put before him to be sorted according to their physical likenesses and unlikenesses. And by distinct races I mean those which do not grade into one another, except under such circumstances as make it certain, or at any rate highly probable, that inter-breeding has taken place.

"The number of races in this sense appears to me to be small; indeed, I do not see my way to the recognition of more than four, which I shall call Australioid, Negroid, Mongoloid, and Xanthochroic races.

"The characteristics of the Australioid are: A dark complexion, ranging through various shades of light and dark chocolate color; dark or black eyes; the hair of the scalp black, neither coarse and lank, nor crisp and woolly, but soft, silky and wavy; the skull always belonging to the dolichocephalic group, or having a cephalic index of less than 0.8.

"Under the head of Negroid race are included those people who have dark skins ranging from yellowish brown to what is usually called black; dark or black eyes; dark or black hair, which is crisp, or what is usually called woolly in texture; with very rare exceptions these people are dolichocephalic.

"In the Mongolian race the complexion ranges from brownish yellow to olive; the eyes are dark, usually black; the hair of the scalp black, long, coarse and straight; that of the body remarkably scanty; the proportions of the skull, so constant in the two preceding races, vary in this from extreme dolichocephalic to extreme brachycephalic.

"Finally, in the Xanthochroic race the complexion is very fair; the eyes are blue or gray; the hair yellow or yellowish-brown. In this race again the skull ranges through the whole scale of its varieties of proportion from extreme breadth to extreme length."

All other forms of mankind he considers lie between some two of these primary stocks.

"The Australioids include only the inhabitants of Australia, and are not found in any of the neighboring islands. But, in the Dekkan, which is bounded on the north by the valley of the Ganges, Indus, and Himmalaya mountains, and on the east and west by the sea, there is a people—the Coolies of East India, which, though they have undergone considerable change by intermixture with an invading arianised population, are, he thinks, clearly referable to the Australioids. While the inhabitants of Malacca and the Andaman islands are not considered sufficiently distinct to form a separate race from the true negro who inhabits Africa south of the Sahara, he has applied to them the name of Negritos.

"The Mongolians have their most prominent home in Central Asia, and extend from thence to Lapland, and the Arctic Circle on the north-west and north; to North Hindostan on the south to the Malay archipelago on the east; on the east to China, and thence over the whole of the Pacific islands (except those occupied by Negritos), in the extreme northeast to America, and then through its whole length and breadth.

"The Xanthochroi inhabit a much smaller area of the earth's surface than the Mongoloids. Their center being in Central Europe, whence they extend into Scandanavia and the British islands on the northwest. They extended their wanderings over the great plains of Northern Asia to the frontier of China, and are traceable southward into Syria, and in a fragmentary fashion through Northern Africa to the islands of the western coast, while eastward they occur as far as Northern Hindostan."*

*Report International Congress Pre-historic Archæology, 1868.

The manner in which these races dispersed themselves from specific centres to their present habitats, is a matter of very great interest. It is generally believed that the Mongoloid, or Indians of America, came from Asia by way of the Aleutian islands, but it is far more difficult to understand how the Australioid people found their way to the Dekkan, and the Negros to the islands of Polynesia, that are separated by "broad and stormy seas, when their only known means of navigation was a rude raft."

Mr. A. R. Wallace, President of the biological section of the British Association, in his address at the Glasgow meeting, in September, 1877, among other points of interest bearing on the subject before us, says that "while all modern writers admit the great antiquity of man, most of them maintain the very recent development of his intellect, and will hardly contemplate the possibility of men equal in mental capacity to ourselves having existed in pre-historic times." The weakness of this argument, he says, has been shown by Mr. Albert Mott, in his "very original but little known presidential address to the Literary and Philosophical Society of Liverpool, in 1873," in which he maintains that "our most distant glimpses of the past are still of a world peopled as now with men both civilized and savage," and "that we have often entirely missed the past by supposing that the outward signs of civilization must always be the same, and must be such as are found among ourselves." In support of these views Mr. Mott, as quoted by Mr. Wallace, calls attention to the existence of gigantic stone images, now mostly in ruins, often thirty or forty feet high, and formed of stone, some of which must weigh over one hundred tons. The Easter Islands, he says, on which these images are seen, are more than two thousand miles from South America and two thousand miles from Marquesas and more than one thousand from the Gambier Islands. It has only an area of thirty square miles. The existence of such works, Mr. Mott says, "implies a large population, abundance of food and an established government," and to maintain all of which, he thinks, "necessarily implies the power of regular communication with larger islands or continents, the arts of navigation, and a civilization much higher than now exists in any part of the Pacific." Very similar remains in other islands scattered widely over the Pacific, Wallace says, adds weight to this argument.

While there is little room to doubt, as I have already stated, the existence of various stages of civilization in pre-historic times, yet we must admit that if the Pacific Islanders ever possessed the art of navigating broad seas and carrying on commerce from island to island, or with the continents, they must have lost it before losing the art of fashioning the soft coral rock into images, since Capt. Cook mentions that on some of the islands these images were being constructed at the time of his visit, and the canoe constituted their only means of ocean trade. But it may be well to state here, that it is very singular, in his special mention of Mr. Mott's lecture, Mr. Wallace overlooked the fact that Mr. J. H. Lampry read a paper, in 1868, before the British meeting of the Pre-historic Congress of Archæology, in which he calls attention to the antiquities in the Easter and other South Sea islands as a proof that "in ancient times these seas may have been traversed in all directions by a race of men of high intelligence, great physical endurance, capable of patient toil in the accomplishment of great works, whose scant remains, simple as they are in form, are not destitute of that mystic rythm in arrangement which at once entitles them to a place in the records of pre-historic times."

In answer to Mr. Wallace, I desire simply to call your attention to the fact that ethnological authorities seem now disposed to agree that the aborigines of America belong to the Mongoloid race without admixture of other races. Admitting, then, that the latter conclusion is perfectly tenable, how does it happen that the builders of stone images, upon stone terraces, in the Polynesian Islands, by a people who are of the Negrito type, if possessed of a superior knowledge of arts and skill in navigation, failed to leave the impress of their race upon the American continent? It is a little singular, also, that while Terra del Fuego and Patagonia are inhabited by man, the large islands of the Falkland group, off their coast, were uninhabited; so with the Galapagos, under the equator, while numbers of inhabited islands in the Pacific are less favorable for man's support. I do not believe that man has been degraded from a higher knowledge of art to a lower, nor do I believe that his dispersion over the Pacific islands and the American continent can be explained by a passage from Asia to America by the aid of the Aleutian chain of islands alone, but by a much broader and more extended area of land which in pre-historic times connected the two continents. For the existence of such a connection we need not, from a geological point of view, go farther back than the glacial epoch, when, in order to spread over North America a glacial sheet of ice reaching as far south as 37° of latitude required an elevation of the region to the north that would lay bare vast areas of land now covered by the waters of the Pacific ocean. And it is to geological changes in the physical geography of the earth that we must mainly look, as a cause, for the distribution of pre-historic men. The time required to swell the population of America from a few pairs of voluntary or involuntary voyagers to its aboriginal magnitude could scarcely be less than that required by the intervention of geograpical changes.

In evidence of the slow rate of increase among savage tribes I may cite the accounts furnished by the Jesuit Fathers who settled among the Indians of the Pacific coast soon after its discovery by the whites, for the purpose of converting them to Christianity and instructing them in agriculture and other industrial pursuits. They state that debauchery, tribal wars and exposure of infants, through neglect of the mothers, are fast decimating the race.*

In regard to the character of the works left by pre-historic man, whether in Europe or America, after a careful study of what has been written on the subject, and making due allowance for the inaccuracies of detail woven into many of the accounts from hearsay traditions of the savages, I have failed to see in the antiquities any evidence of a higher order of intellect or mechanical skill than is to be found in the tribes now living. The massive structures, of which the ruins are now only to be seen in New Mexico, Arizona, and other portions of the Rocky Mountain region, Mexico, Central America and Peru, while impressive in size and remarkable for the amount of labor required for their completion, do not surpass or equal for comfort and the moral development of the people, the present adobe houses to be found in some of the existing Pueblo tribes of North America.

In studying the ancient Pueblos, we must discard as totally worthless the grossly false and mythical histories published of the conquest of Mexico by Cortez, Bernal Diaz, the anonymous conqueror, and other Spanish writers. They were subject to revision by the seven ecclesiastical censors of Spain, and made to glorify the church and to magnify the importance of the empire, vanquished by the basest treachery and cold-blooded massacres; yet these so-called histories have been copied and quoted from by subsequent historians, eminent as scholars, without questioning their inaccuracies.

We are indebted to Robert Anderson Wilson, author of the "Conquest of Mexico," for a complete refutation of these authors, based upon a careful study of the subject and a survey of the field of Cortez's exploits. Instead, therefore, of seeing in the Aztecs a people highly advanced in the art of government and surrounded with luxuries, indicative of refinement, we must look upon them as they really were, naked savages, and in no way differing from the Pueblo, or town Indians, of the present day.

In this State the antiquities we have to deal with are, so far as at present known, earth mounds, stone mounds, earth wall enclosures and stone wall enclosures. These remarkable monuments of an extinct people may be traced from Texas to Florida, scattered along the shores of the

*Smithsonian Contributions to Knowledge.

Gulf of Mexico, and extending along the Atlantic coast as far north as South Carolina, and from the mouth of the Mississippi river almost to its head-waters, and following up all its tributaries, and their innumerable branches, to the southern shores of the great lakes. Indeed, so abundant are these antiquities that many have been led to believe that the people who constructed them were at one time the most numerous of all the inhabitants of America. Neither history nor trustworthy tradition can furnish any account of these antiquities, and all efforts, therefore, to define the uses to which they were put, beyond the fact substantiated by exploration, that some of the mounds were used as sepulchers for the dead, is, in my opinion, sheer guesswork. From the fact that these antiquities are never found except along the sea shore, water courses, or by the side of lakes or living springs of water that are not far from a stream, and that the sites which were selected for them have, in many cases, proved the most eligible locations for modern towns and cities, we may reasonably infer that the builders cultivated the alluvial river bottoms and depended mainly on vegetables, fish and mollusks, for their food. The mounds vary in hight from three feet and less, to sixty feet and more, and from a few feet in diameter to several hundred feet.

In shape they are circular, oval and square; some are conical, others truncated, and a few are reported to have winding stairways leading to their summits. The great mound at Grave creek, West Virginia, is said to be seventy feet high, and one thousand feet in circumference at the base. At Miamiburg, Ohio, there is a mound, reported by Squier and Davis, to be sixty-eight feet high and eight hundred and fifty-two feet in circumference at the base. The Cahokia truncated mound in Illinois, is, by the same authority, 700 feet long, 500 feet wide and 90 feet high.

The highest mounds yet found in Indiana are in Knox county. Prof. Collett, in his report on this county, says the "Pyramid mound, one mile south of Vincennes, is 47 feet high, greatest diameter 300 feet, lesser diameter 150 feet; the level area on the top is 15 by 50 feet, and is crowded with intrusive burials of a later race." Sugar Loaf mound, just east of the city limits, was opened up by a shaft which, he thinks, reached the bottom at forty-two feet after passing through:

	Ft.	In.
Loess sand	10	00
Ashes, charcoal and bones		10
Loess sand	17	00
Ashes, charcoal and bones		10
Loess sand	9	00
Ashes, charcoal and bones	2	00
Red altar-clays, burned	3	00
Total	42	8

The mound E. N. E. of Vincennes Court House, is built on a spur of the hills, and the top is sixty-seven feet above the plain. Mr. Collett calls it a "terraced mound," which has a winding roadway to the top. Archæologists have, as I think, without due consideration, classified the mounds into altar and sacrificial mounds, sepulcral or burial mounds, lookout mounds and mounds of habitation.

When we dig into a mound and find that it contains human bones, it may then with propriety be called a sepulchral or a burial mound. But to speak of others as altar mounds or mounds of worship, mounds of habitation or lookout mounds, is assigning to them a purpose which can not be sustained unless fortified by some better proof than the mythical writings of Spanish historians.

It is a common occurrence to find in mounds some ashes and charcoal mixed with human bones, and for this reason the builders have been accused of cremating their dead. So far I have not been able to find any charred human bones, though charred wood and charcoal are of common occurrence. A few fragments of charred bones are reported by Squier and Davis in their so-called sacrifical mounds at Mound City, Ohio. My own opinion is that mounds were simply erected as burial places for the bones of dead chiefs or other persons high in authority. The bones were sprinkled over with ashes and, finally, with earth. Where ashes and charcoal are found in mounds, but no bones, it is possible that the latter disappeared from decay. Charcoal, as is well known, is the most durable of all known substances. Associated with human bones are sometimes seen flint flakes, arrow and spear points, stone axes, knives, pipes, pottery, etc. The practice of burying with the dead, flints, gravel and ashes, prevailed in Europe to a comparatively modern time. It is an old usage, hence "ashes to ashes, dust to dust."

Shakspeare alludes to this custom in the play of Hamlet, in the scene where the priest who had charge of the burial of Ophelia, is made to say, in reply to Laertes:

"Her obsequies have been so far enlarged
As we have warranty: Her death was doubtful;
And but that great command o'ersways the order,
She should in ground unsanctified have lodged
Till the last trumpet; for charitable prayers,
Shards, flints and pebbles should be thrown on her,
Yet here she is allowed her virgin crants,
Her maiden strewments, and the bringing home
Of bell and burial."

In Wisconsin there are a large number of mounds built to imitate the shape of various kinds of animals, not omitting man. These mounds contain ashes and the remains of human skeletons, with copper and carved stone trinkets, pottery, etc. In the latter respect they do not differ from the conical, square and truncated mounds of other localities.

The romance which has been thrown around the so-called *Teocalli*, or temple-mounds of Mexico, by the Spanish historians of the conquest, and so inconsiderately adopted by American archæologists, vanishes when put to the crucial test by accurate observations.

Torquamana, who examined the celebrated Mexican temple-mound of Cholula, says: "It still remains without any steps by which to ascend, or any facing of stone. It appears now like a mound covered with grass and shrubs, and possibly it was never anything more."

Mr. Robert A. Wilson also visited this mound before writing his history of the "Conquest of Mexico," and corroborates the statement of Torquamana, and he is further satisfied, from the general appearance, that it is of common origin with similar mounds scattered through the country.

Associated with the mounds we have earth wall and stone wall enclosures—some are perfect circles, some square, some ovoid, and still a larger number that are anomalous in design. The hight of the walls vary from a foot or two to ten feet or more. Most generally they are accompanied by a fosse, or ditch, which is placed on the inside, rarely on the outside of the wall. In area these works include from a few square feet to upwards of one hundred acres. Like the mounds, they are built on river terraces or high table-lands, bordering streams.

The uses for which they were designed by the builders are, in most cases, to say the least, beyond the discernment of careful students of antiquities; and opinions on the subject are almost as numerous as the observers themselves. Where the walls are built around the brow of a high point of land with a level area on top, and is not commanded by the surrounding high-lands, as the "stone fort" at the mouth of Fourteen-mile creek, in Clark county, figured and described in the Indiana Geological Report, 1873, we may reasonably infer that the wall was built as a means of security against intruders upon their privacy or as a defence against warlike foes. The small circular enclosures are generally looked upon as being subservient to some religious ceremonies, I should rather say, superstitious weight, in commemoration of human prowess.

One of the most eminent of American archæologists—Dr. Lewis C. Morgan, of Rochester, N. Y.—in the July number of the *North American Review*, 1876, entertains the opinion, in an ably written article, that the earth walls served as the foundation upon which to construct dwellings. The article is accompanied by figures to show the manner of house that might be adapted to the walls, and the facility with which it could be built by inclining poles of wood against the sides and securing them at the top.

The house is divided into a number of rooms to suit their communal customs. These rooms are occupied by separate families. A place for the fire is arranged at intervals in a hall which runs the entire length, so as to accommodate the necessities of four compartments. In answer to this very plausible theory of my learned friend—Dr. Morgan—I wish to say that if his views are correct we should be able to find at intervals on the embankments, ashes and charcoal and other refuse kitchen matter, but, so far as I know, this has never been done.*

What is now demanded of the archæologist is a more careful study of these mounds and enclosures; maps should be made of the grounds, and sections given which accurately delineate the order of arrangement of the internal structure of the works, and a careful record given of the position occupied by the relics which they may contain. We should by all means discourage, and turn a deaf ear to the relation of ingeneous traditions gleaned from unworthy sources, or wormed from the aborigines by leading questions, and concluded in too many cases by affixing imaginary answers. I repeat that the problem of the condition of pre-historic man can alone be satisfactorily solved by a study of his remains and the works he has left behind him.

With regard to the cranial differences in the races of men, I wish to call your attention to a paper read by Dr. T. O. Summers, Jr., at the late meeting of the A. A. A. of Sci., in Nashville, wherein he pointed out that there is a constant relation existing between the length of the spheno-parietal suture and the capacity of the brain case, determining the brachycephalic or the dolichocephalic character of the skull. Dr. Summers has had the rare opportunity of examining the large collections of skulls in the various cities of Europe, and has also a large collection of his own, and by the aid of this important discovery unhesitatingly declares that he could at once separate from one another the skulls of white men negroes and mulattoes.

The ethnologist has long felt the want of more certain rules for the classification of crania than that afforded by a mere measurement of capacity, dolichocephalic and brachycephalic, and I believe that this discovery of Dr. Summers will, if not infallible, prove to be at least of very great assistance in accomplishing so desirable an object, since it is by a

*Since writing the above I have had an opportunity to visit a Pima Indian village in Arizona. The houses are usually made of bows stuck into the earth and the tops are bent over and tied, giving the dwelling the shape of a bird cage. A wall of earth, one to two feet high, is thrown up around the base on the outside. I saw many of these earth rings where the brush had been taken away, and they have exactly the appearance of the small circular enclosures seen in this and adjoining States, but there was no ditch on the inside. They were simply thrown up to keep out the wind and water.

study of the osteology of man that we must look for a true classification and a solution of his capabilities.

Archæologists are now fully aware that the neolitic implements and pottery of the mounds are in no way distinguishable from those made by the aborigines from pre-columbian to the present time, and as a means of classification they must totally fail. My distinguished friend, Dr. Lewis H. Morgan, in his recent and very able work called "Ancient America," has given a division and classification of ethnical periods that indicates a thorough acquaintance with the subject, and his book should be in the hands of every student of ethnology. No man in America has done more than Dr. Morgan to systematize and make known the true status of the aborigines, and I take pleasure in thus publicly acknowledging my obligations to him for so valuable a contribution to our knowledge.

In conclusion, I desire to call your attention to the care which must be exercised in reaching conclusions on the examination of objects which come under the notice of collectors.

George Rapp, who was at the head of a community of Germans known as "Harmonists," that came to this State in 1815, and settled on the Wabash river, in Posey county, where they built the town of New Harmony, found at St. Louis a large stone slab, eight feet long, five feet wide and eight inches thick, upon which is seen the images of two human feet; in front of these images is an irregularly rounded mark; the feet have the appearance of being the impress made on mud, and the scroll as having been made with a stick in the hands of the owner, and the mud so impressed subsequently hardened into stone.

This foot-print slab was held in high esteem by Rapp, and he played upon the superstitions of his followers by stating that they were left by the angel Gabriel, who alighted on the earth to warn the people of the near destruction of the world. It must be remembered that the Rappites or Harmonists were Second Adventists.

Schoolcraft, in his journey down the Wabash, in 1821, stopped at New Harmony, and gives an account of this foot-print slab, accompanied with accurate drawings. In this account he expresses the opinion that the impressions were those made by an Indian who stepped out of his canoe on a mud beach and made the mark in front of the tracks with a stick and then stepped back into his canoe; subsequently the mud hardened into stone, which preserved the fossil imprints.

Mantell, one of the ablest and most fascinating writers on geology, saw this account of the foot-print slab, and transferred it to his "Wonders of Geology," Vol. 1, p. 75, American edition from third London edition, in the following language:

"*Impressions of Human Feet in Sandstone.*—In connection with the occurrence of human bones in limestone, I will here notice a discovery of the highest interest, but which has not as yet excited among scientific observers the attention which its importance demands. I allude to the fact announced in the American Journal of Science, Vol. V., 1822, of impressions of human feet in sandstone, discovered many years ago in a quarry at St. Louis, on the western bank of the Mississippi river. The above figure is an exact copy of the original drawing, and exhibits the impressions of the soles of two corresponding human feet placed at a short distance from each other, as of an individual standing upright in an easy position. The prints are described as presenting a perfect impress of the feet and toes, exhibiting the form of the muscles and the flexures of the skin, as if an accurate cast had been taken in a soft substance. They were at first supposed to have been cut in the stone by the native Indians, but a little reflection sufficed to show that they were beyond the efforts of these rude children of nature; since they evinced a skill which even my distinguished friend, Sir Francis Chantry, could not have surpassed. No doubt exists in my mind that they are the actual prints of human feet in soft sand, which was quickly converted into solid rock by the infiltration of calcareous matter in the manner already described. The length of each foot is 10½ inches, the spread of the toes 4 inches, indicating the usual stature; and the nature of the impression shows that the feet were unconfined by shoes or sandals. This phenomenon, unique of its kind, is fraught with so much importance that I have requested Prof. Silliman to ascertain the nature of the sandstone and the period of its formation."

My honored preceptor, the late David Dale Owen, soon exposed the fallacy of the hasty conclusions reached by Schoolcraft, and pointed to the fact that the slab was a limestone belonging to the palæozoic age, and was studded with brachiopod shells, characteristic of the sub-carboniferous period, and the tracks, however perfect in form, were carved into the solid rock by human hands. The most zealous advocate of man's antiquity would hardly dream of tracing him back to palæozoic times. Subsequently Dr. Owen collected a large number of stones containing carved human feet, and from a careful study of the subject came to the conclusion that in most cases they were carved in stone, so situated, as to commemorate the highest water-mark of the streams, or to note some other memorable event.

I mention these facts to show how easy it is for one to be led astray, when every possible phase of the subject is not carefully studied. Let us, therefore, attend strictly to detailing facts of observation, and they are sure to lead to a correct solution of all problems within the compass of the human mind.

PORCELAIN, TILE AND POTTERS' CLAYS.

With a view to promote the pottery industry, and point to the value of the clays in Indiana for manufacturing porcelain, iron-stone china and encaustic tile, I have had analyses made of a large number of clays found in different parts of the State, as well as of some of the most noted clays of other States, for comparison. The large deposit of white porcelain clay found in Lawrence county has already been alluded to in my previous reports, but from its vast importance it will not be inappropriate to make further mention of it here. This large bed of white clay, to which I have given the name of *Indianaite* (Indiana stone), has been sold to the Pennsylvania Salt Company of Philadelphia, and is being extensively used by them for the manufacture of sulphate of alumina. It is readily soluble in dilute sulphuric acid, and the absence of iron and other foreign substances renders it of the greatest value for this branch of manufacture, and alum made from it has no equal in the market. It is called Indianaite because it differs from kaolin in the manner of its origin and in the amount of water which it contains. In the latter respect it is closely allied to halloysite, but differs from that in its physical characteristics. Associated with Indianaite (not Indianite, since that name is derived from Indian, not Indiana, and is pre-occupied,) we have typical specimens of halloysite and allophane.

The bed is four to ten feet thick and, where mined, has been pretty well proved to cover forty-two acres of ground. For the manufacture of fine grades of porcelain and granite ware it surpasses all other clays for purity of color and homogeneous texture. It is principally sold to the potters of Cincinnati, Tempest, Brockman & Co., being the largest customers, and the excellent quality of ware which they turn out is largely due to the use of Indianaite. East Liverpool, Ohio, potters also use a considerable quantity of this clay, and some goes to the potters of Trenton, New Jersey.

I have received and answered letters from a great many persons who make inquiries about the clay with a view to starting potteries in this State. They all admit the advantage of a closer proximity to the clay and coal, but the general depression in all kinds of business, and a want of sufficient capital, has prevented the consummation of these enterprises. Not so, however, with the manufacture of encaustic tile. After proving the existence of a great many beds of excellent clay suitable for the business, Mr. Hall succeeded in inducing Messrs. Douglass, Lyon and Harrison to join him in putting up a factory in the latter part of 1877. The manufacture proved to be a splendid success. Clays giving a variety of natural colors were obtained at a very low price, and just suited to the purpose. They are now turning out floor and mural tile that are in every respect equal to the best foreign tile. They have already had to increase the capacity of their factory to meet the growing demand for encaustic tile floors.

The following analyses indicate the composition of the porcelain, encaustic tile, and common potters' clays:

Indianaite, white porcelain clay, Lawrence county, section 21, township 3, range 2, amorphous, cuts smooth without grit, greenish white color, fades on long exposure to the light, powder white, unctious feel.

Specific gravity, 2.31; hardness, 2 to 2.5.*

	Per Cent.
Water, dried in hot air oven for six hours, at 212° F.	9.50
Water, combined	14.00
Silicic acid	39.00
Alumina	36.00
Lime and magnesia	0.63
Alkalies	0.54
	99.67

*For further information on this mineral see Indiana Geological Reports, 1874 and 1875.

Henry Pemberton, of Philadelphia, found a trace of cobalt in a sample of Indianaite.

Alophane, from same locality, emerald color, amorphous, crumbles to powder after being exposed to the atmosphere of a dry room, powder white:

	Per Cent.
Hygroscopic water	26.50
Combined water	14.50
Silicic acid	15.71
Alumina	42.74
Carbonate of magnesia	0.59
	99.54

Kaolin, Woodbridge, New Jersey, analysis by Henry Pemberton, Jr.:

	No. 1.	No. 2.
Loss by ignition	14.90	14.80
Silica	44.10	44.70
Alumina	39.36	38.77
Ferric oxide	1.04	1.08
Nickel and cobalt	trace.	trace.
	99.40	99.35

Magnesia and alkalies undetermined.

South Carolina Kaolin, by same analyst:

	No. 1.	No. 2.
Loss by ignition	14.65	14.22
Silica	44.10	44.60
Alumina	40.00	41.00
Ferric oxide	0.64	0.00
Titanic acid	0.08	0.13
	99.47	99.95

Mr. Pemberton made analyses of two samples of Indianaite. No. 1, soft white variety; No. 2, hard white variety:

	No. 1.	No. 2.
Loss by ignition	22.90	23.60
Silica	39.35	38.90
Alumina	36.35	37.40
Lime	0.40	undt.
	99.00	99.90

Dr. Robert Peter, of Lexington, Ky., Chemist of the Geological Survey of that State, found, in a sample of Indianaite:

	Per Cent.
Potash	0.190
Soda	0.204

Dr. Peter also found in the celebrated glass-pot clay of Gobel & Co., from Germany:*

	Per Cent.
Potash	0.578
Soda	0.112

Kaolin, from Wilmington, Delaware, from samples at the Centennial Exhibition:

	Per Cent.
Moisture at 212° F.	0.50
Loss by ignition	12.40
Insoluble silicates	72.40
Alumina	14.80
Ferric oxide	trace
Lime	0.35
Alkalies	0.85
	101.10

Kaolin, from National Clay Company's exhibit at Philadelphia:

	Per Cent.
Moisture at 212° F.	0.30
Loss by ignition	11.17
Silica	68.50
Alumina	17.20
Ferric oxide	1.30
Lime	0.25
Alkalies	0.79
	99.51

*Letter from Dr. Peter to the State Geologist.

Kaolin, Chester county, Pennsylvania, from Centennial Exhibition:

	Per Cent.
Water at 212° F	0.80
Loss at red heat	10.70
Silica	70.80
Alumina	17.00
Ferric oxide	0.40
Alkalies	0.66
	100.36

Kaolin, J. Leslie Skelton, Irwinton Depot, Nelson county, Virginia, Philadelphia Exhibition:

	Per Cent.
Water at 212° F	1.00
Loss at red heat	11.12
Silica	69.50
Alumina	19.10
Ferric oxide	none
Alkalies	1.00
	101.72

Clays used for fire brick, coarse pottery and encaustic tile manufacture. Under clay to coal seams, soft, plastic, unctious feel, and more or less gritty when tested by the teeth. Specimens sent from Parke county, by Professor Barnabas Hobbs, marked "fire clay," light gray color:

	Per Cent.
Loss by ignition	4.10
Silica	66.18
Alumina	21.15
Ferric oxide	5.30
Lime	0.70
Magnesia	0.14
Sulphuric anhydride	0.67
Soda	0.33
	98.57

Specimen from the same county, marked "slip clay," also sent by Professor Hobbs:

	Per Cent.
Loss by ignition	8.60
Silica	55.20
Alumina	14.40
Ferric oxide	9.40
Manganic oxide	1.80
Lime	6.12
Magnesia	0.90
Sulphuric anhydride	0.34
Soda	0.52
	97.28

This is a very remarkable clay, melts at a moderately low temperature, and is highly useful as a glaze for common stone pots. Potters from all parts of Illinois and Indiana use it, and so far they have not been able to find any clay in the West that can be substituted in its place.

Potters' clay from Barnett's land, near Reelsville, Putnam county; color, grayish white; unctious to the feel and remarkably plastic; it lies under a seam of coal and is four feet thick. The following section shows the order of associated beds at the crop:

Black bituminous shale	1 ft. 6 in.
Cannel coal, good	0 ft. 5 in. to 7 in.
Caking coal, good	0 ft. 9 in.
Rotten coal	0 ft. 4 in. to 6 in.
Good coal	0 ft. 9 in.
Potters' clay	4 ft. 0 in.

A sample washed lost 12 per cent. of gray sand.

Washed clay, after being air-dried in the room of the laboratory, was analyzed, and also unwashed specimens:

	Washed.	Unwashed.
Loss by ignition	6.30	6.30
Silica	60.56	61.20
Alumina	27.00	25.45
Ferric oxide	3.48	0.39
Sulphuric anhydride	0.27	0.30
Calcium carbonate	0.25	0.39
Potash	2.48	undt
Soda	0.32	undt
Magnesia	undt	0.85
	100.66	94.88

The silica contained 0.25 per cent. of baryta. This clay burns to a high cream color.

Potters' clay from Martz, Clay county, under clay to coal seam, very light ash color, unctious to the touch, contains a very small quantity of grit, is very plastic, and burns of a light cream color:

	Per Cent.
Loss by ignition	8.10
Silica	65.66
Alumina	17.20
Ferric oxide	4.05
Manganic oxide	0.80
Calcium carbonate	0.73
Sulphuric anhyd-ide	0.74
Alkalies and loss	2.72
	100.00

Ganister Rock, hard, compact, silicious clay, immediately over block coal at Watson's mine, Knightsville, Clay county.

It is used for fire-brick and for lining Bessemer converters, being very refractory:

	Per Cent.
Loss by ignition	6.80
Silica	67.87
Ferric oxide	7.24
Manganic oxide	1.95
Alumina	12.70
Calcium carbonate	1.45
Magnesia	0.85
Potash	0.17
Soda	0.08
Sulphuric anhydride	0.29
Baryta	trace
	99.40

Analysis of decomposed silica from Alex. McPike's mine, near St. Genevieve, Mo.; it is a fine powder and as white as flour, used in glazing porcelain:

	Per Cent.
Moisture	0.80
Silica	97.95
Alumina	1.00
Lime	trace
	99.75

This is a very pure silica, and requires very little preparation for the potter's use. The usual form of flint has to be calcined and ground at considerable expense to the manufacturer.

No locality in our own State has yet been discovered where flint, suitable for potter's use, can be had at a reasonable cost. Tempest, Brockman & Co., the large potters of Cincinnati, have used the St. Genevieve flint powder, and pronounce it good.

Feldspar is another mineral used along with flint in making the glaze for porcelain. The most available localities for this mineral are in Alabama and New Hampshire.

Attention is called to these minerals that potters may know where to get the materials best suited for the manufacture of porcelain, terra cotta and encaustic tile.

WYANDOTTE CAVE.

When on a visit to Wyandotte Cave, in Crawford county, I collected a number of samples of earths, some of the water from the sulphur spring,* and bat guano.

Analysis of red plastic clay, unctious to the touch, and without grit, cuts very smooth:

	Per Cent.
Loss at red heat	11.70
Silicic acid	48.50
Ferric oxide	12.30
Manganic oxide	1.05
Alumina	19.50
Lime	1.79
Magnesia	0.52
Carbonic anhydride	1.97
Sulphuric anhydride	1.11
Phosphoric acid	0.44
Chloride of alkalies and loss	1.12
	100.00

Magnesian earth, so-called, is more properly a combination of gypsum and ferruginous clay. Analysis:

	Per Cent.
Loss at red heat	24.10
Silica	31.60
Ferric oxide	10.70
Manganic oxide	trace)
Alumina	3.90
Lime	8.28
Magnesia	1.54
Carbonic anhydride	8.22
Sulphuric anhydride	11.00
Phosphoric acid	0.41
Chloride of alkalies and loss	0.25
	100.00

* For the location of this spring see Map of Wyandotte Cave, accompanying Prof. Collett's report of Crawford county, in this volume.

Nitre earth. This is a red clay similar to that used for the manufacture of saltpetre during the war of 1812. A large amount of this earth was lixiviated during that period, and owing to the high price of nitre the manufacture was conducted with profit. It contains in 100 parts:

	Per Cent.
Loss at red heat	16.50
Silica	20.60
Ferric oxide	6.03
Manganic oxide	0.75
Alumina	20.40
Lime	8.06
Magnesia	4.58
Carbonic acid	10.38
Sulphuric acid	6.55
Phosphoric acid	2.43
Nitric acid	3.50
Chloride of alkalies and loss	0.32
	100.00

The 3.5 per cent. of nitric acid would unite with 3.05 per cent. of potash to form 6.55 per cent. of nitre, or 100 pounds of the earth would yield 6.55 pounds of nitre. The large amount of phosphoric acid present is probably due to the clay containing some decomposed animal bones.

Bat guano. In portions of both the old and new caves there are large deposits of bat guano, but it is possible that the expense of bringing it out through some very narrow and rugged passages will be too great to render it available for fertilizing purposes. Composition:

	Per Cent.
Loss at red heat	44.10
Organic matter	4.90
Ammonia	4.25
Silica	6.13
Alumina	14.30
Ferric oxide	1.20
Lime	7.95
Magnesia	1.11
Sulphuric acid	5.21
Carbonic acid	3.77
Phosphoric acid	1.21
Chloride of alkalies and loss	5.87
	100.00

It will prove an admirable fertilizer, though not nearly so good as Peruvian guano.

Analysis of water from the so-called sulphur spring in Wyandotte Cave. An imperial gallon contains 55.3 grains of solid matter, composed of:

	Per Cent.
Insoluble silicates	0.200
Ferrous oxide	0.144
Calcium oxide	4.170
Magnesium oxide	9.830
Sulphuric anhydride	25.180
Carbonic anhydride	8.160
Sodium oxide	1.127
Potassium oxide	0.560
Chlorine	0.350
Loss and undetermined	5.579
Total solid matter	55.300

This is a sulphate of magnesia water, and might be more properly called an epsom spring.

The above substances are probably combined to form the following salts:

	Per Cent.
Carbon dioxide, free	5.6946
Silicic acid	0.2000
Ferrous carbonate	0.2319
Calcium carbonate	3.8899
Calcium sulphate	6.4537
Magnesium sulphate (epsom salts)	29.4929
Potassium sulphate	1.0366
Sodium sulphate (glauber salts)	2.2088
Sodium chloride (common salt)	0.5767
Loss and undetermined	5.5149
Total solid matter	55.3000

Medical properties, diuretic and tonic.

THE COST OF MAKING BESSEMER IRON IN INDIANA.

While there is much ore in Indiana that will answer for making iron, it is either lean or containing so much sulphur and phosphorus that it is useless for good grades of metal and Bessemer steel, or it is so situated with reference to fuel that the cost of transporting one or the other will place its value beyond what the present price of iron will justify. It is useless, in my opinion, to base any calculation upon an advance in the metal. If anything, iron will be lower rather than higher within any reasonable space of time.

In looking, then, for a location where iron smelting can be made profitable under the existing conditions of the market, and to meet the highest wants of the trade, the very first thing to be taken into consideration is where to find a suitable fuel and existing railroad communication with the surrounding world.

There can be no question as to what kind of fuel is required. It must be mineral coal. The days of charcoal furnaces are numbered, and they will soon be of the things that are read of in history. The fossil fuel, according to quality, must be in its natural condition, as anthracite, dry-burning bituminous, or block coal, or coke made by charring bituminous coals. The coal must contain the smallest possible quantity of sulphur, phosphorus and ash, since these impurities will be imparted to the iron, and thereby reduce its market value. If bituminous coal is used raw, or without being coked, then its physical properties must be such as will cause it to coke and burn in the furnace without melting and forming a cake, since the latter coals obstruct the draft of the furnace and interfere with ready combustion. The proper fuel having been found, the next point to be settled is the location of an abundance of iron ore that is rich in metal and poor in sulphur and phosphorus. In the west there is at present but two districts known where such ores can be found that answer these requirements in the fullest possible manner: the Lake Superior iron region and the Iron Mountain, Missouri. At neither of these celebrated districts can coal be had, and charcoal furnaces can no longer be made to pay. The question of freight now settles the point with regard to the fact that the ore must be transported to the fuel, since it will require twice as much coal, by weight, as ore to produce a ton of metal.

There are, in my opinion, only three districts where coal can be found that will enter into competition for the smelting of these ores: Youngstown and Pittsburg, Pennsylvania, and their vicinities and Clay county, Indiana. The two former localities and their capabilities are well known, so that it will not be necessary for me, at this time, to make further mention of them, but will confine myself to bringing more prominently before the public the facilities afforded by Indiana for the production of Bessemer pig iron profitably at the present low rates of iron and steel.

There are three seams of block coal in Clay county, and they are designated by the miners as upper, middle and lower block coal seams. It is rarely that the three seams can all be worked on the same property in this county. The glacial drift covers the land to a depth varying from twenty to sixty feet, and the lower seam of coal seldom lies more than eighty feet below the surface, so that the upper coal is often absent, and when present is seldom found with any roof more than gravel and sand of the drift, which makes it costly and difficult to mine. The middle and lower seams are often present and worked on the same property from a single shaft. The three seams are respectively twenty and forty feet apart, and each average from three feet to four feet six inches in thickness. The lower seam is considered the best blast furnace coal, and even this is, at some localities, unfit for such use on account of the sulphur which it contains; while at others it is as free from sulphur as wood charcoal. It contains from fifty-six to sixty per cent. of fixed carbon, and only from one to two and a half per cent. of white ashes. This coal burns freely without caking, and in grates or furnaces never leaves any cinders. Charred in ovens it makes a steel-grained, hard coke, resembling in shape the raw block coal from which it was made.

I desire to say here that many writers who have compared the block coal of Indiana with the coal of other districts, have either selected specimens from the grate and steam coal, or have extracted from my reports the analyses of coals that are not used or fitted for smelting iron. Indeed, in some instances men, eminent as geologists and chemists, have selected from my tables of analyses as a typical specimen with which to compare coals they are writing up—coals that are not block coals at all, and it is so stated in the body of my report. I do not pretend to deny that we have in Clay county caking coals and block coals that are totally unsuited for smelting iron, and I want it particularly understood that I am now writing of none but the best, and of these we can find plenty in the State and district of which I am writing.

Since the blast furnaces were built in Clay county there has been something learned in regard to the best form of furnace to run with raw coal, and especially with regard to the necessary amount of blast and the best mode of heating it, so that it will be safe to say that a furnace may now be built that will materially lessen the consumption of fuel and increase its monthly product.

We propose now to build a modern blast furnace in Clay county, Indiana, which shall be moderate in dimensions and supplied with Whitwell's hot-air ovens, and give from this the cost of making the very best grade of pig iron, such as will be suited for Bessemer steel. Before commencing its construction we will have to consider the place it is possible to have—

1. Suitable coal close at hand.
2. Abundant supply of water.
3. Railroad facilities to reach the ores and iron markets.

We will now suppose the furnace to be built sixty feet high, eighteen feet wide at the boshes, and supplied with three benches of Whitwell's hot-air ovens. The cost will be about $60,000. With regard to the cost of the property upon which to place the furnace. I will take a coal lease which I have in my mind, that comprises about 240 acres of good block coal, and pay a royalty of ten cents per long ton of 2,240 pounds of screened coal. The nut coal does not have to be paid for, and is a clear gain. The mine is opened by shaft, seventy feet deep, and is supplied by every convenience for hoisting and preparing the coal for market. This property will cost as it stands, with lease to run ninety-nine years, $6,000.

Cost of furnace	$60,000
Cost of coal property	6,000
Cost of coking ovens	2,000
	$68,000

In order to convey a better idea of the cost of running the furnace it will be necessary to quote from the accounts of the Brazil furnace, which went out of blast in the spring of 1877. In this furnace it required to make a ton of bessemer pig:

One and a half tons of Lake Superior Iron ore, which costs at Escanaba	$7 50
Freight to Michigan City, by lake	75
Freight from Michigan City to Brazil	1 30
4,250 pounds of raw coal	3 18
650 pounds of coke	1 33
1,200 pounds of limestone	62
Labor	2 50
	$17 18

At the new furnace, built on the coal seam, we will get the coal at a cost not to exceed ninety cents per ton, including royalty, delivered at the furnace. The account at this furnace will then stand thus:

One and a half tons best Lake Superior ore	$7 50
Freight from mine to furnace	2 05
4,250 pounds of raw coal	1 91
650 pounds of coke	1 33
1,200 pounds of limestone	45
Labor (about)	1 25
Repairs and incidentals	25
Cost of one ton of Bessemer pig	$14 74

The run will be about 1,600 tons per month, and the pig will be worth $19 per ton, at the furnace, for consumption in bessemer plants. In this calculation the consumption of fuel is based upon the amount required in the Brazil furnace, but with the Whitwell hot-air stoves it is reasonable to suppose that the consumption of fuel will be reduced, as well as the cost of labor, which is just as much every day or month, whether the furnace makes twenty-five or fifty tons of pigs per diem, and it must be admitted, at the present low price of labor, that in our new furnace the cost, per ton of iron, should not exceed $1.25 per ton of make.

With the advantages which Clay county unquestionably possesses for the manufacture of Bessemer pig, the iron-master can not doubt for a moment that the Bessemer plant should be placed here and by the side of the blast furnace, and the melted iron run direct from the furnace into the converters. This will secure an immense saving on the cost of making steel rails.

There are already furnaces enough in the United States, if all were in blast, and a material rise in iron would soon put them in, to supply not only this country, but leave a large surplus for exportation. Europe is also overstocked with idle furnaces, ready to rush into blast with the first symptom of an improved market for iron. Such a blowing in, it is easy to foresee, would soon cause the market to tumble. Consequently the day is close at hand when blast furnaces and Bessemer plants must be brought together and located on the coal.

Coal can be mined as cheaply in Indiana as in any other coal field. The shafts are shallow and inexpensive; the roof is good, and cheaply secured against danger of falling, and the mines are free from noxious gases. The coal itself is as free as possible from deleterious impurities, rich in carbon, and from physical structure and the peculiar arrangement of its proximate constituents, is peculiarly adapted for fuel and metallurgical purposes. The field is accessible from all points by railroads, and lies in the very center of western commercial prosperity and progress. With such advantages can any one doubt for a moment that Bessemer pig and Bessemer steel can not be made here at a less cost than in plants, located where neither the coal nor ore are to be had, without being brought from a distance. In the struggle for existence now going on, those alone can live that have the most favorable locations with regard to the cost of fuel and ore. It is the question of the survival of the fittest, and those who look for any material advance in the price of iron will look in vain.

Far better will it be to seek for furnace locations, where a ton of steel can be produced with profit under the most depressed condition that may arrive in the market. After a study of the western coal field, extending over a period of more than thirty years, I can point with confidence to the block coal field of Indiana as the locality in which to solve the problem of the lowest cost of production. Cheaper iron may be made elsewhere, but it is of *Bessemer pig* and *Bessemer steel* I speak, and for which I commend this field to the attention of ironmasters.

WAYNE COUNTY.

Wayne county was organized in 1810, and was named in honor of General Anthony Wayne. Previous to this time there were only three counties in the then Territory of Indiana, viz: Knox, Clark and Dearborn. Wayne county was formed from a portion of the latter county. The first county seat was called Salisbury; but this town was doomed soon to be deprived of its honors as a law center, and so rapid was its decay that not a vestige now remains to mark its location.

The county seat was moved from Salisbury to Centreville, so named from its geographical position in the county. It remained there until moved to Richmond, in 1875, which is the present seat of county business.

The early settlers of this county were mostly from North Carolina and Virginia, and belonged to the society of Quakers. They were mostly intelligent, sober and industrious people. They took an active interest at an early day in the internal improvement system organized by the General Assembly for the cheap transit of western produce to the chief markets of the country. The Cumberland or National road, designed by the General Government to connect Baltimore with St. Louis, passes very nearly through the center of the county from east to west. Though never completed beyond the western border of Indiana, this road was of incalculable value to the farming and manufacturing industries, and important towns grew up at short intervals along its entire course. The largest of these are the city of Richmond (which contains a population of 12,600), Centreville, Germantown, Cambridge City and Dublin. The National road was followed by the White Water Valley canal. This great improvement extended from Hagerstown, on the west branch of White Water river, down the valley of that stream to Cincinnati, on the Ohio river, passing through Cambridge City and Milton. The canal soon made Cambridge City a large shipping point for produce, and it became the center of a vast trade with the surrounding country. Another canal was located from Richmond to Brookville, in Franklin county. This work was partly completed, but never finished. The White Water canal is no longer in use for the transportation of produce, having been completely superceded by the White Water Valley railroad, which runs along its banks. Locally the Canal furnishes an admirable water power, and is still an important adjunct to the manufacturing interests of this and the adjoining county of Fayette. In the latter county, at Connersville, it furnishes the power for the large works of Messrs. Roots, in which is manufactured the world-renowned Roots' blower. At Cambridge City and at Milton the Canal is also utilized as a water-power for manufactures.

This county is now well supplied with railroads. The Pan-Handle road, from Indianapolis to Pittsburg, follows the course of the old National road, and passes through Dublin, Cambridge City, Germantown, Centreville and Richmond; the Fort Wayne & Richmond railroad, running through Fountain City, in Garden township; the Chicago division of the Pittsburg, Cincinnati & St. Louis railroad passes from Richmond through Washington and Hagerstown; Dayton & Richmond railroad; Richmond division of the Cincinnati, Hamilton & Dayton railroad; Cambridge City & Columbus railroad; Fort Wayne, Muncie & Cincinnati railroad runs through Cambridge City; White Water Valley railroad runs from Cambridge City to Cincinnati, Ohio, following the line of the old Canal; there is also a short line of road running from Hagerstown to Cambridge City. In addition to this very extensive system of railroads there are innumerable gravel roads leading in and out of all the principal towns and villages in the county, and, indeed, through almost every neighborhood, so that in respect to internal improvements, that furnish egress and ingress for travelers and commerce, no county in the State, except Marion, can boast of greater facilities.

TOPOGRAPHY AND HYDROGRAPHY.

The characteristic topographical feature of the county is that of an elevated campaign, or table-land, which gradually slopes from the northern boundary of the county to the southwest. The general elevation of the north part may be stated at 1,200 feet above mean ocean tide in New York harbor, and that of the southern part of the county at 900 feet.

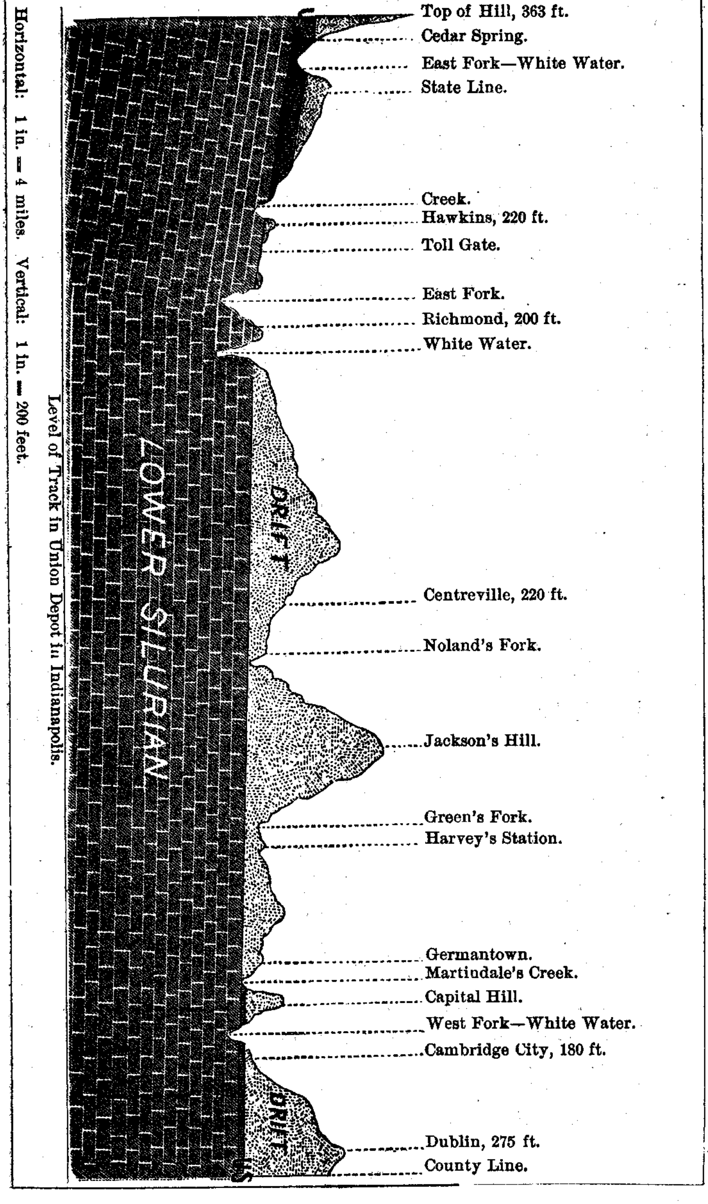
This plateau is cut through by innumerable rivulets and larger streams that have their sources in the north part of the county, and flow to the southwest, and finally fall into the White Water river. The eroding effects of these streams are not so marked in the north, where they carry but a small volume of water, as we find in the south; there they run through broad shallow valleys that are not cut below the tough boulder clays of the drift, but in the south part of the county the erosion has, in some places, been carried far down into the beds of the Hudson River group of rocks. At the city of Richmond this phenomena is so marked that we may, with propriety, speak of the eroded bed of White Water river as a veritable canon. The banks here are composed of 100 to 110 feet of Hudson River rocks, that in places form almost vertical mural shores to the stream. The Pan-Handle railroad bridge spans this stream across a narrow part of its canon. Along the principal water-courses there, this plateau is interrupted by deep erosions, which terminate very rapidly as you recede from the streams, and the country opens into beautiful level tracts. A glance at the map will show that this county is well supplied with streams of living water. The west branch of White Water river, with its principal tributaries, Nettle fork, Martindale's fork, Green's fork and Noland's fork, spread out over at least two-thirds of the county, and the balance is watered by White Water river and its tributaries, Elkhorn creek, Short creek, East fork, Middle fork, West fork, Lick creek, and numerous smaller branches that have only local names. The large area of level lands, covered with a grand forest which includes every variety of timber that grows in this latitude, and the numerous streams of clear running water, must have proved an attractive sight to the early emigrants, and the rapid growth of the county in population and wealth, has given proof that no part of the country afforded a truer prospect for happy homes.

GEOLOGY.

The oldest stratified rocks in this county belong to the Hudson River group of Prof. James Hall. The name was first applied to the rocks of the Lower Silurian age that crop on the Hudson river at New York. The name was subsequently changed by Meek and Worthen to that of Cincinnati group. I have already, on page 4, given my reasons for retaining Hall's name. This group of rocks has also been called the Nashville group by Prof. Safford in his report on the geology of Tennessee. At Cincinnati and at Nashville there are extensive crops of these rocks, and hence the desire to apply to them local names. Now, if the relative strata were found no where else we might tolerate these new names, but it so happens that they exist in various parts of the United States and cover large areas of its surface, and to multiply names is simply adding confusion to the nomenclature. The Hudson River beds are seen in the southern part of the county, where they have been exposed by the removal of the Niagara beds and the surface drift. The geological structure of the county will be better under-

PLATE 3.

Profile and Section across Wayne County, along the Pan-Handle Railway from Dublin to Richmond, from thence east along the Turnpike.



stood by the following section, which shows the order of the strata from the eastern boundary of the State to Dublin, on the western boundary of the county. It is taken for convenience along the line of the Pan-Handle railroad, from Dublin to Richmond, and from the latter place to the State line along the turnpike road from Richmond to New Paris. See Plate No. 3.

From the State line to Richmond the direction is a little south of east, and from Richmond to Dublin the course is nearly east and west. The levels are given above the city of Indianapolis, which has been taken as a base line. The Union Depot track at the latter city is, by the best authorities, computed to be 721 feet above mean ocean tide in New York harbor. The horizontal scale of the section is four miles to the inch, and the vertical scale 200 feet to the inch. The highest point reached lies to the south of New Paris, in the State of Ohio, and near the celebrated Cedar Springs. The top of the hill is here, by barometer, 365 feet above the level of Indianapolis, or 1,086 feet above the ocean. The top is covered with a deposit of drift composed of large and small boulders of crystalline and metamorphic rocks, pebbles, sand and clay, in all thirty feet thick or more. Under the drift is twenty feet or more of Niagara limestone, which is best seen at the quarries between Cedar Springs and New Paris. The Niagara beds are here worked extensively for flagging and for foundations to houses, bridge piers, etc. It is a light-buff magnesian limestone in the upper part and bluish colored in the bottom. The section seen at Leander Marshall's quarry showed the following order:

	Ft.
Soil	1
Buff magnesian limestone, flagging	7
Clay	2
Magnesian limestone, 8-inch layers	2
Blue magnesian limestone of coarse crystalline structure	2
	14

The lower bed contains one layer about one foot thick. The Niagara rocks are seen in the bank of the west fork of White Water river at several places contiguous to the State line, and are marked by characteristic fossils: *Orthoceras angulatum, O. columnare, O. crebescens, Hemipronites radiata, Pentamerus oblongus, Calymene blumenbachi, Favosites niagarensis, Lichenalia concentrica, Orthis elegantula, Platyostoma niagarensis and Dalmania verrucosus.*

Going west, the Niagara beds are mostly covered with drift, but there is a very good exposure in a ravine where it has been cut through by a small creek. The beds here are more shaly than at New Paris, and are of but little use for building purposes. The blue argillaceous soft shales of the Hudson river beds are exposed in the bed of the creek, and the Niagara above is about twenty feet thick. It contains a few fossils: *Meristina nitida, Rhynchonella tennesseensis, Orthoceras simulator, Platyostoma niagarensis, Pentamerus oblongus, Favosites niagarensis, Streptelasma minima* and reticulated Bryoza.

As we approach Richmond the Niagara is absent, and was probably removed by erosion, which must have taken place on a large scale at this part of White Water valley. There are then no other exposures of this formation along the line of the section until we reach the valley of Martindale's creek at Germantown, and the valley of west branch of White Water river at Cambridge City. The difference in elevation of the Niagara at the State line and where it is seen at Cambridge City is about sixty feet, and the distance is about twenty miles. If the section, then, was in the line of greatest dip, it would only be at the rate of three feet to the mile. Indeed, I do not feel able to say in what direction will be found the greatest dip of the strata, for locally the pitch is very slight, and you may find at any large exposure of the rocks in this county that the dip is sometimes in one direction and sometimes in another, as though the strata had been laid down on an uneven sea bottom. Jackson's hill, on the divide between Noland's fork and Green's fork, is 330 feet above the Union depot tracks at Indianapolis, or 1,051 feet above the ocean; and the hill at Cedar Springs, at the eastern end of the section, is 1,086 feet. These numbers agree so closely that I am led to conclude that at one period of the Glacial epoch the country between these two points was almost a level plain, and the intervening gaps have been eroded by the vast volume of water which flowed from the glaciers' southern border as it gradually retreated to the north. There are great numbers of large erratic boulders on the top of Cedar Spring hill, and on the dividing ridge of which Jackson's hill is a part.

At the falls of Elkhorn creek, four miles nearly south of Richmond and southwest of the Niagara crops, on the east fork of White Water, there is a crop of buff-colored magnesian limestone overlying the Hudson River rocks, and form the falls of that stream. It is from twenty to twenty-five feet thick, and has been variously referred to the Clinton and the Niagara. The upper part of this bed is unquestionably Niagara, and, for my part, I have no hesitation in referring the whole to that age, and it is also my opinion that no distinction can be drawn, either from lithological or palæontological evidence that will justify the placing of the Upper Silurian rocks of this State in any other than the Niagara epoch.

A vertical section of the rocks at this locality shows the following order:

	Ft.	In.
Drift, composed of large boulders, gravel, sand and clay...	80	
Niagara, buff magnesian limestone..................................	25	
Blue argillaceous shale..	3	

Blue limestone, Hudson River rocks, in seven layers:

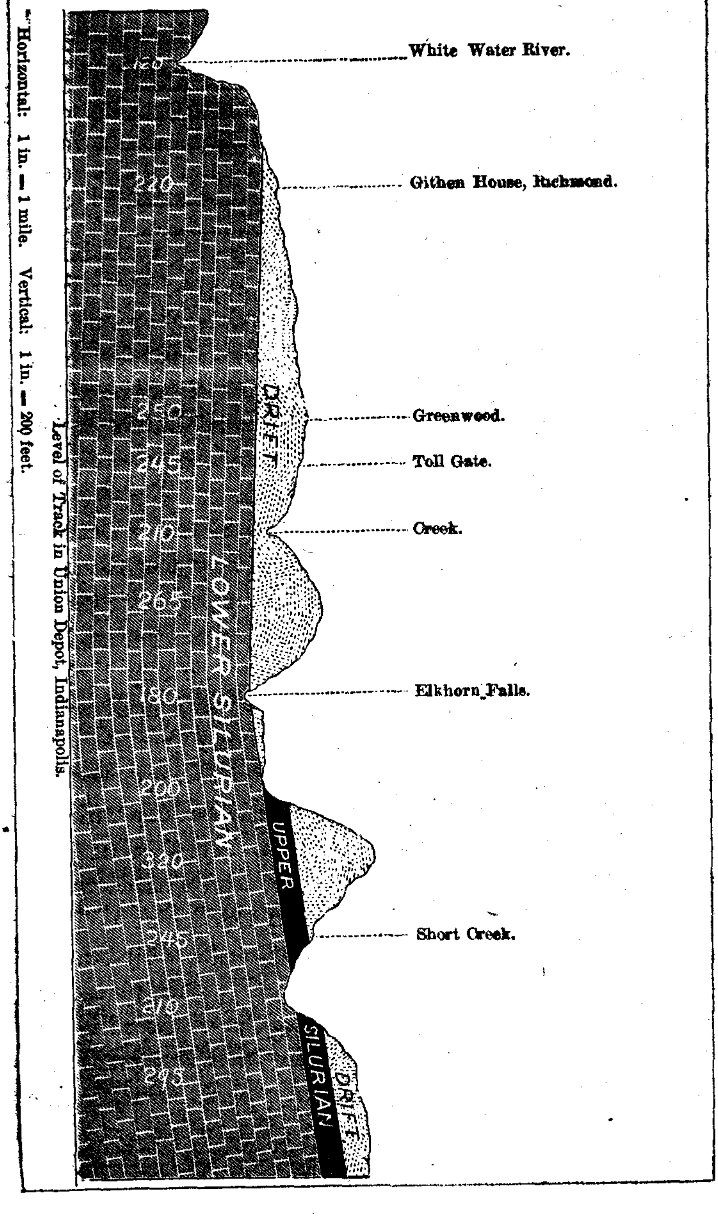
	Ft.	In.
First layer	0	7
Second layer	0	8
Third layer	0	6
Fourth layer	1	0
Fifth layer	0	6
Sixth layer	0	8
Seventh layer	0	4
Bed of Elkhorn creek.		
	112	3

The upper part of the Niagara is grayish-colored magnesian limestone, very coarse-grained, and contains a few fossils of which I recognized: *Halysites catenulata, Favosites niagarensis, Chonophyllum niagarensis, Meristina nitida,* reticulated Bryozoans, fragments of *Calymena blumenbachii,* and numerous fragments of stems of Crinoids.

The lower part of this formation is a buff-colored, coarse-grained magnesian rock, that contains very few fossils of any kind. In the upper part I found a badly-weathered specimen of *Halysites catenulata.* These magnesian beds are hard weathering, and rest upon soft, shaly beds of Lower Silurian, which are more easily eroded and carried away. At the Elkhorn mills they form a vertical wall across the creek, over which the water falls some twenty to twenty-five feet, and has cut away a portion of the underlying Hudson River shales. These falls have in time been cut back a half a mile or more, or from a point down the stream where the Niagara first makes an appearance. Where this magnesian rock terminates lower down the stream it maintains its full thickness, and there is reason to believe that the absence beyond that point to the westward is due to glacial abraision. Plate No. 4 shows a horizontal section from the falls on Elkhorn creek to Richmond, Ind., a distance of four miles. The Upper Silurian beds are here 245 feet above Indianapolis, or 966 feet above the ocean.

PLATE 4.

Section from Richmond to Elkhorn Falls, Wayne County Ind. Distance 4 miles.

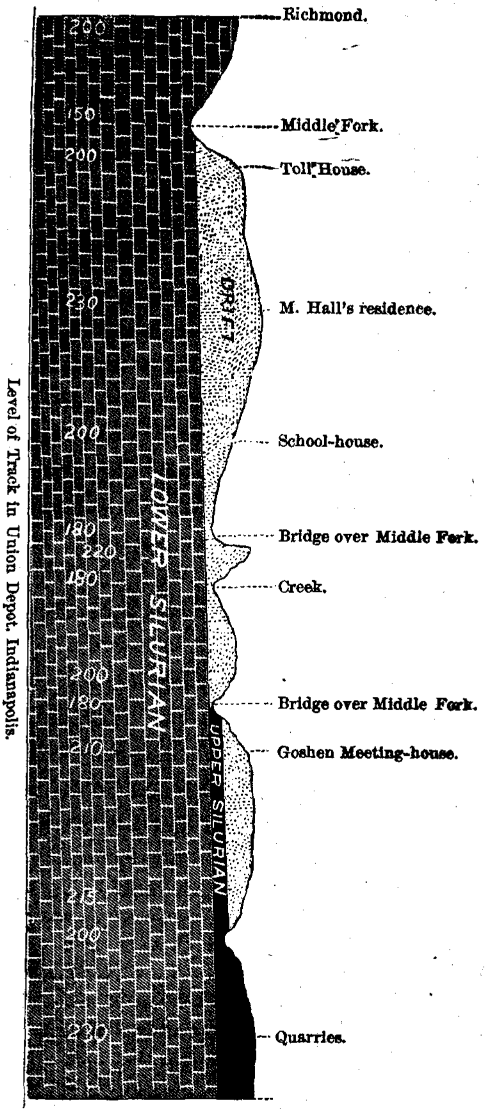


If we compare this elevation of the Niagara here with the elevation of the same beds on the East fork of White Water, and near the State line, and about six miles to the northeast, it will be found that they agree so closely that it affords no evidence of a dip in that direction. The elevation of the latter above the ocean is 961 feet—a difference of only five feet. Then, again, it will be seen by the section extending from Richmond to Middleboro, a distance of ten miles, taken along the Middle fork of White Water and following the turnpike road (Plate No. 5), that the elevation of the Niagara beds are 230 feet above Indianapolis, or 951 feet above the ocean. By this section the Niagara is thirty-six feet lower at Middleboro than at the falls of Elkhorn, and thirty-one feet lower than the crop at East fork, which lies about three miles to the south. From these sections it would appear that there was a slight dip of the strata to the northward. At Middleboro the Niagara has been extensively quarried for burning into lime and for building purposes. By the Hillsboro pike it is called seven miles from Richmond to the quarries. Boyd & Cook's quarry lies in the valley of Muddy fork, and about one hundred yards from the bank of the stream. The rock has been worked down about four feet below the bed of the river, and at the time of my visit the large basin which had been excavated by removing the stone was filled with water from an overflow of the stream, so that I did not get to see the lower beds in place. The section obtained shows:

	Ft.	In.
Buff decomposing rock, not used	1	6
Gray friable beds, lower part filled with Pentamerus oblongus	2	6
Gray and mottled schistose, thin bedded	4	0
Lower layers, under water, containing chert, and called flint stone	4	0

PLATE 5.

Section from Richmond to Middleboro, along the Middle Fork of White Water.
Distance 5½ miles.



Horizontal: 1 inch = 1 mile. Vertical: 1 in. = 200 feet.

The analysis of this stone shows it to contain:

	Per Cent.
Water, expelled at 212° F.	1.00
Silicic acid	1.38
Oxide of iron	1.40
Alumina	4.30
Lime	45.10
Magnesia	4.36
Carbonic acid	40.15
Sulphuric acid	0.35
Loss and undetermined	1.96
	100.00

The gray-colored magnesian limestone is not very dissimilar in its composition from the Niagara beds of Huntington county, which are celebrated for the admirable quality of caustic lime which they yield.

Messrs. Boyd & Cook have erected by the side of their quarry two perpetual lime kilns, and burn from 25,000 to 36,000 bushels of lime per annum. The color is white, and it has a good reputation in the market. It is a slow-setting lime, and masons may spread from six to nine brick at a time before leaving.

Their lime is also used in the gas-works at Richmond as a purifier to remove the carbonic acid and sulphuretted hydrogen gas from the illuminating gas.

Boyd & Cook pay $3.00 per cord for wood, and two cords of wood are sufficient, in Page's patent kiln, to burn one hundred bushels of lime, while in Schroder's patent kiln, according to their experience, two and a half cords are required.

The most abundant fossils in the Niagara at this locality is a Brachiopod mollusc—*Pentamerus oblongus*. These fossils are so abundant that in some of the layers they lie packed upon top of one another, and constitute almost the entire substance of the stone, and have the same chemical composition. This quarry has furnished a large number of magnificent slabs, filled with these fossils, to decorate and add to the scientific value of all the cabinets in the country.

If we take a close view of the exposures made by the quarrying of the stone over a large area of its surface, it will be seen that by the road it dips 3° or 4° to the west, and on the east side the dip is at one place to the south and at another to the north, but at most only three or four degrees. In fact, the quarrymen say there is no regular dip—the slight pitch is sometimes in one direction and sometimes in another. It will be observed on the section that there is a crop of the Niagara at two places on the Middle fork, between Middleboro and Richmond, at about the same level as the quarries; at these localities there is a paucity of fossils. We have here the following succession:

	Feet.
Drift, composed of large boulders of metamorphic and crystalline rocks, lying upon the surface gravel and clay......	20
Niagara beds:	
Buff colored, rough weathering magnesian limestone, containing *Halysites catenulata*, and *Favosites niagarensis*...............	10
Hudson river:	
Blue schistose limestone, with intercalated argillaceous shale, containing *Zygospira modesta*, *Rhynchonella capax*, *Orthis occidentalis* and *O. biforata*..	8
Bed of Middle fork.	

A little to the southeast of the above crop of the Niagara we have at nearly the same elevation another crop of these beds that give rise to the falls of the West fork of White Water river. It is here, also, a buff magnesian limestone, about ten feet thick, and forms a complete mural cliff across the stream, over which the water falls a distance of ten feet or more. The surface above the falls is scratched and grooved by glaciation. Some of these grooves are deep and long. Their direction, as nearly as I could determine, is south 40° west. The following section shows the order of strata at this locality, extending up to the mound in Mr. Ratliff's field:

	Feet.
Surface soil and clay	10
Drift, large boulders, gravel, sand and clay	40
Niagara limestone	10
Argillaceous shale and bluish thin-bedded schistose limestone, belonging to the Hudson River series, in the bed of stream.	?

The rock forming the falls is a buff-colored magnesian limestone, that contains in the upper part a number of fossils; the most abundant are Rhynchonella.

There can be no doubt of this rock being the equivalent of the strata that form the falls of Elkhorn creek, about eight miles to the south, with which it agrees also in its color and general lithological features. Though in the latter respect it differs from the beds at Middleboro and on the the East fork. The equivalency is clearly proved by tracing the intervening crops.

To the south of Cambridge City about two miles, and on Simon's creek, the Niagara appears only a few inches thick, and rests immediately upon thin layers of Hudson River limestone. The position is shown on Plate No. 5. Along the bottom of Simon's creek, and on Mr. M. K. Meyer's land, section 33, township 14, range 12, the above rocks are seen at the water's edge, and have been quarried on a small scale for lime and for walling cellars, underpinning barns and dwelling houses.

The quarrying is carried on in the bottoms along the creek, by throwing off the superincumbent alluvial deposit, some three or four feet thick, and then prying up the stone, which is in quite thick layers, and has a rough, uneven surface. The first freshet of the creek fills up these pits with sediment and water, so that it becomes easier to make a new opening than to clean out the old, when the work of quarrying is renewed, and a great many abandoned pits are scattered over the locality. As no quarrying has been done here for some time, the only opportunity afforded for the examination of the stone was a small lot of partly refuse stone, which still remained by the side of one of these pits. In times past this locality furnished caustic lime for the surrounding country, but the quality is not good, and with the improved facilities for transportation, it has been entirely replaced by a better article from a distance, and the manufacture abandoned. The Niagara layers are buff-colored, coarse-grained, and contain a number of crinoid stems. The Hudson River layers contain *Orthis lynx, O. occidentalis* and *Strophomena alternata.*

On Mr. A. Baldwin's farm, not far from this place, there is a so-called "Shaky Hill." The citizens of Cambridge City were from time to time astounded by reports, which found their way into the newspapers, of the wonderful shakes that were convulsing this hill, and my friend Dr. E. S. Hoshour, of that city, sent for me to come down, and accompanied me to the spot to take a look at it. Mr. Baldwin says that "Shaky Hill" was first settled by Willis Ragan, over fifty-five years ago, and that he was repeatedly alarmed, while living there, by the violent shaking of his house, when all other portions of the country were undisturbed. Other families, who subsequently lived in the house, testified also, that the hill was known to shake, and at one time so violently as to throw the dishes from the table, and that the shaking was accompanied by a rumbling noise. The spot is not, strictly speaking, a hill, but is a portion of the tableland that terminates abruptly on the bottom of Simon's creek, and is bordered on the sides by shallow washes that give rise to ravines. The elevation above the bottom is about sixty feet, and the whole mass is made up of glacial drift—gravel, clay, sand and small boulders. The drift is underlaid by Niagara limestone, which is seen in the bed of Simon's creek, and just covered at low water.

Everything was quiet at the time of my visit, and I could see no trace of any kind of disturbance in the heterogeneous drift which everywhere forms the high land in this part of the county, and is from sixty to 120 feet thick. The underlying stone is not seen immediately at the so-called hill, consequently we have to judge its character by what is known at the quarries already alluded to above; this indicates that it is a schistose and thin bedded rock near the surface, and here, as elsewhere in the county, underlaid by thin-bedded limestone, alternating with beds of argillaceous, shaly rocks, a character of strata that are yielding and too much broken by vertical joints or fissures to lead us to attribute to them the cause of any local disturbance that would give rise to the phenomenon claimed to have been witnessed at "Shaky Hill."

Though I can see nothing here that would enable me to refer such a phenomenon to geological or any other cause than of unconscious personal deception, it will not do to lose sight of the fact that in certain localities disturbances of the surface strata have been known to take place from the cracking and bursting of the rocks. This may be due to various causes, some of which may not be fully understood. Colonel Totten, of the United States department of engineers, made a series of experiments to determine the rate of expansion of various kinds of rock for an increase of one degree of temperature. From the data he furnished, Sir Charles Lyell has calculated that a mass of sandstone a mile thick, raised in a temperature 200° F. would have its upper surface elevated ten feet.*

*Principles of Geology, Vol. 11, p. 237.

Elevations or depressions of the surface of rock beds due to climatic changes would naturally be brought about very slowly, but where the beds are of an unyielding character, or in very thick and persistent layers, the strain may become sufficient to finally crack and break the mass, accompanied by a report and more or less shock.

Mr. W. H. Niles, of Cambridge, Mass., gave a very interesting account of the uneasy condition of rocks in a quarry at Munson, Mass., in a paper read before the American Association for the Advancement of Science, and published in their proceedings of the Portland meeting, 1873, p. 156, from which the following extract is taken:

> The quarry embraces an area of five or six acres, upon the gentle slope of a moderate-sized hill. The rock is gneiss, without any apparent planes of stratification, but of schistose structure. Divisional planes cut across the stratification and divide the rock into beds, which vary in thickness from one inch and a half to five feet or more. These beds are extensive, and are not broken by any other divisional planes. They conform to the surface of the hill, being in some places horizontal, at others dip about 10°. When a strata of any considerable length is quarried, it is found to expand in the direction of the strike, northerly and southerly. The expansion was found to be one and a half inches in 354 feet long.

Another result of this rock expansion, he says, is the formation of numerous cracks and fissures, attended sometimes by violent explosions. Mr. A. T. Wing informed him that in the latter part of June, 1872, there was a natural breakage which extended about two hundred and seventy-five feet, and was about seventy-five feet back of the working face. One end of the loosened mass remained solidly attached to the underlying rock, and by its expansion about 10,000 tons of rock were moved.

These cracks or rents are more commonly formed slowly, but sometimes suddenly, attended not only by the breaking, shattering, and even crushing of the solid rock, but by a loud report and sometimes by the throwing of stones of considerable size for a short distance. On the morning of the 18th of June, 1873, at about six o'clock, the engineer was startled by an explosion, and looking toward the quarry saw stones and other debris in the air, being thrown to a considerable distance. Mr. Niles visited the spot on the 20th, and found it looking much as though a small but powerful earthquake had taken place. A bed five feet four inches thick had been ruptured in two nearly parallel fissures, each of which measured sixty-eight feet in length. Besides these the rock was otherwise much broken, and in places shattered and crumbled, and some of the liberated stones were thrown southward, but none in any other direction. These fractures were from eighteen to twenty feet from the working face.

I mention these phenomena for the purpose of showing that we have well authenticated cases of uneasy beds of rock, which may under certain conditions give rise to a local shaking up of the surface.

There is another tradition connected with that relating to "Shaky Hill," and that is, on a spot near by, and also on Mr. Baldwin's land, the surveyor's compass will not point to the magnetic pole. This being a question susceptible of direct proof, I was enabled to show that my own compass was in no wise disturbed at any place tested, but would point out with unerring accuracy that the fence on a section line was in a north and south course.

I will state in this connection that it is not an uncommon thing for me to receive notice that in certain localities, on land in different parts of the State, the surveyor's compass will not work properly. When such localities have been examined it invariably proved that the compass will work as readily there as anywhere else. But it is not to be denied that there are places on the earth's surface where the magnetic needle is disturbed and drawn from the magnetic pole, such as in the presence of large bodies of magnetic iron ore. But there is no possibility of finding this mineral in places within the borders of Indiana. Small pieces have been picked up now and then from the glacial drift, but at no time has it been found in sufficient quantity to effect the needle of a compass unless they are purposely brought very close together.

The needle of a surveyor's compass may be disturbed by the possible electrical state of the glass which covers it, and this might lead to the belief that the cause was to be looked for in the earth.

There is a general tendency in the minds of people, who have not been schooled to observe, to deceive themselves and indulge in mysteries where none exist; such illusions are readily dispelled when put to a crucial test.

By looking at the plates giving sections of the rocks in different directions from Richmond, north, south, east and west, it will be seen that there is but little difference in the elevation of the Niagara beds at any of the crops, and if left to study the dip from them alone, we should be unable to decide on its general direction; but carrying the investigation beyond the boundary of the county it is proved to be in a west or southwesterly direction. At Terre Haute the Niagara was probably reached at the depth of 1,700 feet in the artesian well bored for petroleum. The elevation of the Niagara on Elkhorn creek is 965 feet above tide-water in New York harbor. In the artesian well at Terre Haute it is 1,196 feet below tide-water, and 216 feet below the crop on Elkhorn creek. The lineal distance between the two points is about 140 miles, and the dip is consequently, in this direction, about fifteen and a half feet to the mile.

HUDSON RIVER GROUP.

The rocks belonging to this group lie immediately under the Niagara, since we are not able to establish the presence of the Clinton, which in regular sequence forms the intervening strata.

The Hudson River group is well expressed in this county on the three forks of White Water river near Richmond, and from thence southward along the main stream and its tributaries to Abington, in Abington township. Horizontal sections were made from the latter place to Richmond, following the pikes on both sides of the river, a distance of about eight and a half miles. Plate No. 6 is taken on the west side of the river and shows the position of the rocks above the horizon of Indianapolis and the degradation which has taken place along the streams.

Plate No. 7 is taken on the east side of White Water river. This section, going south from Richmond, first strikes the river below the cemetery, Elkhorn creek at its mouth, and again reaches the bed of the river at Abington. It will be observed that the Lower Silurian rocks have the same thickness on the east side of the river at Abington as at Richmond. Between the highest point traversed there and the school-house, No. 4, the total elevation is about the same, that is 240 feet above Indianapolis, or fifty feet higher than Richmond. This difference is due to the removal of the greater portion of the drift at the latter place. The following sections, taken along the river bank at Richmond, exhibit the arrangement of the strata comprising the Hudson River group:

Section near Starr's gas-works:

	Ft.
Drift	4
Buff shaly limestone	90
Bed of river.	

PLATE 6.

Section from Richmond to Abington, Wayne county, Indiana, west of White Water River. Distance 8½ miles.

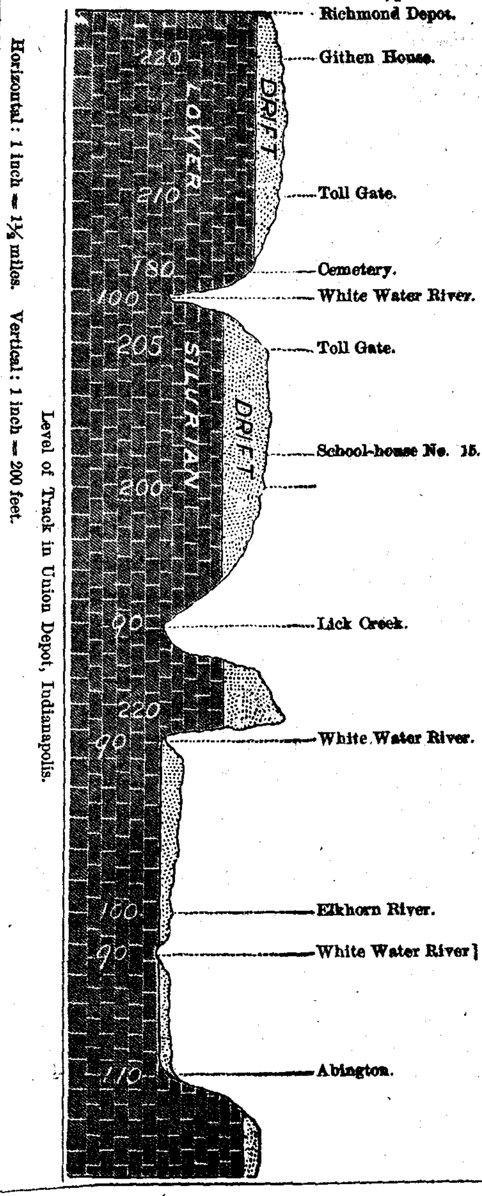
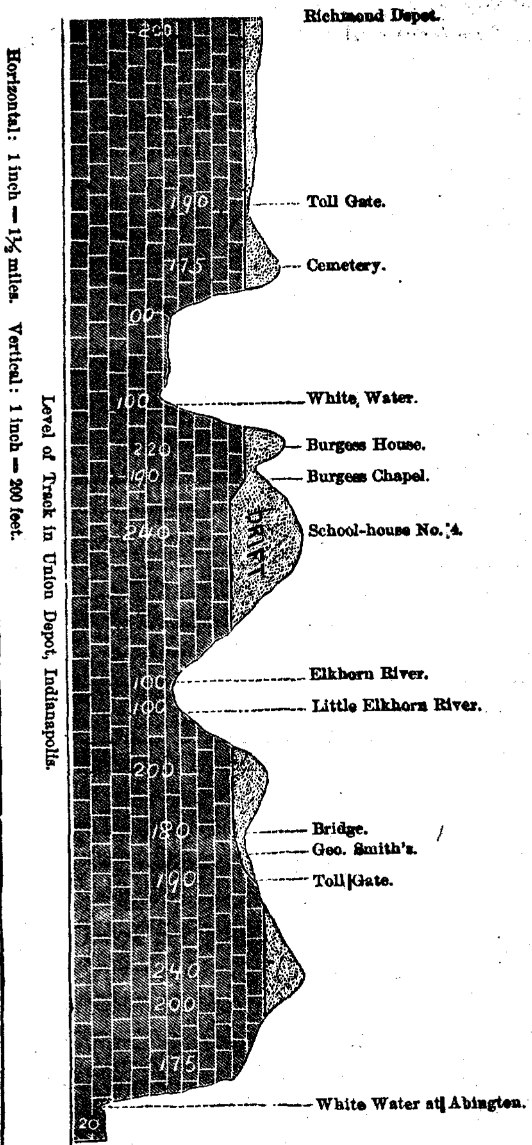


PLATE 7.

Section from Richmond to Abington, east of White Water River. Distance 8½ miles.



The buff shaly limestone of the above section contains an abundance of *Orthis lynx*, *O. biforata*, *O. lynx*, *var. acutilirata*, *Rhynchonella capax*, *Zygospira modesta*, *Strophomena attenuata*, *Chonetes frondosus* and *Petraia corniculum*. Under these beds are bluish argillaceous shale and hard bands of stone, here covered with the debris from above.

Only a few of the most common occurring fossils are here given, as Mrs. Mary Haines, of Richmond, was kind enough to supply me with a complete list of fossils found in the Hudson River beds in this county, so far as they are known, and are represented in her extensive cabinet. This list will be given in full on page 201.

A little further down the river, and at Brinkmire's quarry, the following section is seen, and commences sixty-five feet above the river:

	Ft.	In.
Grayish buff, soft shale	8	0
Bluish gray, soft shale	5	0
Top layer, quarry stone	0	10
Blue stone	2	0
Shale	0	2
Blue stone	0	8
Shale	0	5
Stone	0	4
Shale	0	2
Stone	0	7
Covered	47	0
River.		
	65	2

These beds all contain fossil shells—*Strophomena alternata*, *Rhynchonella capax* and branching species of *Chætetes*. The top layers were especially full of fossils. The stone from the quarry sells at seventy-five to eighty cents a perch.

At the mill-dam just below the city of Richmond, and on the east side of the river, the banks rise abruptly to the table-land, leaving a fine exposure of rock that is highly fossiliferous from top to bottom. The section exhibits:

1.	Thin-bedded, buff-colored limestone, alternating with argillaceous shale, buff and bluish color	20 to 30 ft.
2.	Quarry rock	30 to 40 ft.
3.	Bluish shaly beds	10 ft.
		80 ft.

No. 1 of the above section contains a great abundance of *Petraia corniculum*, small branching *Chætetes* of various species, *Palæophycus simplex, Buthotrephis gracilis, Tetradium fibratum, Orthis occidentalis, O. lynx, var. biforata* and *acutilirata, Rhynchonella capax, Strophomena alternata, Zygospira modesta, Ambonichia radiata, Modiolopsis modiolaris, Cyclonema bilix*, etc.

No. 2 contains *Rhynchonella capax, Strophomena alternata*, etc.

No. 3 shows a great abundance of *Leptæna sericea*, and the slopes are literally covered with the valves of these shells and *Streptorhynchus*, at the water's edge.

In the lower beds Mr. W. D. Schooley, who accompanied me, had previously found a *Calymene senaria*, but they are not common. Following down the stream to the crossing of Elkhorn and Little Elkhorn, the same beds are found in the cuts below the drift. Opposite the town of Abington the country rises very rapidly from the stream to the table-land, and we find the same succession of thin bedded limestones and shale as at Richmond:

	Feet.
Drift, composed of gravel, sand and clay, with a few large boulders here and there over the surface	40
Yellow, schistose limestone, with an abundance of *fucoids, Buthotrephis gracilis, B. succulosus, Chætetes frondosus, C. lycoperdon, Favistella stellata, Petraia corniculum, Orthis occidentalis, O. biforata, Rhynchonella capax, Strophomena alternata, Zygospira modesta, Ambonichia radiata, Cyclonema bilix, Murchisonia bellicincta*	25

	Feet.
Bluish shale and thin bands of limestone, containing a variety of fossils, the most notable of which are *Streptorhynchus planumbona*, *Leptæna sericea.* These species are in the greatest abundance near the water's edge, and literally cover the entire surfaces of two distinct layers of stone. This part is	175
Total	240

I consider *Orthis lynx*, *O. laticosta*, *O. dentata* and *O. acutilirata*, the same as *O. biforata*. This shell has a wide range of variation, being sometimes very gibbous, with rounded hinge line on the sides; in others the hinge line is prolonged into ears. It also varies in the number and character of the longitudinal plates; in some, these are shallow and numerous, in others they are comparatively small and thin. It is not an uncommon thing to find in the same beds specimens of this Orthis with the hinge line extending beyond the margin on one side, making an acute ear, while it rounds off on the other side.

Prof. James Hall justly remarks in regard to this Orthis, Palæontology of New York, p. 133: "This species, like many of the brachiopoda, is influenced by local circumstances, and in its wide geographical distribution presents varieties of forms or types peculiar to different localities dependent apparently upon the condition of the ancient ocean bed."

The variations which they undergo may be considered as due to the environments, and therefore their use to point out a difference in geological time can not be relied upon.

Back of the town of Abington we have the same succession of strata, but the upper beds are covered by drift.

The same beds are also seen on the west side of the river, on the banks of Lick creek, and may be traced from there for two or three miles up the latter stream. In the deep cut of all the streams that flow into Elkhorn creek the Hudson River beds are well exposed, and the rocks are crowded with fossils. It will be noticed also, by reference to the maps, that there are no tributaries entering Elkhorn creek from the north. A few hundred yards below the falls in Elkhorn, this rock is quarried for building purposes. At Mr. Provard's quarry, which lies on the south side of the creek, the stone is in good thickness—bluish-colored and close-grained. The following section shows the succession and thickness of the respective layers:

	Inches.
Friable Niagara stone	15
Two layers, 7 to 8 inches	15
One layer	10
One layer	6
One layer	12
One layer	6
One layer	8
One layer	4
Bed of creek	0

There is a slight covering of earth in places, and the strata has a very gentle dip to the southeast. The stone contains vast quantities of fossils, which are inseparable from the metrix in some of the layers. The third stratum from the bottom is considered the best stone.

Fifty feet below this quarry, on the creek, we have at Clayton Brown's quarry the following section:

Soil and clay, drift	5 ft. 0 in.
Buff magnesian limestone, Niagara epoch	2 ft. 0 in.

Hudson River stone in layers:

One layer	0 ft. to 0 ft. 8 in.
One layer	1 ft. to 1 ft. 3 in.
Shale	0 ft. to 0 ft. 6 in.
Stone	0 ft. to 1 ft. 0 in.
Shale	0 ft. to 0 ft. 6 in.
Stone	0 ft. to 0 ft. 4 in.
Stone	0 ft. to 0 ft. 8 in.
Bottom layer	0 ft. to 2 ft. 0 in.

Johnson's quarry has the same character of rock. The quarrying here is conducted for home consumption; the quality of the stone is fully equal to the best stone found anywhere in this formation. Rough stone sells at twenty-five cents per cubic foot, or three dollars a perch on the ground.

The Hudson River rocks are also seen in considerable force along the east, middle and west forks of White Water river, for short distances above their embouchure. On these streams the bluish, argo-calcarious shale, which underlies the Niagara where the succession is seen in this county, is here from thirty to forty feet thick, and the layers at the water's edge are thickly studded with fragments of *Asaphus megistos, Acidaspis cincinnatiensis*?, *Ceraurus sp.*?, *Dalmanites sp.*?, as well as other forms not sufficiently perfect to enable me to make out their species.

It is noticeable in this county, as well as elsewhere in the State, that the Hudson River beds of equivalent age do not always present the same lithological and palæontological features. On the east fork, where the identical beds with the above are exposed, I was not able to find a single fragment of crustacea, and but very few fossils of any kind. As observed by Mr. S. A. Miller, of Cincinnati, who has made a thorough detailed study of the Hudson River rocks, "the variation in color from blue to brown is due to the various stages of oxidation of the iron which they contain." Shales that are invariably blue when the face is exposed in a mural bluff and fresh surfaces formed, through more or less rapid erosion, are, under other circumstances, browned by the oxidizing influence of the atmosphere.

The following are among the best localities for collecting Hudson River fossils: At Richmond, on the banks of White Water and its branches, and on both banks of the main stream to the southern limits of the county. From the falls of Elkhorn to its mouth. The banks of this stream present a number of admirable exposures, where the fossil contents of the rocks are weathered out and in an excellent state of preservation. The same may be said of the banks of Brush creek, near its mouth.

The close proximity of these admirable localities for collecting fossils, to the city of Richmond, has enlisted the attention of a number of its citizens, and no place of its size in the West can boast of more students of palæontology or exhibit a greater number of fine cabinets of fossils and other objects of natural history. While I do not pretend to give the names of all the collectors, I will mention those who are particularly noted for efficiency and zeal, and when I place the name of Mrs. Mary P. Haines at the head of the list, it is not from an act of courtesy or gallantry, but on account of real merit. Mrs. Haines is an earnest worker in science, and her vast collection of fossils and scientific researches has done much to advance our palæontological knowledge of the Silurian beds at Richmond. Mrs. Haines has very kindly furnished, at my solicitation, a catalogue of fossils in her collection that were collected at and in the vicinity of Richmond. This list is given on page 201. At the time of my visit her collection contained:

Fossils	1,628	
Minerals	1,016	
Land and fresh water shells	760	species.
Marine shells and corals	753	"
Musi	296	"
Hepatica	206	"
Filices	245	"
Algea	200	"
Total	5,104	

Mr. L. B. Case, the efficient secretary of the Indiana Archæological Society, is a man of very marked scientific attainments, and has a very large collection of fossils, minerals and archæological specimens. His excellent cabinet has furnished a number of specimens that have served to extend our knowledge of the diversified forms of extinct life.

Dr. Barr is also a scholar and physician of note and ability. In addition to the labors of an extensive practice, the doctor has not been oblivious to the fascinations with which nature allures her gifted sons to unravel her mysteries, and his well-filled cabinet of fossils attests his zeal in the study of palæontology. Dr. Barr's cabinet has also served to enrich science with many new species.

J. F. Miller, superintendent of the Pan-Handle railroad, has also made a large collection of fossils, minerals and archæological objects.

President Moore, of Earlham College, is a well-known devotee of science and an eminent teacher. He has succeeded in building up at Earlham College one of the most efficient collections of natural history, for study, that is to be found in the West. Prof. Moore made a trip to the Sandwich Islands some years ago, where he collected a great variety of rocks and minerals, illustrating the character of the remarkable volcanic action of Kilawa, a great many kinds of corals and marine shells. This collection was selected with great care, and forms a valuable addition to the college museum.

The geology, palæontology and natural history of the State, is also very complete in this museum.

Mr. J. C. Ratliff, one of the trustees of Purdue University, is also a collector and student of natural history. While more especially devoted to botany, the abundance of fossils, shells and corals that lie exposed upon the surface of the weathered rocks, have not escaped his notice, and his well-selected cabinet of fossils bears witness to his interest in palæontology. The State cabinet has been enriched by numerous fine specimens from his collection.

Mr. J. Shinn also finds leisure from his mechanical operations to make collections of rocks and fossils. His yard contains rockerys made of a vast collection of curious and interesting boulders from the drift and shale of Niagara, *Pentremites oblongus* and Hudson River fossils.

Mr. W. D. Schooley collects fossils of all kinds for sale. He is well acquainted with the best localities, and is a good collector. I am indebted to him for the gift of a number of fine specimens:

LIST OF FOSSILS FOUND IN THE LOWER SILURIAN ROCKS IN THE VICINITY OF RICHMOND, INDIANA.

[By Mrs. Mary P. Haines.]

PLANTS.

Buthotrephis gracilis	Hall.
B. succulosus	Hall.
Paleophycus simplex	Hall.

PROTOZOANS.

a Spongites, one species	
Stromatocerium rugosum	Hall.

RADIATES.

Aulopora arachnoidea	Hall.
Chætetes (Monticulipora) dalei	E. & H.
" " approximata	Nich'n.
" " pulchellus	E. & H.
" " Ortoni	Nich'n.
" " mammulatus	E. & H.
" " frondosus	D'Orb.
" " delicatulus	Nich'n.
" " gracilis	James.
" " petropolitanus?	Pandu.
" " rhombicus	Nich'n.
Columnipora cribriformis	Nich'n.
Favistella stellata	Hall.
Favosites gothlandica	Lam'k.
Protaria vetusta	Hall.

RADIATES—CONTINUED.

Petraia corniculum .... Hall.
Stellipora antheloidea .... Hall.
Tetradium fibratum .... Saff'd.

ECHINODERMS—CRINOIDS.

Glyptocrinus Baeri .... Meek.
" Nealli .... Hall.
Poteriocrinites Casei .... Hall.
" polydactylus .... Shu'd.

CYSTIDS.

a *Agelacrinites cincinnatiensis* .... Roemer.
Cyclocystites, two species.
Lichenocrinus crateriformis .... Hall.
" tuberculatus .... S. A. M.
b Lepocrinites Moorei .... Meek.
" (un. de.) ....

ASTERIDS.

Stenaster grandis .... Meek.
Paleaster granulosus ? .... Hall.
" sp.

MOLLUSKS—POLYZOANS.

Alecto auloporoides .... Nich'n.
" confusa .... Nich'n.
" frondosa .... Nich'n.
Ceramopora ohioensis .... Nich'n.
a Fenestella.
Hippothoa (alecto) inflata .... Hall.
Intricaria ?
Ptilodictya Shafferi .... Meek.
" emacerata .... Nich'n.
Retopora ? sp.

BRACHIOPODS.

Crania laelia .... Hall.
" scabiosa .... Hall.
Leptena sericea .... Sow'by.
Orthis occidentalis .... Hall.
" sinuata .... Hall.
" subquadrata .... Hall.
" biforata, var. acutilirata .... Con'd.

BRACHIOPODS—CONTINUED.

Rhynchonella dentata	Hall.
" capax	Con'd.
Strophomena alternata	Con'd.
" alternistriata	Hall.
" alternata, var. loxorhytis	Meek.
" rhomboidalis	Wilckens.
Streptorhyncus filitextus	Hall.
" sulcatus	Verneuil.
" subtentus	Con'd.
" planumbona	Hall.
Shizocrania filosa	Hall.
Trematis millipunctata	Hall.
Zygospira modesta	Say.

LAMELLIBRANCHS.

Ambonychia radiata	Hall.
" (Megaptera) casei	M. & W.
" carinata	Hall.
and two or more other species.	
Anomoladonta gigantea	S. A. M.
" alata	Meek.
Cypricardites sterlingensis	M. & W.
" ventricosa	Hall.
" Hainesi	S. A. M.
" ungulatus	Bill.
Modiolopsis modiolaris	Con'd.
" curta	Con'd.
a " terminalis	Hall.
" concentrica	H. & W.
Orthodesma contracta	H. & W.
" recta	H. & W.
Pterinea demissa	Con'd.
" insueta	Con'd.

GASTEROPODS.

Bellerophon bilobatus	Sow'by.
" Mohri	S. A. M.
Bucania expansa	Hall.
" sp.	
Cyrtolites ornatus	Con'd.
" Dyeri	Hall.

GASTEROPODS—CONTINUED.

a Carinaropsis patelliformis..Hall.
Cyclonema bilix..Con'd.
" " var. lata..Meek.
" " " conica..S. A. M.
" " " pyramidata..James.
" percarinatum..Hall.
Murchisonia gracilis..Hall.
" bellicincta..Hall.
" perangulata..Hall.
Pleurotomaria subconica..Hall.
" lenticularis..Sow'by.

PTEROPODS.

Tentaculites richmondensis..S. A. M.
c Conularia papillata ?..Hall.
c " sp.

CEPHALOPODS.

Orthoceras junceum..Hall.
" vertebrale..Hall.
and other species.
Ormoceras tenuifillum..Hall.
Troceras Baeri..M. & W.
Cyrtoceras—several sp.
a Endoceras proteiforme..Hall.
a Gomphoceras eos..Meek.
" sp?

ARTICULATES—TRILOBITES.

Asaphus gigas..DeKay.
" megistos..Locke.
Calymene senaria..Con'd.
Ceraurus icarus..Billings.
Delmanites Carleyi..Meek.

OSTRACOIDS.

d Beyrichia Chambersi..S. A. M.

ANNELIDS.

Ortonia minor..Nich'n.

a In the collection of L. B. Case.
b In the collection at Earlham College.
c In the collection of the Richmond Scientific Association.
d Mr. S. A. Miller's collection, Cincinnati, O.

GLACIAL DRIFT.

Nowhere in the State are the effects of glaciation more apparent than in Wayne county. The north part of the county borders on the very highest land in the State. The water-shed of all the streams that flow into the Wabash on the south, as well as White Water and its tributaries, take their rise from an elevated table-land which occupies a portion of Jay, Randolph and Wayne counties, and probably reaches its greatest elevation within the borders of Ohio. But the entire region where these waters start and flow to the north, west, south and east is so level that one is puzzled to point out any one spot that should be called the comb of the divide. Indeed, it is my opinion that these streams were the outlets of a shallow lake or basin, which has been filled up with sediment. From this divide glaciers poured their frigid streams in several directions. One of the principal found its way to the south, and was instrumental in forming at least a portion of the channel of the West and Middle forks and that of White Water river. Indeed, large granite boulders are found on all parts of the table-land of Wayne county, but they are particularly numerous along the shores of the West fork, just above the falls. The upper surface of the Niagara rocks which form these falls are distinctly scratched and grooved, and the lateral moraines are well defined. The bearing of these grooves is nearly north and south. At Richmond there appears to have been the coalescence of two or more streams, which were instrumental in cutting out the canon through which White Water river flows. The soft and easily weathering shales and bands of stone that form the shores of the river have caused the glacial marks to be obliterated, but the large boulders which still lie along the bluffs, or fallen to the stream by the undermining which has been going on, leave abundant evidence to justify the above conclusion. Large and small boulders are seen on all the high ridges that mark the boundaries of the streams. White Water canon is shown on Plates 2 and 6. On the former it will be seen that Richmond lies in a basin, and this basin has been grooved out by glaciation. About seven miles to the east the drift reaches an elevation of 365 feet, and the top and sides of the hill at Cedar Springs, just beyond the State line, in Ohio, is covered with large boulders, and the entire deposit is 100 feet thick, the lower part being alternations of sand, gravel and boulder clay.

At Jackson's hill, eight miles to the west of Richmond, the drift is one hundred and forty feet thick. On the top there is a number of large boulders, and beneath this we have the usual alternations of clay, sand and gravel, and blue boulder clay. Jackson's hill is on the divide between the waters of Green's fork and Nolan's fork. On the divide between the latter streams and White Water, the drift is ninety feet thick, and in places the large boulders are quite abundant on the surface. In the city of Richmond the drift is only locally represented, and the greatest depth will not exceed twenty feet. At James Starr's gas works the Hudson River rocks form the surface stratum. Plate 4 shows the position of the drift along the turnpike which follows the course of the Middle fork to Middleboro'; it is here about sixty-five feet thick, and the surface has a great many large boulders. Plate No. 3 indicates the position and general depth of the drift along the road from Richmond to Elkhorn falls. Large boulders are numerous on the divide between Elkhorn and Short creek. The valley of the latter creek, where the road crosses, contains a great many boulders which have been washed down from above. The drift along this road is eighty to ninety feet thick. Plates Nos. 5 and 6 show the position of the drift and the eroded river and creek beds. The dividing ridges, on the line of both these sections, contain large boulders which mark the shores of lateral morains.

The material comprising the main body of the drift appears to be laid down with considerable regularity, and the order may be represented by the following section:

Large boulders, surface soil and clay	1 to 3 ft.
Clay, gravel and sand, mixed	10 to 20 ft.
Sand and gravel, containing water, first seam	5 to 15 ft.
Clay and gravel, mixed	10 to 25 ft.
Hard-pan	1 to 2 ft.
Sand and gravel, containing water, second seam	10 to 25 ft.
Clay and gravel	10 to 25 ft.
Hard-pan, with blue clay and small boulders	1 to 5 ft.
Sand and gravel, containing water, third seam	2 to 20 ft.
Stratified rock	140 ft.
Total	280 ft.

Usually there are three horizons of impervious, compact blue clays, mixed with well-rounded boulders from the size of a small gravel to six inches or more in diameter. This boulder clay is very tough, and difficult to dig through, whence it has received the name of "hard-pan." These hard-pans are usually underlaid and overlaid by sand and gravel beds that are strongly charged with water, and from these latter beds the supply of potable water is obtained in wells. Almost throughout the entire region of the drift it is an observed fact, also, that the water from the lower stratum will, when penetrated by a well, rise to the level of the upper stratum, usually ten to twenty feet below the surface. This is a matter of very great interest to towns and cities located on the drift, as it furnishes them with a never-failing supply of wholesome water. While in thickly settled localities the upper water supply may be contaminated by sewage and the contents of privy-vaults which have penetrated to that depth; the lower water reservoirs are protected against these pollutions by the impermeable floors of hard-pan. We have only, then, to obtain the water supply from the lower stratum, and so tube the well as to preclude the possibility of contamination from the streams above. The water so obtained can not, in my opinion, be excelled as a potable water, though, in the common acceptation of the term, it is a "hard water"—that is, it contains calcium carbonate and magnesium carbonate, which decompose the soap by combining with the alkalies, and the grease is set free. This decomposition forms in the water curd of soap. To use such a water at all for laundry purposes, a large quantity of soap is required, since it must be added until the calcium and magnesium carbonates are saturated. In all cases where examined the total quantity of solid mineral constituents in an imperial gallon of water taken from the drift does not materially differ in quantity—no matter from what horizon it comes, so long as it remains free from sewage contamination. The minimum quantity may be stated at twenty-three grains, and the maximum at twenty-nine grains, in a gallon. The upper stream contains the largest amount of carbonic acid and carbonates of the earthy minerals, and the lower one the least quantity of this acid and its salts—it being replaced in a manner by sulphuric acid, combined, in part at least, as calcium sulphate (gypsum) and magnesium sulphate (epsom salts). These salts are undecomposed by boiling; the latter is soluble in three parts of water, and the former does not, when precipitated, form a crystalline mass, but is miscible in water, and aids in preventing the formation of "fur" on steam boilers. For that reason the lower stratum of water is far preferable for use in steam boilers.

In Indianapolis, where well water is largely used in steam boilers, I was long puzzled to account for the fact that at the gas works, where the water supply is taken from the lower stream of water, the boilers are not incrusted, and the same was the case at the old starch factory, while all those who were using the upper seam of water were greatly troubled by the incrustation which formed on the bottom of the boiler and caused them to rapidly burn out. The Indianapolis rolling mill company were using water from the upper seam, and the incrusting of the boilers was so great that new boilers would not last over six months before burning out. This water contains, in different parts of the city, from thirty-six to forty-three grains of solid matter to the imperial gallon, and in some wells as much as 5.46 grains of chloride of sodium. The latter is undoubtedly nearly all derived from sewage infiltration. Being consulted in the matter of the water supply at the rolling mill, I advised them to go down to the second seam, and if that would not serve a better purpose, then go to the lower seam. The latter water at the gas works well contains 25.9 grains of solid matter to the imperial gallon, and the seam is there reached at the depth of ninety-two feet. The well at the old starch works was said to be only forty-three feet deep, and was probably in the second seam of water; the solid constituents in a gallon of the latter is 24.8 grains. For comparison, I will state that the water from White river, when filtered, contains fourteen grains of solid mineral matter in an imperial gallon. This sample was collected above the mouth of Fall creek. The rolling mill company ordered a well to be made; and on reaching the second or middle seam of water at fifty feet, which rose in the inner tube to within twenty-one feet of the surface, a sample was sent to the laboratory for examination. It was simply tested for solid mineral matter, and found to contain 24.6 grains in an imperial gallon. This solid matter was found to be, from frequent analyses made of other waters in the city, composed principally of calcium carbonate, magnesium carbonate, sulphuric acid, some chlorine, a little iron, silica, alumina, and alkalies. The water sent for examination was about as free from mineral salts as any examined from the lower stratum, and the company concluded to make a trial of it in the boilers, but the incrusting was as bad as ever.

Without being able, at the time, to account for the cause, the company were advised to sink their well to the lower seam. This was done, and the water was reached at 83 feet in gravel, sand and small boulders. On analysis it proved to contain the same amount of solid mineral matter, 24.6 grains to the gallon, but it gave no further trouble from fur in the boilers—the precipitated salts are in the condition of incoherent mud, and that is readily blown out through the mud valve. The good behavior of this water in boilers is found to be due to the presence of a large per cent. of sulphuric acid, which is probably combined with magnesium and calcium in proportions that prevent the formation of a solid incrustation. The per cent. of sulphuric acid in the upper water is from 1 to 2.5 grains to the gallon, while the lower seam contains from 4.5 to 5.5 grains. This, then, appears to be the main difference in the water. Now, if the presence of sulphates prevent the formation of boiler incrustation, it is possible that the addition of a small amount of sulphate of soda (glauber salts), or sulphate of magnesia (epsom salts), to waters that contain but a small amount of sulphates, may prevent the formation of fur in boilers. The effect of adding sulphate of soda would be to bring about an interchange of acids to form sulphate of lime and sulphate of magnesia and carbonate of soda. The two latter are quite soluble salts, but the benefits to arise from the addition of sulphate of magnesia is not so clear, since, by an interchange of constituents, there will be formed sulphate of lime and carbonate of magnesia, both sparingly soluble salts. It is possible, therefore, that the beneficial results arising from the presence of sulphates is, in a large measure, due to the physical properties of the respective molecules. Whether able to explain the matter or not, the fact has, time and again, been practically tested that water from the upper and middle streams in the drift uniformly incrust steam boilers, and the solid mineral constituents are principally carbonates with but little sulphates, while water from the lower seam does not incrust the boilers, though the total amount of mineral constituents remains about the same, but the latter contains more than double the amount of sulphates found in the former; and this is true of the water outside, as well as inside, the city limits.

I have dwelt at considerable length on this subject, because the water supply of a country for potable and manufacturing purposes is of very great importance to the people.

I will here give an analysis of water from two wells that have gone down to the lower seam of water, and find no trouble from its use in steam boilers:

	Kingan & Co.'s Pork House. Grains in 1 gal.	Peil & Co.'s Starch Fact'y. Grains in 1 gal.
Insoluble matter	trace.	0.70
Alumina, with trace of iron	2.10	3.15
Lime	8.43	9.85
Magnesia	2.04	1.20
Carbonic acid	6.36	6.24
Sulphuric acid	4.55	5.04
Chlorine	trace	trace
Loss and undetermined	0.32	0.77
Total grains in one gallon	23.80	26.95

The well at the rolling mill only differed from that of Kingan & Co. in having a little more solid matter to the gallon.

The water formerly used at the starch factory gave an immense amount of trouble; it was reached at a depth of about fifteen feet, and contained only 2.1 grains of sulphuric acid to the imperial gallon. At the request of Mr. Peil I made this examination, and advised him to procure his water supply from the lower seam, and since doing so they have had no further trouble from fur in the boiler. The above analysis indicates the character of this water.

The Indianapolis Water Works company have commenced a well that will reach this lower stream of water, and as soon as completed they will be able to supply the same to their customers.

While other cities may have softer water derived from river sources or lakes, these are liable to pollution from surface drainage, and the saving in soap is more than overbalanced by the danger to health. But here, when the supply is obtained from the lower stream, and the upper waters are stopped out, it is hardly possible to find a safer or more wholesome water, or one better adapted for steam purposes.

The streams of water which permeate the drift often find an exit where the beds are worn through by erosion in valleys or ravines, and give rise to springs. Some of these are quite large, and discharge a great volume of water. At some localities these springs, especially when they come from the upper stratum of water, are so largely charged with bicarbonate of lime that there is formed around the discharge great masses of tufa. In Wayne county this is particularly noticeable in the romantic valley of Little Elkhorn creek, near the crossing of the pike leading from Geo. H. Smith's to Richmond, section 31, township 12, range 1, and not far from the mouth of the creek. The water is discharged in a bold stream from the upper bed of gravel and sand, and has built up large blocks of tufa twenty-six feet thick on that side of the valley. These tufa blocks add wildness to the scenery, and the delightful shade cast by the forest trees over the cool water of the spring has made this spot a pleasant resort for picnic parties on hot summer days. George H. Smith has a large artificial pond in front of his palatial farm residence, not far from this locality, that is fed by spring water. Another large spring, breaking out from the drift, is on the north side of Elkhorn creek, on Mr. H. Sulsor's land, by the side of the pike, and is turned into a long wooden trough, from which the passing teams are permitted to quench their thirst. The temperature of the water of these springs is about 52° F. There is a very large spring, that furnishes water-power for a large grist mill, on section 36, township 13, range 1. This spring forms part of a small creek that empties into the East fork of White Water. Above the spring, the branch, which is called Sink creek, disappears beneath the surface and comes up at the spring. The most important springs, in a medicinal point of view, are on Mr. John Hawkins' farm, just east of the city of Richmond. The water breaks out from the junction of the drift and the blue argillaceous shales that form the upper part of the Lower Silurian beds. There are a number of springs on the place, but Mr. Hawkins has only thought proper to inclose three with cement pipes that are about two feet in diameter. They are situated on the south side of the East fork of White Water, and about twenty feet above the bed of the stream and sixty feet below the crest of the hill, at Mr. Hawkins' residence. The springs are only a few feet apart, and arranged in the form of a triangle, °₀°. The ground around is neatly paved, and the overflow of water is carried off in a paved shute. This shute is well lined with a brownish-red gelatinous precipitate of ferric oxide which tells at once the chalybeate character of the water. There is considerable gas bubbling up from the bottom of each spring, but I had no means of collecting it for special analysis at the laboratory. It appeared to be mainly carbonic anhydride and carbonic dioxide. No odor of sulphydric acid could be detected at the spring or in the water shipped to the laboratory for analysis. On the curbing there were vast quantities of fresh water conferva, algæ, diatoms and desmids. The algæ would extend their rich green filaments for several inches beyond the curb into the crystal-clear water. A number of these microscopic plants were collected for examination, and proved to be (*Algæ*) *cosmaria, Oscillatoria, Euastra, Staurastra, Closteria, Pediastra, Spirogyra,* and some undetermined genera, (*Diatomacia*) *Staroneis, Gomphonema, Podosphenia, Nitschzia, Navicula, Pleurosigma, Pinnularia, Eunotea, Fabulria, Surivella, Synedra, Fragillaria, Cocconema, Meridion,* and other genera not determined.

It is a curious fact that desmids more rarely, but diatoms may always, be found in the water that flows through the drift. I have never failed to find them in the three subterranean waters that underlie the city of Indianapolis. They are brought up in driven wells from the lower stream when tubed so as to exclude the upper water.

ANALYSIS OF WATER FROM HAWKINS' MINERAL SPRING, RICHMOND, INDIANA.

Sample collected from the west gum. It imparts an alkaline reaction to litmus paper. An imperial gallon (10 lbs.) contains of solid matter 32.2 grains, consisting of:

	Grains.
Insoluble silicates	0.1900
Ferrous oxide	0.1429
Calcium oxide	10.3800
Magnesium oxide	0.4400
Potassium oxide	0.6600
Natrum oxide	0.2120

	Grains.
Sulphuric anhydride	9.5300
Carbonic anhydride	10.0800
Chlorine	0.4900
Loss	0.0751
	32.2000

Free carbonic acid 5.1643 cubic inches in an imperial gallon.

These bases and acids are probably combined as follows:

	Grains.
Silicates	0.1900
Ferrous carbonate	0.2303
Calcium sulphate	14.0261
Magnesium sulphate	1.9198
Calcium dicarbonate	11.3416
Potassium carbonate	1.4042
Sodium chloride	0.4001
Carbonic anhydride	2.4429
Calcium chloride	0.3862
	32.2148

This is a sulphatic and carbonated chalybeate water; its action is that of a mild tonic, aperient and diuretic and decided alterative.

A qualitative examination of the two other springs on Hawkins' farm showed no perceptible difference in the quality of the water.

The water from Cedar spring, Preble county, Ohio, near New Paris, is similar to the above; it also rises from the same geological horizon, *i. e.*, the blue shales which form the junction of the Upper and Lower Silurian beds in Wayne and Preble counties.

At Hawkins' spring the Upper Silurian has been removed by denudation, and the drift lies immediately on the blue shales.

These springs are located in a very beautiful grove on the second bottom of East fork of White Water, and at the foot of the grassy slope which rises rapidly to the table-land Considerable use is made of the water by the citizens of Richmond, but it is worthy of a more extended celebrity.

There are other springs in the county that break out from the same horizon, which contain a notable quantity of iron. They may be recognized by the reddish-brown gelatinous precipitate which stains the sides of the gums. There are several very large and valuable springs of this character on J. W. Vestal's place, near Cambridge City.

The drift has been of very great use to this county in supplying an endless quantity of gravel suitable for making gravel turnpikes. And probably no county in the State contains so many of these admirable channels of commerce. On Mr. J. C. Ratliff's place the pure gravel bed is from twenty-five to thirty feet thick.

In 1851, when making a cut through the divide, between Noland's fork and Green's fork, for the Richmond and Logansport division of the Pittsburg, Cincinnati and St. Louis railroad, at the depth of about twenty-one feet in the middle of the cut, the workmen struck upon what seemed to them a solid pavement of boulders. The upper part of each boulder appeared neatly dressed on the surface, as though done by the hand of a skilled workman. This pavement extended nearly the entire length of the cut, though towards the ends it was considerably broken up, and finally gave out entirely. It was very thick near the center of the cut, and appeared to dip toward the east, but as the grade of the railroad was forty feet to the mile in the opposite direction, this may not be the correct dip. The width of this pavement of boulders must be considerable, since at the distance of half or three quarters of a mile on the north side four wells had been dug, and in three, at about the same depth beneath the surface, a layer of scratched boulders was encountered. The whole deposit of boulders is in a matrix of hard, blue clay—"hard pan." On the face of these boulders are a number of parallel scratches, the direction being nearly north and south. Many of the boulders are of large size, and nearly all are a bluish colored, crystalline rock, susceptible of receiving a fine polish. One of these boulders measured two feet in diameter and eighteen inches thick, and was as round as a grindstone.*

Scratches, or rather fine parallel striæ, bearing north a little east, and south a little west, are also seen in the bed of Noland's fork, near Centreville, and on rocks of Hudson River age. The face of the rocks are ground down to a level, and the striæ are plainly visible. Indeed, everything leads to the conclusion that the glaciation was carried on in great force in this part of the State.

On Levi Jessup's land, about one mile northeast of Richmond, there is a fine bed of potters' clay exposed in the east bank of the Middle fork of White Water. The following shows the character of the exposure:

	Ft.	In.
Soil	2	0
Sand, with gravel and small boulders	16	0
Yellow plastic clay, burns reddish	0	10
Blue plastic clay, when damp soft and cuts like cheese, unctuous feel, has a little grit, tested with the teeth, burns cream color, lies in thin laminæ of about half-inch thick, dips 3° S. of E.	8	6
Gravel, sand and small boulders	25	0
Bed of creek	0	0
	52	4

Bott, Hammersley & Co. have established a pottery at Richmond for the manufacture of garden and green-house flower-pots and saucers. They use this clay, and the ware has a very agreeable cream color. They also manufacture a

*The above information was furnished by Prof. J. C. Macpherson, county superintendent, Richmond, Ind.

great variety of ornamental hanging-baskets and vases. Mr. Bott is an experienced potter and most excellent workman, and their wares find a market as far south as Texas. They use about six tons of this clay in a week, and produce about 30,000 flower-pots in the same time. The following analyses show the composition of these clays:

UPPER BED—YELLOW CLAY.

	Per Cent.
Loss at red heat	9.50
Silicic acid	44.50
Ferric oxide	16.00
Alumina	6.80
Calcium carbonate	12.30
Sulphuric anhydride	0.20
Chloride of alkalies	3.80
Loss and undetermined	6.90
	100.00

BLUE PLASTIC CLAY.

	Per Cent.
Loss at red heat	12.60
Silicic acid	45.30
Ferric oxide	13.20
Alumina	9.60
Calcium carbonate	12.90
Magnesium carbonate	2.98
Sulphuric anhydride	0.63
Chloride of alkalies	2.30
Loss and undetermined	0.49
	100.00

The yellow clay appears to contain too much calcium carbonate, ferric oxide and alkalies to stand a very high heat.

Clays are found elsewhere in this county in the drift, but none have been tried at the pottery that gave as good results as the above.

ANTIQUITIES.

The high table-lands of this county, and its deep canon-like river vallies, afforded the mound-builders favorable sites for their settlements, and we constantly find the remains of a number of large and interesting earthworks and a great many mounds scattered along the bluffs of the streams. Prof. J. C. Macpherson, county superintendent of schools of Wayne county, has kindly furnished me with a sketch of these ancient works, and as he has given considerable attention to the study of archæology, his report is a very valuable acquisition to our knowledge on this subject, and I take pleasure in presenting it to the public.

OBSERVATIONS ON THE PRE-HISTORIC EARTHWORKS OF WAYNE COUNTY, IND.

[By J. C. Macpherson.]

The surface of Wayne county presents many evidences of occupancy by the mound-builders. Mounds are found in all parts of the county—situated on the uplands and along the courses of the streams. The plowshare has leveled many, and some have been removed in opening roads or the material used in making brick. Twenty-five mounds have been located on a map of the county prepared in connection with the geological report.

The works in this county seem to be a continuation southward from the works along White river in Randolph county, and follow the branches of the White Water. Perhaps, when all the works located in this part of the Ohio Valley are mapped, some systematic arrangement may be discovered.

Three miles north from Fountain City (formerly called Newport), on a rise overlooking the wooded valley of Noland's fork, is a mound seventy-five feet in diameter, (section 19, township 18, range 15 east).

Another is on the farm of Daniel Hough, adjoining Fountain City. A third is said to have been removed in making the principal street of that town.

One mile northeast from Fountain City, on level ground, between Noland's fork and a small tributary—Buck run—is an embankment inclosing eleven acres. The figure (Plate C) of this earthwork is a square with curved corners. The length on the inside of the embankment is 780 feet. The

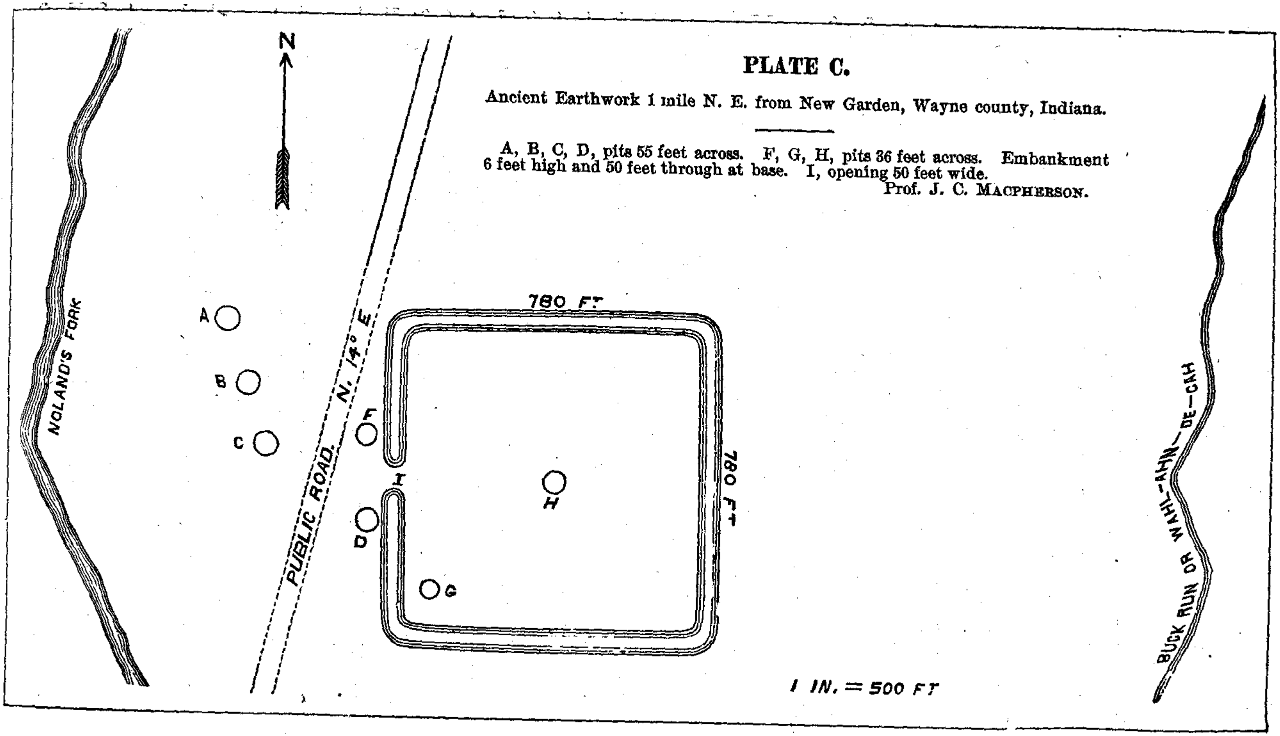


PLATE C.

Ancient Earthwork 1 mile N. E. from New Garden, Wayne county, Indiana.

A, B, C, D, pits 55 feet across. F, G, H, pits 36 feet across. Embankment 6 feet high and 50 feet through at base. I, opening 50 feet wide.

Prof. J. C. MACPHERSON.

embankment has been plowed over for years, yet can be plainly traced. A gateway is discernable on the west side, and hollows are found in the vicinity, which some suppose were made by the builders when collecting material for the embankment. Since the accompanying map was made, a more careful survey has discovered the fact that the direction of the embankment is not due north and south, but at an angle, with the west side nearly parallel with the road.

A large mound stood two miles north from Chester (section 4, township 14, range 1 west). The greater part was removed in making the Arba road. A copper ring was found therein, and is now in the collection at Earlham College.*

Several mounds are situated in the neighborhood of Middleboro. Some have been opened, but no contents worthy of notice have been obtained.

One mile north from Richmond, on the Hoover farm, and in that vicinity, several small mounds were located. In one, when removed, was found a copper ornament.

A mound near Earlham College was opened by President Moore, and the usual contents of mounds found—pieces of pottery, ashes and other evidences of fire.

On the J. C. Ratliff farm a mound was opned, and some small articles, which were at first supposed to be beads, but are now thought to be parched corn, found therein. L. B. Case, of Richmond, has some grains of corn which were found in a jar some distance below the surface of the ground, in the vicinity of that place.

A large mound south from the town of Centreville was deemed of sufficient note to be marked upon an early map of the State, but has since been destroyed.

In the southwestern part of Boston township is a mound hidden away in a "hollow"; and one formerly stood south from Richmond near the Boston pike.

Traces of a mound are to be seen on the farm of James W. Martindale, adjoining Washington. This mound was opened in early times, and charcoal found near the original surface of the ground. A great quantity of arrow-heads have been found around a spring (long since dry) near this mound.

A circular embankment was found near Green's fork, east from Jacksonburg, twenty-five feet in diameter. It was long since plowed down.

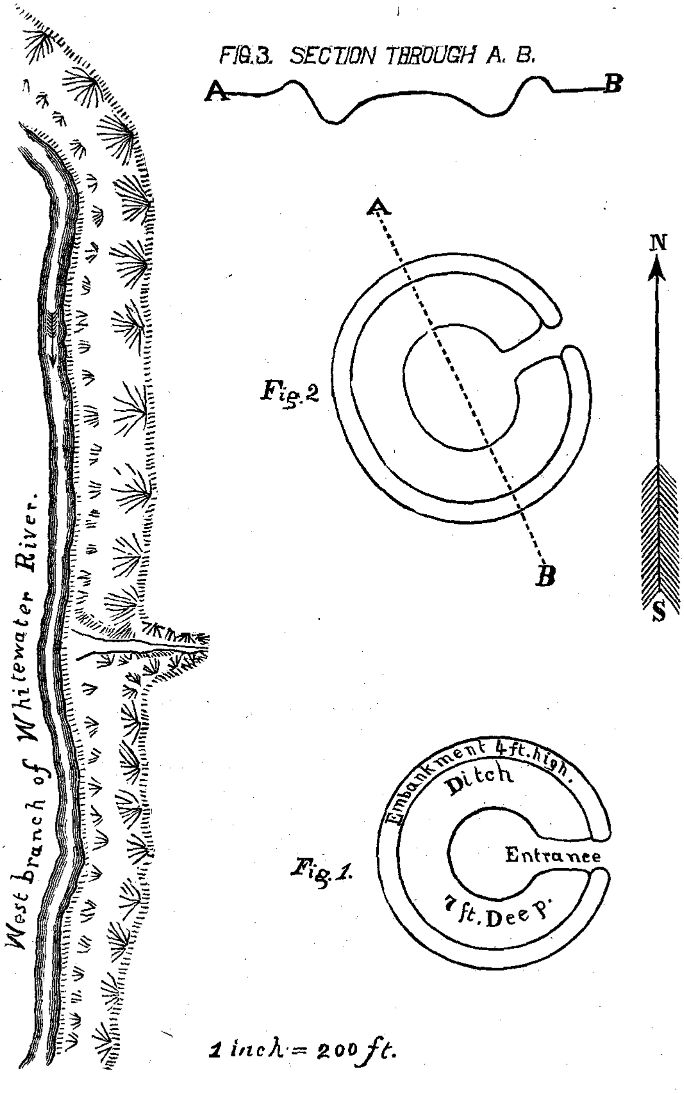
Two mounds are to be seen a short distance northwest from Jacksonburg.

*Judge N. R. Overman informs me that four copper bracelets were found. He has one in his cabinet. He also has three flint implements taken from this mound. E. T. C.

PLATE A.

Ancient Earthworks north from Cambridge City, Wayne county, Ind.

J. C. MACPHERSON.



Overlooking Martindale's creek in Jefferson township (section 18, township 17 north, range 13 east,) is a mound. Also two in the bottom land along West river, at Hagerstown.

Two miles southeast from Milton (section 6, township 15, range 13 east,) is a beautiful mound, fifteen feet in diameter. Forest trees are still standing upon it; also a stump measuring two feet across.

Near the county line, about one mile north of Waterloo, Fayette county, is a mound upon high ground, and about a mile to the southeast, in Fayette county, is a curiously shaped work.

The most notable mounds (Plates A and B) in Wayne county are located on the left bank of the west branch of White Water river, one and a quarter miles north from Cambridge City. They consist of a series of circular embankments, continued over half a mile of ground.

The south circle (Plate A) is in the best state of preservation. The embankment was made of the earth taken from the trench which is on the inside of the embankment. Within, the ground has been made to slope gently from the center to the bottom of the trench, except to the east, where there was left a roadway leading from the center through a gateway in the embankment to the level ground beyond. The embankment is four feet above the surface of the field, and seven feet above the bottom of the trench, and wide enough on the top to allow two carriages to pass each other. The gateway is one rod wide. This circle is made of gravelly soil, while the north circle is composed of a loam, and has yielded more to the destroying influence of plowing. It is not as symmetrical as the other, being more oval in outline.

The class of works to which these belong is described in "Ancient Monuments of the Mississippi Valley," page 47, and are denominated "Sacred Enclosures."

These two circles on Plate A, are about fifteen rods apart, and about the same distance from the bluff of the stream. In the bluff, equally distant from both the circles, is a passage way cut from the top of the bluff to low ground bordering the water, some twelve feet below. This cut is evidently not a water-wash, for along the sides can be seen the earth which was removed in making it thrown up as dirt is thrown up along the sides of a ditch.

The bluff here spoken of is the edge of the first terrace. The rounded margin of the second terrace can be seen a quarter of a mile to the east.

Several hundred feet north from the second of the above described circles is a group of five small circles (Plate B). With one exception these are about sixty feet in diameter, and are now from one to two feet high. The circle nnmbered 3, on Plate B, is at the point of a tongue of higher ground, and affords an outlook over the other works. The embank-

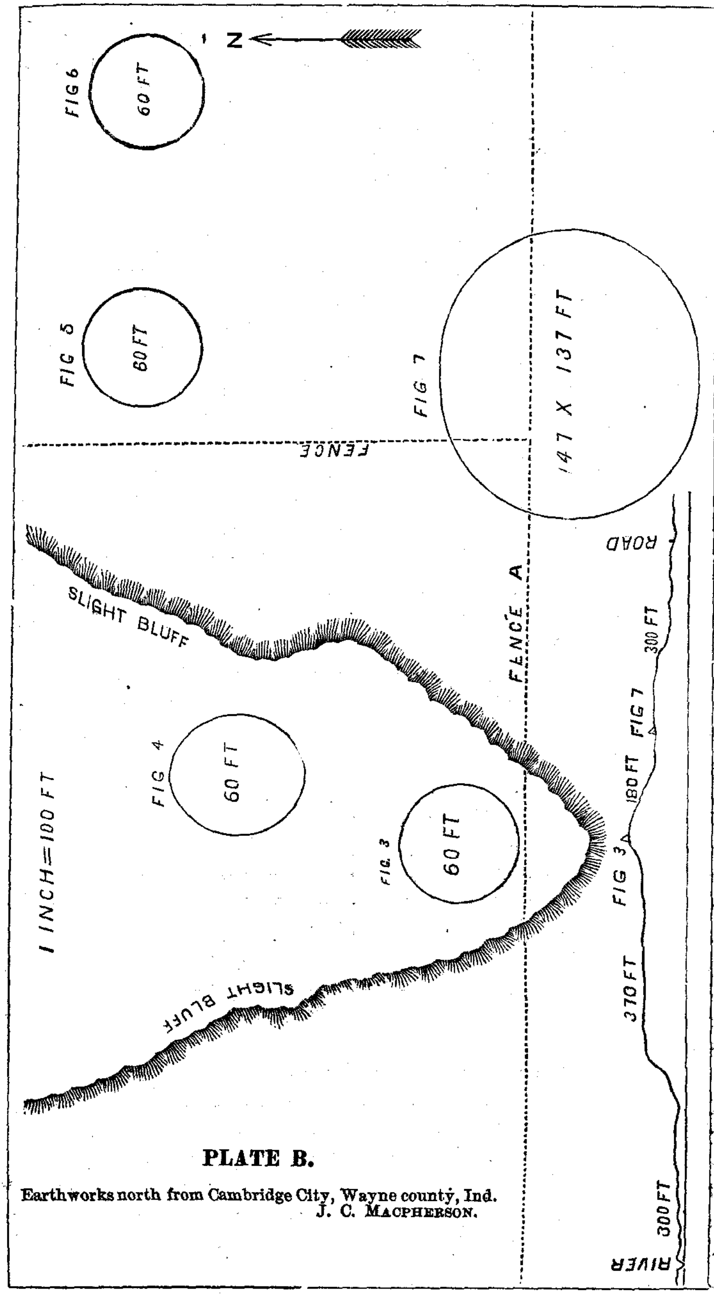


PLATE B.

Earthworks north from Cambridge City, Wayne county, Ind.
J. C. MACPHERSON.

ment of the largest work in this group (numbered 7,) can not be traced on on the south, that part being in a field which has long been cultivated. Trees of large size were, until recently, standing upon the embankments of these works.

Burial places and remains have been found in various localities within the county. A number of years ago, in removing the gravel from a bank in the northwest part of Jefferson township, nine feet below the surface, eight skeletons were discovered. They had been buried in an upright position. These bones were gathered together by the workmen and reburied in a common grave. In constructing the Valley railroad from Hagerstown to Cambridge City, human remains were exhumed; also some at the latter place.

O. Beesom* communicated to the local papers, some twelve years ago, an account of the discovery of a burial place in the extreme southwest corner of the county. Many skeletons were found in a gravel bank, some having been placed in a sitting posture, and some with the head downward.

Recently some twenty or more skeletons were unearthed in a gravel-pit on George Jordan's farm, about two miles northwest from Economy. These bodies seem to have been buried in graves a few feet apart, and six feet below the surface. Some of them were in a sitting position, while others were in various positions.

The discovery of a human skeleton in a mound on the bank of White Water, near Richmond, many years ago, was the occasion for the following lines from the pen of the late John Finley, author of the "Hoosier's Nest," and other poems, and once Mayor of Richmond:

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

* * * * * * * * *

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

Stone and flint implements were formerly found in great numbers in this region. Wayne county, like the rest of our State, has suffered in

*Mr. O. Beesom very kindly presented a stone spinner and several stone totems, taken from these graves, to the State cabinet. E. T. C.

being robbed by collectors and traffickers, who have carried away many specimens to grace the museums of other States. But recently more interest has been manifested in the subject of archæology, and the collection at Earlham College, and several private collections, are beginning to assume interesting proportions.

TIMBER.

Wayne county was covered with a dense growth of trees indigenous to this latitude, but now more than half of the land has been cleared for cultivation.

Among the most important trees are black walnut (Juglans nigra), at one time very abundant, especially on a ridge known as black walnut ridge, extending through a portion of Harrison, Jackson and Washington townships.

Poplar (Lyriodendron tulipifera); large, and once very abundant.

White oak (Quercus alba); large, and quite abundant on uncleared land.

Burr oak (Quercus macrocarpa); found on bottom lands.

Black oak (Quercus tinctoria); on upland.

Red oak (Quercus rubra), red beech (Fagus ferruginea) and white beech (Fagus sylvestris); very common, especially on clay slopes.

Buttonwood (Platanus occidentalis); grows along the borders of all the streams.

Shellbark hickory (Carya alba), pignut hickory (Carya glabra), thick shellbark (Carya sulcata), sugar maple (Acer saccharum); still very abundant.

White maple (Acer dasycarpum), red maple (Acer rubrum); common on wet ground and bordering on streams.

White walnut, or butternut, (Juglans cinerea), sweet gum (Liquidamber stryaciflua), slipery elm (Ulmus fulva), white elm (Ulmus americana.)

Wild cherry (Cerasus virginiana), blue ash (Fraxinum quadrangulata), hackberry (Celtis occidentalis), honey locust (Gleditschia triacanthos); on bottom lands.

Buckeye (Æsculus canadensis), cottonwood (Populus canadensis); grows along the streams. Basswood (Tilia americana), and coffee nut (Gymnocladus canadensis).

AGRICULTURE.

The soil of Wayne county has been derived from the disintegration of crystaline rocks lying north of the State, as already stated. The physical features of this soil are various, but usually it is rich in fertilizing elements. No county in the State contains so many good farms, or a more thrifty class of farmers. The fields are kept in admirable order; the homesteads look comfortable, and are surrounded with good stables and barns to give shelter to stock and storage for grain. The land may be called level, and is either river bottom or table-land. The former is mostly sandy loam, well supplied with organic matter, and produces large crops of all kinds of grain, but is particularly suited for corn. The table-land is mostly clay loam; grows corn well, but is generally better adapted for wheat and other small grain.

Clover and grass grows well in all parts of the county. Blue grass is indigenous, and there are many excellent pastures of this grass. The late General S. Meredith, of Cambridge City, was a warm advocate of the cultivation of blue grass and the raising of fine horses and cattle. His blue grass farm at Cambridge City is excellent proof of the value of this kind of pasture, and his herd of blooded short horn cattle were unequalled by any in the country.

Wayne is the largest flax-growing county in the State. The acreage sown in 1877 amounted to about 6,000 acres. The average yield is twelve bushels to the acre, so that the total product amounted to about 72,000 bushels of seed, and about 10,000 tons of flax straw. There are three flax mills in the county: McKennett & Pierce at Hagerstown, I. S. Gary, Jr., at Cambridge City, and Joseph Shilleto at Richmond. The annual value of the materials, lint or fibre and bagging manufactured, is estimated at over $100,000. Mr. Gary has much the largest factory, and turns out alone about one-half of the above amount. The remainder is about equally divided between the Hagerstown and Richmond mills. Flax (Linum usitatissimum) extracts from the soil a large quantity of mineral matter, especially potash and phosphoric acid, which are the most valuable constituents of arable land. It is considered, therefore, one of the most exhaustive crops, when no part of the plant is returned to the land. Neither the pure fibre or the oil contains any of the mineral constituents, but they are to be found in the cake after the oil has been pressed out. In Europe the oil-cake is extensively used for food for cattle, and appears to possess extraordinary fattening properties. This cake should be returned to the soil as manure. It may be ground to a coarse powder, and applied as a top-dressing.

The stem of the flax plant consists of an inner part or core; sometimes hollow, but more frequently solid, and is composed of ligneous matter, surrounded with a bark of fibres united to one another by a gum and covered with a fine epidermis. To separate the linen fibre from the gum and woody matter, after removing the seed, the stems are steeped in a stream of running water for a period ranging from seven to twenty-one days. By this operation they undergo a kind of putrefaction which decomposes the gum and loosens the fibres from one another and from the woody core. The stems are washed and the fibre removed by an operation called "scutching." The fibre is thus removed whole, while the brittle, woody part of the stem is broken into small pieces. The greater part of the mineral matter is removed in the steeping and wash water, and in this state it may be returned to the land. The woody part is generally burned, and the ash should at least be saved and returned to the soil. By the use of these precautions flax may be grown with as little danger of impoverishing the soil as any other crop.

An analysis of the ash of the best quality of flax stems gives the following:*

	Per Cent.
Silica	2.68
Ferric oxide	1.10
Alumina	0.72
Lime	18.52
Magnesia	3.93
Carbonic anhydride	16.38
Sulphuric anhydride	6.83
Phosphoric acid	8.81
Potash	22.30
Soda	14.11
Chloride of sodium	4.58
Loss	0.04
	100.00

Flax straw dried at 100° gives 3.67 per cent. ash.

Nitrogen in the plant, 0.876 per cent.

Flax seed dried at 100° gives 3.05 per cent. of ash, and 0.23 per cent. of nitrogen.*

An analysis of the ash of flax seed gives the following:

	Per Cent.
Silica	1.46
Ferric oxide	0.38
Lime	9.45
Magnesia	16.23
Sulphuric anhydride	1.43
Phosphoric acid	35.99
Potash	32.55
Soda	2.51
Chlorine	trace
	100.00

*Flax analyses from Watts' chemical dictionary.

From this it will be seen that a crop of flax will extract about 300 pounds of mineral matter from an acre of ground, the two most essential being potash and phosphoric acid. About twenty-one pounds of this mineral matter will be found in the seed and 279 pounds in the stems of the plants.

These substances may be returned to the land in barnyard manure, if it is to be had, or in the form of mineral fertilizers, bone-dust, sulphate of magnesia, common salt and carbonate of potash, or fresh wood ashes and sulphate of ammonia.

Flax requires a fine pulverulent loam soil, and is materially injured by the presence of stagnant water held by the subsoil on undrained lands. I would recommend as a suitable fertilizer, for one acre, the following substances, which may be had of the Indiana Fertilizer company, of Indianapolis, with the exception of the salt, for the prices affixed:

Bone dust, 200 pounds, cost	$2 50
Dried blood, 50 pounds, cost	75
Common salt, 100 pounds, cost	40?
Total cost not to exceed	$3 65

A cheap kind of salt may be used, such as the waste from the pork houses; the whole should be intimately mixed with 400 or 500 pounds of dry muck, vegetable mould or ashes, and scattered broadcast over the field. The same fertilizer, with the addition of fifty pounds more of dried blood, will be found to be an admirable top dressing for wheat, and one that will more than repay the cost by the increased product of grain.

As a general thing the soils of Indiana have been gradually losing their fertility by a constant removal of mineral constituents by the crops. The impoverishment from this cause has been carried on to such an extent that it is now absolutely necessary that farmers should turn their attention to the study of the best and cheapest way in which they may be returned. If the savings at the barn from the liquid and solid voidings of stock, and the unconsumed straw or fodder, is not sufficient to make a full return, then let the deficit be made up by a portion of mineral fertilizers. As a test of this matter I would recommend the careful farmer to apply to different plats of ground of equal good or poor quality, but not suffering for want of proper drainage, either natural or artificial, a dressing of barn-yard manure in such quantity as he may deem ample for a good crop, and of equal moneyed value to the mineral fertilizers above recommended. On the other plat let him put the mineral fertilizers in proportions and quantity per acre herein given, and then compare the yield of the two plats. By this means, but not from the single experience of one year, but of several years, he will be able to arrive at the true value of the mineral fertilizer, and whether it can be relied upon to restore to the land the fertilizing properties which have been removed by cropping.

The mineral fertilizers here recommended for an acre of ground will not cost more than the price stated—$3.65; now if this outlay will bring on ground which has received but little if any fertilizers, a crop of flax worth from seven to eight dollars more than the product of unfertilized land, it is plain to see that a handsome interest has been received on the money expended, as well as leaving the land in a better condition than before. I know that I am addressing a good class of farmers in Wayne county, for they raise here eighty to ninety bushels of Indian corn and twenty to thirty bushels of wheat to the acre. This bespeaks for them not only a good natural soil but admirable tillage, and a careful regard to keeping up the land by returning, what can be saved from all available farm sources, back to the soil, and by due regard to a rotation of crops.

Large quantities of timothy, red-top and clover, are grown, and clover is especially cultivated with a view to the improvement of the land. The advantages to be derived from growing and turning under clover can not be denied, but the farmer must not lose sight of this fact, that these benefits are derived from a partial rest which the land receives from the greater needs of the grain crop for the most important mineral food—phosphoric acid. By this rest the atmosphere and waters have time to aid in promoting the better chemical decomposition of the soil, and to render an additional portion of what phosphoric acid remains available to the succeeding crop of grain. Clover and other green crops, when turned under, supply the organic matter and nitrogen which are beneficial to agricultural plants. But they add no mineral matter that did not already exist in the soil. So that, upon reflection, one is compelled to admit that by rotation of crops, that while it enables the farmer to obtain a larger yield of produce, it will not alone prevent the final exhaustion of mineral plant-food, and that it is not possible to keep up land to a normal state of fertility without restoring to it by a direct application in some form of combination, the phosphates and alkalies which have been removed. Then, again, it is not always convenient or profitable to be compelled to raise a crop for the sole purpose of keeping land in heart, and the farmer should be apprised of the fact that he may raise any crop he desires, congenial to our climate, on the same piece of ground, by an annual application of such food as the crop needs for nourishment. This, then, brings the question down to a matter of dollars and cents, in which the increased value of a crop figures against the cost of fertilizers. The solution of this question is within the reach of every farmer.

MANUFACTURES.

Wayne county has long been noted for its extensive manufacturing establishments, especially those for the production of agricultural implements. The Gaar, Scott & Co. Machine Works have long held an enviable reputation for their steam and horse threshing machines, portable and stationary engines, clover hullers, saw-mills, etc., etc.

S. Horney & Co.'s steel plows have found their way into every county in the State, and their good qualities are recognized in all the adjoining States, where they meet with ready sale.

The Hoosier Drill, lately manufactured at Milton, now at Richmond, is one of the best grain, grass and clover-seed drills manufactured in the Union. The Emperor of Brazil, who takes the deepest interest in all kinds of machinery destined to promote the interests of agriculture, saw the Hoosier Drill on exhibition at the Centennial, and purchased one after a thorough examination of it. Dr. Nicolau J. Moreira, Brazilian judge on group IV, "Vegetable products and machinery," a gentleman of great learning, and author of a very important work on the agricultural resources of Brazil, and one more competent to judge of the merits of the machine could not well be found, examined this drill and recommended it to the Emperor. His favorable opinion is highly commendatory of the mechanical skill and genius of the manufacturers.

There are a number of other manufacturing establishments in Richmond, Germantown, Centreville, Cambridge City and Hagerstown, besides those mentioned in this brief notice.

At the dedication of the new works of the Hoosier Drill company, at Richmond, J. M. Westcott, president of the company, gave a brief review of the progress of manufactures in Richmond by decades. From this address I learn that the number of manufactories now in operation at Richmond is 139. The amount of sales for 1877 was $3,315,510, and the wages paid during the same time for labor in these factories amounted to $702,693.

THANKS.

To the citizens of the entire county I am indebted for the most cordial treatment while prosecuting my investigations. Mr. J. C. Ratliff let all business go and traveled with me day after day. Mr. L. B. Case, a most indefatigable student of natural history, Prof. J. C. Macpherson and Mr. M. J. Shinn, also accompanied me on many occasions. These gentlemen are all well acquainted over the county, and familiar with the most important geological localities. I am, therefore, greatly indebted to them for much valuable information and their able assistance. To Mrs. Mary P. Haines I am also under obligations for the privilege of studying her ample collection of fossils and cryptogamic plants collected in the county; notice has been made of this collection, together with a catalogue of the specimens, on page 201 of this report.

Though Dr. O. P. Barr happened not to be at home when I called to see him, I must not omit to mention that he has an admirable collection of fossils collected in the county, and has done much to enrich the science of palæontology by his discoveries.

I must also notice the Hon. William Baxter for the warm interest he manifested in the progress of the survey. Mr. Baxter has an extensive library, and is a great reader and student, as well as energetic business man and prominent legislator.

Hon. John Yaryan, the able representative of the county, also very kindly tendered all the assistance in his power.

James Starr, president of the Richmond Gas-works, was likewise active in showing me what attention he could. Mr. Starr is one of the most enterprising gentlemen in the State; he is known in Richmond as "the great American tree-planter," having set out, within the year, over one thousand trees. He has purchased a large plat of ground in the city, and is ornamenting it with walks, drives, shade-trees and shrubbery, to be open to the people as a public park.

To the press of the county I am also under many obligations for encouraging notices and kind words regarding the progress of the survey.

The following is a list of the ferns, mosses, hepaticæ and lichens collected in Wayne county, Ind., by Mrs. Haines, and furnished by her for publication in this report:

FERNS.

Adiantum pedatum ....L.
Asplenium angustifolium..................................Mx.
Asplenium thelypteroides.................................Mx.
Asplenium felix-fœmina...................................Bernh.
Asple. felix-fœmina, var. Michauxii.
Aspidium acrosticoides...................................Swtz.
A. acrosticoides, v. incisum.
A. thelyptera..Sw.
A. spinulosum..Will'd.
A. spinulosum, var.
Botrychium virginicum ....L.
Camptosorus rhizophyllus ....Lk.
Cistopteris fragilis......................................Bernh.
C. bullifera..Bernh.
Onoclea sensibilis..L.
Polypodium hexagonopterum................................Mx.
Pteris aquilina ....L.

MOSSES.

Aulocomnion heterostichon................................Br. & Sch.
Anomodon rostratus.......................................Sch.
A. tristis.

MOSSES—CONTINUED.

A. fragilis.
A. attenuatus...Hub.
A. *obtusifolius*...Br. & Sch.
Atrichum angustatum...Hood.
At. undulatum...Beau.
Bartramia *pomiformis*...Hedw.
B. marchica...Brid.
Barbula fallax...Hedw.
B. *cæspitosa*...Schwaegr.
B. unguiculata...Hedw.
Bryum argenteum...Linn.
Bry. caespiticium...Linn.
Bry. nutans...Schreb.
Bry. pyriforme...Hedw.
Bry. pseudo-triquetrum...Hedw.
Bry. roseum...Dill.
Ceratodon purpureus...H. & B.
Climacium americanum...Brid.
Cylindrothicum seductrix.
Cyl. cladorrhizans.
Cyl. brevisetum.
Cyl. seductrix, var.
Drommondia clavellata...H. & T.
Dicranium flagellare...Hedw.
D. scoparium...Hedw.
D. viride.
Funaria hygrometrica...Hedw.
Fissidens adiantoides...Liv.
F. taxifolins...Liv.
F. subbassilaris.
Grimmia pennsylvanica...Sch.
Gymnostomum curvirostrum...Hedw.
Homalothecium subcapillatum.
Hypnum acuminatum...Beau.
Hyp. boscii...Schwaegr.
Hyp. cordifolium...Hedw.
Hyp. cylindrocarpum...C. Mull.
Hyp. campestre...Br. & Lch.
Hyp. delicatulum...Linn.
Hyp. deplanatum.
Hyp. fluitans...Linn.

MOSSES—CONTINUED.

Hyp. gracile...Br. & Leh.
Hyp. gracile, v. lancastriense.
Hyp. hispidulum..Brid.
Hyp. hians...Hedw.
Hyp. imponeus..Hedw.
Hyp. laetum..Brid.
Hyp. riparium, v. cariosum.
Hyp. rutabulum...Linn.
Hyp. serrulatum..Hedw.
Hyp. serpeus...Linn.
Hyp. serpeus, v. orthocladon.
Hyp. serpeus, v. radicle.
Hyp. salebrosum..Hoff.
Hyp. strigosum...Hoff.
Hyp. tamariscinum..Hedw.
Hyp. varium.
Hedwigia ciliata...Ehrh.
Leucobryum vulgare.
Leskia polycarpa...Hedw.
Leptodon trichomitrion...Brid.
Leucodon julaceus..Hedw.
Len. brachypus...Brid.
Leptodon ohioense.
Leskia denticulata...Sull.
Mnium affine...Bland.
M. cuspidatum..Schreb.
M. rostratum...Schwaegr.
Neckera pennata—small var.
Orthotrichum strangulatum.
Polytrichum formosum...Hedw.
Physcomitrion pyriforme..Brid.
Pylaisea denticulata.
Py. intricata..Hedw.
Py. velutina...Bryol. En.
Platygerium repens...Bryol. En.
Schistidium confertum..Funk.
Trichostomum pallidum..Hedw.
Thelia asprella..Sull.
Thelia hirtella...Sull.
Weisia viridula..Brid.

HEPATICÆ.

Conocephalus conicus...Durn.
Frullania aeolotis...Nees.
F. eboracensis...Leh.
F. virginica.
Aneura sessilis.
Blephoragia ciliaris...Nees.
Chiloscyphus ascendens...H. & T.
Calypogeia trichomanes.
Jungermannia curvifolia.
J. schraderi.
Lophocolea maconni.
L. minor.
L. bidentata.
L. heterophylla..Nees.
Madotheca platyphylla.
M. thuja.
Marchantia polymorpha.
Radula complanata.
Reboulia hemispherica.
Trichocolea tomentalla.

LICHENS.

Cladonia mitrula...Tuck.
Cl. cristatella...Tuck.
Cl. fimbriata..Fr.
Cl. fimbriata v. tubæformis.
Cl. squamosa...Tuck.
Endocarpum miniatum..Sch.
Graphis dendritica.
G. scripta.
Lecanora pallescens..Ach.
Leptogium pulchellum...Nyl.
L. lacerum.
Parmelia caperata..Ach.
P. lævigata.
P. tiliacea..Ach.
P. Borreri...Turn.
P. perforata v. cetrata.
Pannaria nigra.
Physia stellaris..Wallr.
P. speciosa..Ach.

LICHENS—CONTINUED.

P. speciosa, v. hypolenca.
P. obscura, v. agglutinata.
Peltigera canina.
Ramalina calycaris.
Sticta pulmonaria ....Linn.
Sticta glomerifera.
Theloschistos parietinus...Norn.
Usnea barbata...Fr.
U. barbata, v. florida.
U. angulata.

TABLE OF ALTITUDES.

[By Hon. Jesse L. Williams, C. E., Fort Wayne, Indiana.]

Jesse L. Williams, of Fort Wayne, has, at my request, presented for publication in this report an interesting collection of altitudes gathered through a long professional career as civil engineer, beginning with the commencement of the Wabash and Erie canal in 1832. These tables of elevations comprise several hundred points in various localities between the Allegheny mountains and tide water of the Pacific ocean, and between the Ohio river and Lake Superior.

The elevations were ascertained in the course of numerous surveys for canals and railroads under his supervision, and that of other civil engineers, by the more accurate method of the spirit level.

More than half the points are in Indiana—many of them in adjoining States into which our public improvements run—while their scope is so extensive as to give hights of prominent mountain ranges and valleys on each of the five Pacific railroad routes, either constructed or located across the Rocky mountain region.

E. T. Cox, State Geologist.

INDIANAPOLIS, January 1, 1879.

TABLE OF ALTITUDES along line of Wabash and Erie Canal, from Toledo, Ohio, to Evansville, Indiana.

LOCALITY OF OBSERVATION.	COUNTY.	STATE.	Feet above Lake Erie.	Feet above Ocean.
Low water of Maumee river at Toledo—average lake level	Lucas	Ohio	0	573
do do do foot of Maumee rapids	Lucas	Ohio	0	573
do do do head of Maumee rapids, below Providence dam	Lucas	Ohio	59	632
Pool of Providence dam at head of Maumee rapids	Henry	Ohio	63	636
Low water of Maumee at Defiance	Defiance	Ohio	94	667
Surface of Wabash and Erie canal at junction of Miami and Erie, and Wabash and Erie canals	Defiance	Ohio	148	721
do do do at east line of Indiana	Allen	Indiana	177	750
do do do at Fort Wayne, Indiana, (summit level)	Allen	Indiana	194	767
Low water of Maumee at Fort Wayne, Indiana	Allen	Indiana	164	737
Court-house square at Fort Wayne, Indiana	Allen	Indiana	199	772
Summit, four miles southwest of Fort Wayne—divide between the Maumee and Wabash drainage	Allen	Indiana	193	776
Railroad track of Pittsburg, Ft. Wayne & Chicago depot, at Fort Wayne	Allen	Indiana	212	785
*Rock ledge across bed of Little river, three and one-half miles above Huntington	Huntington	Indiana	171	744
Court-house square in Huntington	Huntington	Indiana	168	741
Low water of Wabash river at mouth of Little river, two miles below Huntington	Huntington	Indiana	126	699
do do do Salamonie	Wabash	Indiana	94	667
Court-house square in Wabash	Wabash	Indiana	157	730
Low water of Wabash river at mouth of Mississinnewa	Miami	Indiana	60	633
Court-house square in Peru	Miami	Indiana	84	657
Low water of Wabash at mouth of Eel river	Cass	Indiana	10	583
do do at Delphi, below Pitttsburg dam	Carroll	Indiana	Below 47	526
do do at mouth of Tippecanoe	Tippecanoe	Indiana	Below 57	516
do do at Lafayette	Tippecanoe	Indiana	Below 67	506
do do three miles below Clinton	Vermillion	Indiana	Below 115	458
do do at Terre Haute	Vigo	Indiana	Below 122	451
Public square in Terre Haute	Vigo	Indiana	Below 75	498
Summit level, cross-cut canal, the divide of drainage between Wabash and White rivers, twelve miles east of Terre Haute (ground)	Vigo	Indiana	0	573
Surface of canal at mouth of Eel river feeder	Clay	Indiana	Below 18	555
Plane of town at Worthington—junction of Eel river with west fork of White river	Greene	Indiana	Below 49	524
Low water of White river below Newberry dam	Greene	Indiana	Below 117	456
Surface of canal at Petersburg and Patoka summit, in the deep cut	Pike	Indiana	Below 129	444
Low water of White river at junction of east and west forks	Pike	Indiana	Below 177	396
Surface of canal at Dongola and Patoka summit	Pike	Indiana	Below 137	436

Pool of Pigeon creek dam	Gibson	Indiana.	Below 118	385
Plane on which Evansville stands	Vanderburg	Indiana.	Below 190	383
Low water of the Ohio at Evansville	Vanderburg	Indiana.	Below 247	326

*Note.—A singularly shaped granite boulder growing out of this ledge, and rising above the water with a form slightly resembling a saddle, gave to this spot the name of "Saddle Rock," by which it was known to early traders and navigators. Geologists agree that this rocky barrier was once the overfall outlet of the great Lake basin, or inland sea.

TABLE OF ALTITUDES on the Line of the Cincinnati, Richmond & Ft. Wayne Railroad, from Fort Wayne to Richmond.

LOCALITY OF OBSERVATION.	County.	State.	Feet above Lake Erie.	Feet above Ocean.
Low water at Fort Wayne, junction of St. Mary's and St. Joseph rivers	Allen	Indiana.	164	737
Water surface Wabash and Erie canal, summit level at Fort Wayne	Allen	Indiana.	194	767
Railroad track at Fort Wayne, opposite P., Ft. W. & Chi. passenger depot	Allen	Indiana.	212	785
Adams' Station (five-mile switch) ground—intersection with Pittsburg road	Allen	Indiana.	223	796
Summit between Maumee and St. Mary's rivers, ⅛ of a mile north of Adams county line (ground)	Allen	Indiana.	273	846
Low water, St. Mary's river, one mile north of Decatur	Adams	Indiana.	197	770
Track at Decatur (opposite station house)	Adams	Indiana.	234	807
Summit between St. Mary's and Wabash rivers (ground)	Adams	Indiana.	292	865
Low water, Wabash river	Adams	Indiana.	249	822
Summit between Wabash and Salamonie rivers (ground)	Jay	Indiana.	382	955
Low water, Salamonie river, at Portland	Jay	Indiana.	331	904
Summit between Salamonie and Mississinewa rivers (ground)	Jay	Indiana.	480	1053
Ridgeville, railroad crossings	Randolph	Indiana.	420	993
Low water, Mississinewa river at Ridgeville	Randolph	Indiana.	391	964
Summit between Mississinewa and White rivers (ground)	Randolph	Indiana.	522	1095
Low water of White river, near Winchester	Randolph	Indiana.	480	1053
Winchester, at crossing of Bellefontaine railroad (track)	Randolph	Indiana.	515	1088
Summit between White river and Green's fork of White Water (ground)	Randolph	Indiana.	615	1188
Low water of Green's fork of White Water	Randolph	Indiana.	548	1111

TABLE OF ALTITUDES on the Line of the Cincinnati, Richmond and Fort Wayne Railroad, Etc.—Continued.

LOCALITY OF OBSERVATION.	COUNTY.	STATE.	Feet above Lake Erie.	Feet above Ocean.
Summit between Green's fork and Noland's fork of White Water, about two-thirds of a mile south of Wayne county line (ground—highest point)	Wayne	Indiana	649	*1212
Low water, Nolan's fork of White Water	Wayne	Indiana	499	1062
Summit between Noland's fork and White Water (ground)	Wayne	Indiana	569	1132
Junction with Cincinnati and Chicago railroad, near Richmond	Wayne	Indiana	396	969
Low water of White Water at Richmond	Wayne	Indiana	312	885
Richmond City (track at passenger depot)	Wayne	Indiana	396	969

* NOTE.—The highest ground in Indiana is found about eight miles southeast of Winchester, in Randolph county, at the source of the White river, White Water and Big Miami rivers—being probably 680 feet above Lake Erie. It is level table-land.

TABLE OF ALTITUDES on the Grand Rapids and Indiana Railroad, from Fort Wayne, Indiana, to Petoskey, Michigan, (Little Traverse Bay).

LOCALITY OF OBSERVATION.	COUNTY.	STATE.	Feet above Lake Erie.	Feet above Ocean.
Junction with P., Ft. W. & Chi. Railway (track), west of St. Mary's bridge	Allen	Indiana	196	769
Wallin Station, do. do.	Allen	Indiana	288	861
Huntertown, do. do.	Allen	Indiana	256	829
Bruce's Station, do. do.	Allen	Indiana	304	877
Swan, do. do.	Noble	Indiana	332	905
Avilla, do. do.	Noble	Indiana	408	981
Summit between Cedar Creek and Elkhart river, half mile south of Lisbon	Noble	Indiana	444	1017
Kendallville	Noble	Indiana	404	977

Rome lake (so-called). This is an artificial reservoir, in Middle fork of Elkhart, built by the State in 1837, to supply summit level of Erie and Michigan canal	Noble	Indiana	364	937
Wolcottville	Lagrange	Indiana	386	959
Valentine station	Lagrange	Indiana	400	973
La Grange	Lagrange	Indiana	354	927
Lima	Lagrange	Indiana	324	897
State line, between Indiana and Michigan			316	889
Sturgis	St. Joseph	Michigan	360	933
Michigan Central Air-Line railway crossing	St Joseph	Michigan	284	857
Mendon, on the Big St. Joseph river	St. Joseph	Michigan	284	857
Vicksburg—crossing of Lake Huron and Chicago railroad	Kalamazoo	Michigan	298	861
Kalamazoo—Michigan Central railway crossing	Kalamazoo	Michigan	214	787
Crossing of Kalamazoo river	Kalamazoo	Michigan	160	733
Plainwell	Allegan	Michigan	184	757
Martin	Allegan	Michigan	272	845
Wayland	Allegan	Michigan	200	773
Moline	Allegan	Michigan	246	819
Track on Grand river bridge, at Grand Rapids	Kent	Michigan	50	623
Detroit and Milwaukee railroad track at crossing	Kent	Michigan	55	628
North's Mills	Kent	Michigan	52	625
Whitney station	Kent	Michigan	75	648
Childs' mill, on Rouge river	Kent	Michigan	111	684
Rockford station	Kent	Michigan	127	700
Edgerton station	Kent	Michigan	110	683
Cedar Springs	Kent	Michigan	280	853
Summit south of Pierson	Montcalm	Michigan	364	937
Pierson station	Montcalm	Michigan	341	914
Howard, one-fourth mile south of Tamarack creek	Montcalm	Michigan	312	885
Summit, north of Tamarack creek	Mecosta	Michigan	355	928
Morley	Mecosta	Michigan	323	896
Summit, north of Morley	Mecosta	Michigan	416	989
Crossing of Mack's creek	Mecosta	Michigan	366	939
Summit, north of Mack's creek	Mecosta	Michigan	407	970
Pine plane at Big Rapids, east side of Muskegon river	Mecosta	Michigan	346	919
Low water, Muskegon river, at crossing	Mecosta	Michigan	325	898
Surface of ground at Paris, on Muskegon river	Mecosta	Michigan	352	925
Hersey river crossing	Osceola	Michigan	427	1000
Summit between Hersey river and Beaver creek, a branch of Pine river of the Manistee	Osceola	Michigan	697	1270
Beaver creek	Osceola	Michigan	635	1208
Summit between Beaver creek and outlet of Rose lake	Osceola	Michigan	687	1260
Outlet of Rose lake	Osceola	Michigan	599	1172
Summit between middle fork of Pine river, and outlet of Rose lake	Osceola	Michigan	678	1251
Middle fork of Pine river	Osceola	Michigan	634	1207
Summit between Middle and North forks of Pine river	Osceola	Michigan	735	1308

TABLE OF ALTITUDES on the Grand Rapids and Indiana Railroad, etc.—Continued.

LOCALITY OF OBSERVATION.	COUNTY.	STATE.	Feet above Lake Erie.	Feet above Ocean.
North fork of Pine river	Osceola	Michigan	679	1252
Summit between North fork of Pine river and Clam lake	Osceola	Michigan	759	1332
Clam lake	Wexford	Michigan	702	1275
Summit ridge, between Clam lake and the Manistee river, on railroad line	Wexford	Michigan	867	1440
Highest points of this range of hills, further east, estimated at	Wexford	Michigan	1000	1573
Head of Cedar creek, 6,000 feet north of the Manistee range of hills	Wexford	Michigan	677	1250
Cedar creek—first crossing	Wexf rd	Michigan	555	1128
Cedar creek—second crossing	Wexford	Michigan	511	1084
Water surface at Manistee river, at crossing on section 9, township 24, range 9	Wexford	Michigan	329	902
Plain, 7,000 feet north of Manistee river	Gr. Traverse	Michigan	420	993
Water in Fyfe lake	Gr. Traverse	Michigan	440	1013
Summit between Boardman river and the Manistee river	Kalcasco	Michigan	545	1118
Boardman river	Kalcasco	Michigan	438	1011
Summit between Boardman and Rapid rivers	Kalcasco	Michigan	510	1083
Rapid river (surface)	Kalcasco	Michigan	389	962
Plain just north of Rapid river	Kalcasco	Michigan	480	1053
Plain at head of Spring creek, a branch of the Boyne river	Charlevoix	Michigan	*657	1230
Boyne river, five miles east of the head of Pine lake	Charlevoix	Michigan	90	663
Summit between Boyne and Bear rivers	Charlevoix	Michigan	140	713
Outlet of Bear lake (Walloon, so-called)	Charlevoix	Michigan	110	683
Bear river crossing	Charlevoix	Michigan	90	663
Bluff at head of Little Traverse bay, near Petoskey City	Emmet	Michigan	74	647
Surface of Little Traverse bay, (Lake Michigan level)	Emmet	Michigan	12	585

* NOTE—About five or six miles east of this point, on the divide between the Cheboygan, Boyne and Manistee rivers, in township 32, range 4, there are sand ridges, rising to the height of 1,100 or 1,200 feet above Lake Michigan. This is undoubtedly the highest ground in the State.

TABLE OF ALTITUDES on the Fort Wayne, Jackson and Saginaw Railroad, from Fort Wayne to Jackson.

LOCALITY OF OBSERVATION.	COUNTY.	STATE.	Feet above Lake Erie.	Feet Above Ocean.
Surface of water in Wabash and Erie canal at mouth of St. Joseph feeder—summit level	Allen	Indiana	194	767
Fort Wayne depot—junction of Muncie and Saginaw railroads, north of St. Mary's river	Allen	Indiana	188	761
North line of Allen county	Allen	Indiana	271	844
New Era station	DeKalb	Indiana	286	859
Eel River railroad crossing (Auburn junction)	DeKalb	Indiana	295	868
Auburn station	DeKalb	Indiana	299	872
Crossing of Lake Shore and Michigan Southern railroad at Waterloo	DeKalb	Indiana	341	914
Summit station	DeKalb	Indiana	428	1001
Pleasant Lake station	Steuben	Indiana	402	975
Angola station	Steuben	Indiana	479	1052
High Point—surface of ground	Steuben	Indiana	513	1086
Fremont station	Steuben	Indiana	482	1055
State line between Indiana and Michigan			500	1073
Montgomery station	Hillsdale	Michigan	462	1035
Low water of St. Joseph of the Maumee	Hillsdale	Michigan	423	996
Reading station	Hillsdale	Michigan	627	1200
High point, one mile north of Reading. In this vicinity is the highest ground in the south half of the State, being the source of the Big and Little St. Joseph, Kalamazoo and the river Raisin	Hillsdale	Michigan	647	1220
Bankers—junction of the D., H. and I. railroad	Hillsdale	Michigan	494	1067
Crossing of Michigan Southern and Lake Shore railroad (old line) at Jonesville	Hillsdale	Michigan	504	1077
Jonesville station	Hillsdale	Michigan	483	1056
Low water in Kalamazoo river, near Mosherville	Hillsdale	Michigan	442	1215
Mosherville station	Hillsdale	Michigan	459	1022
Low water in Horse-Shoe lake	Jackson	Michigan	481	1054
Hanover station	Jackson	Michigan	541	1114
High point, one-half mile north of Hanover	Jackson	Michigan	563	1136
Surface of water in north branch of Kalamazoo—Baldwin's	Jackson	Michigan	429	1002
Baldwin's station	Jackson	Michigan	438	1011
Crossing of Jackson Branch of Lake Shore and Michigan Southern railroad	Jackson	Michigan	362	935
Low water in Grand river—Hayden's mill pond	Jackson	Michigan	357	930
Jackson station—Michigan Central railroad crossing on the Grand river	Jackson	Michigan	358	931

TABLE OF ALTITUDES on Pittsburg, Fort Wayne and Chicago Railway, from Pittsburg to Chicago.

LOCALITY OF OBSERVATION.	COUNTY.	STATE.	Feet above Lake Erie.	Feet above Ocean.
Station at Pittsburg Union depot	Allegheny	Penn	173	746
Lowest point of track, Ohio bottom, just east of Rochester	Beaver	Penn	133	706
Low water of Ohio river at mouth of river	....	....	....	....
Track at New Brighton, on Big Beaver river	Beaver	Penn	178	751
Track in summit cut, west of Homewood	Beaver	Penn	482	1055
Track at New Gallilee, on Little Beaver creek	Beaver	Penn	385	958
Track at Leetonia, on Green creek, a branch of Little Beaver	Columbiana	Ohio	444	1017
Track at Salem	Columbiana	Ohio	601	1174
Track at Woodland, two and one-half miles west of Salem	Columbiana	Ohio	673	1246
Track at Mahoning river, two miles east of Alliance	Mahoning	Ohio	487	1060
Track at Alliance	Stark	Ohio	511	1084
Track at Strassburg, west of Alliance	Stark	Ohio	615	1188
Track at Massillon	Stark	Ohio	382	955
Track at Orville, crossing of Cleveland and Mt. Vernon railroad	Wayne	Ohio	486	1059
Track at Smithville, five miles east of Wooster	Wayne	Ohio	550	1123
Track at Killbuck creek, west of Wooster	Wayne	Ohio	279	852
Track at Loudonville	Ashland	Ohio	403	976
Track at Lucas	Richland	Ohio	519	1092
Track at Mansfield	Richland	Ohio	579	1152
Track at Richland station	Richland	Ohio	629	1202
Track at Crestline	Crawford	Ohio	590	1163
Track at Bucyrus	Crawford	Ohio	358	931
Track at Forrest, crossing C., S. and C. railroad	Hardin	Ohio	368	941
Track at Hog creek marsh	Hardin	Ohio	302	875
Track at Lima, crossing D. and M. railroad	Allen	Ohio	207	780
Track at Delphos (surface of Miami canal)	Van Wert	Ohio	209	782
Track at Van Wert	Van Wert	Ohio	212	785
Track at Fort Wayne (in front of passenger depot)	Allen	Indiana	203	776
Track at St. Mary's river bridge, Arcola station	Allen	Indiana	261	884
Track at Summit, one mile east of Cresse	Whitley	Indiana	304	
Track at Columbia City	Whitley	Indiana	264	837
Track at Summit, between Eel river and Tippecanoe river—8,000 feet west of Larwill	Whitley	Indiana	391	964
Track at Warsaw	Kosciusko	Indiana	252	825
Track at Plymouth	Marshall	Indiana	209	782

Surface of Yellow river at Plymouth	Marshall	Indiana	188	761
Track at Summit station, four miles west of Plymouth	Marshall	Indiana	279	852
Surface of Yellow river ten miles above junction with Kankakee	Starke	Indiana	122	695
Surface of English lake (Kankakee river)	Starke	Indiana	91	664
Surface of Kankakee river—ordinary low water—at crossing of P., Ft. W. and C. railroad	Starke	Indiana	94	667
Track at Hamlet station	Starke	Indiana	126	699
Track at Wanatah	Porter	Indiana	159	732
Summit between Wanatah and Valparaizo	Porter	Indiana	186	759
Track at Valparaizo	Porter	Indiana	166	739
Track at Wheeler	Porter	Indiana	94	667
Track at Hobart	Lake	Indiana	51	624
Track at South Chicago	Cook	Illinois	17	590
Surface of Lake Michigan	Cook	Illinois	12	585

LEVELS along Michigan and Illinois Canal and the Illinois River.

LOCALITY OF OBSERVATION.	COUNTY.	STATE.	Feet above Lake Erie.	Feet above Ocean.
Summit level of canal (surface water) ten or twelve miles southwest of Chicago	Cook	Illinois	22	595
DesPlaines river at Joliet	Will	Illinois	Below 30	543
Track at depot in Joliet	Will	Illinois	Below 23	550
Surface of Illinois river at mouth of Fox river, at Ottawa	Lasalle	Illinois	Below 125	448
Surface of Fox river at Elgin, crossing of railroad	Kane	Illinois	Above 127	700
Surface of Illinois river at Lasalle and Peru	Lasalle	Illinois	Below 134	439
Surface of Illinois river at Peoria	Peoria	Illinois	Below 140	433
Surface of Illinois river at Beardstown	Cass	Illinois	Below 150	423
Surface of Illinois river at Naples, at crossing of railroad	Scott	Illinois	Below 155	418
Surface of Mississippi river at mouth of Illinois river	Jersey	Illinois	Below 163	410

TABLE OF ALTITUDES on Fort Wayne, Muncie and Cincinnati Railroad.

LOCALITY OF OBSERVATION.	COUNTY.	STATE.	Feet above Lake Erie.	Feet above Ocean.
Track at crossing of Pittsburg, Ft. Wayne and Chicago Railway	Allen	Indiana	195	768
Track at crossing of Toledo, Wabash and Western (Wabash Railroad)	Allen	Indiana	225	798
Track at Ferguson's station	Allen	Indiana	231	804
Tradk at Wells county line		Indiana	256	829
Track on 8-mile bridge at Ossian	Wells	Indiana	252	825
Track at summit between St. Mary's and Wabash rivers	Wells	Indiana	301	874
Track on bridge across Wabash river	Wells	Indiana	246	819
Track at Bluffton depot	Wells	Indiana	262	835
Track at Worthington crossing	Wells	Indiana	291	864
Track at summit between Wabash and Salamonie rivers	Wells	Indiana	322	895
Track at bridge across Salamonie river at Montpelier	Blackford	Indiana	292	865
Track at Delaware county line		Indiana	365	938
Track at summit between Hartford City and Mississinewa river		Indiana	382	955
Track at Eaton	Delaware	Indiana	340	913
Track on bridge over Mississenewa	Delaware	Indiana	337	910
Track on bridge over White river	Delaware	Indiana	365	938
Track at Muncie station	Delaware	Indiana	375	948
Track at Henry county line		Indiana	443	1016
Track at Springport	Henry	Indiana	256	829
Track at summit between Wabash waters and Blue river	Henry	Indiana	534	1107
Track at Newcastle, on Blue river	Henry	Indiana	472	1045
Track at New Lisbon	Henry	Indiana	536	1109
Track at Wayne county line		Indiana	483	1056
Track at Cambridge City	Wayne	Indiana	384	957
Track at Beeson's	Wayne	Indiana	313	886
Track at Fayette county line		Indiana	308	881
Track at Connersville	Fayette	Indiana	265	838

TABLE OF ALTITUDES on the Pan-Handle Route (so-called) from Chicago, through Logansport to Union City.

LOCALITY OF OBSERVATION.	COUNTY.	STATE.	Feet above Lake Erie.	Feet above Ocean.
Surface of Lake Michigan			12	585
State line between Illinois and Indiana			48	621
Crown Point station	Lake	Indiana	144	717
Cassville station	Lake	Indiana	114	687
Hebron station	Porter	Indiana	144	717
Koutts' station	Porter	Indiana	118	691
Crooked creek, east of Koutts' station	Porter	Indiana	103	676
Lacrosse station	Starke	Indiana	105	678
North Judson	Starke	Indiana	132	705
Gundrum station	Pulaski	Indiana	140	713
Winamac station	Pulaski	Indiana	143	716
Tippecanoe crossing	Pulaski	Indiana	101	674
Star City station	Pulaski	Indiana	136	709
Rosedale station	Pulaski	Indiana	152	725
Royal Centre station	Cass	Indiana	165	738
Gebhard's station, summit between the Wabash and Tippecanoe rivers, 9 miles west of the Wabash	Cass	Indiana	192	765
Logansport station	Cass	Indiana	23	596
Anoka Junction	Cass	Indiana	126	699
Onward station	Cass	Indiana	193	766
Bunker Hill station	Miami	Indiana	230	803
North Grove station	Miami	Indiana	247	820
Amboy station	Miami	Indiana	240	813
Converse station	Grant	Indiana	245	818
Mier station	Grant	Indiana	246	819
Switzer station	Grant	Indiana	266	839
Marion station	Grant	Indiana	241	814
Jonesboro' station	Grant	Indiana	276	849
Hartford City station	Blackford	Indiana	341	914
Ridgeville station, crossing of C., P. & Ft. Wayne Railroad	Randolph	Indiana	424	997

TA LE OF ALTITUDES on Toledo, Peoria and Warsaw Railroad, from State Line of Illinois and Indiana, to Logansport, Indiana.

LOCALITY OF OBSERVATION.	COUNTY.	STATE.	Feet above Lake Erie.	Feet above Ocean.
State line between Indiana and Illinois	Newton	Indiana	107	680
Kent station	Newton	Indiana	111	684
Goodland station	Jasper	Indiana	148	721
Remington station	Jasper	Indiana	162	735
Wolcott station	White	Indiana	145	718
Reynolds station	White	Indiana	122	695
Surface water of Tippecanoe	White	Indiana	32	605
Monticello station	White	Indiana	102	675
Idaville station	White	Indiana	142	715
Burnettsville station	White	Indiana	136	709
Lake Cecott station	Cass	Indiana	133	706
Curveton station	Cass	Indiana	101	674
Logansport station	Cass	Indiana	23	596

ELEVATIONS on Detroit and Eel River Railroad, from Logansport to Butler.

LOCALITY OF OBSERVATION.	COUNTY.	STATE.	Feet above Lake Erie.	Feet above Ocean.
Track on drawbridge, W. & E. Canal at Logansport	Cass	Indiana	31	604
Bottom of Eel river	Miami	Indiana	115	688
Roann station	Wabash	Indiana	174	747
Bottom Bear Grass creek, tributary to Eel river	Wabash	Indiana	152	725
Laketon station	Wabash	Indiana	186	759
Bottom of Eel river at North Manchester station	Wabash	Indiana	158	721

North Manchester station	Wabash	Indiana	199	772
Bottom of Eel river at Liberty Mills station	Wabash	Indiana	177	750
Bottom of Eel river at Collamer station	Whitley	Indiana	195	768
South Whitley station	Whitley	Indiana	232	805
Bottom of Spring creek at South Whitley station	Whitley	Indiana	218	791
Columbia City station	Whitley	Indiana	264	837
Bottom of Blue river at Columbia City station	Whitley	Indiana	243	816
Cherrubusco station	Whitley	Indiana	319	892
Butler station	DeKalb	Indiana	294	867

TABLE OF ALTITUDES on Louisville, New Albany and Chicago Railroad, from New Albany to Michigan City.

LOCALITY OF OBSERVATION.	COUNTY.	STATE.	Feet above Lake Erie.	Feet above Ocean.
Depot at New Albany	Floyd	Indiana	Below 137	436
Providence station	Clark	Indiana	Below 20	553
Knobs, near Silver creek	Clark	Indiana	Above 144	717
Harristown station	Washington	Indiana	Above 301	874
Salem station	Washington	Indiana	Above 144	717
Smedley's station	Washington	Indiana	Above 304	877
Orleans station	Orange	Indiana	Above 62	635
Mitchell station	Lawrence	Indiana	Above 92	665
White river bridge	Lawrence	Indiana	Below 70	503
Bedford station	Lawrence	Indiana	Above 108	681
Harrodsburg station	Monroe	Indiana	Below 65	508
Bloomington station	Monroe	Indiana	Above 171	744
Gosport station	Owen	Indiana	Below	573
Near Bainbridge station	Putnam	Indiana	Above 382	955
Crawfordsville station	Montgomery	Indiana	Above 171	744
Lafayette depot	Tippecanoe	Indiana	Below 27	546
Wabash river crossing; water at bridge	Tippecanoe	Indiana	Below 59	514
Brookston station	Tippecanoe	Indiana	Above 105	678
Reynolds station	White	Indiana	Above 120	693
Bradford station	White	Indiana	Above 101	674
c isville station	Pulaski	Indiana	Above 107	680

TABLE OF ALTITUDES on Louisville, New Albany and Chicago Railroad, etc.—Continued.

LOCALITY OF OBSERVATION.	COUNTY.	STATE.	Feet above Lake Erie.	Feet above Ocean.
Medaryville station	Pulaski	Indiana	Above 112	685
San Pierre station	Starke	Indiana	Above 127	700
Kankakee river crossing	Starke	Indiana	Above 87	660
Lacrosse station	Starke	Indiana	Above 102	675

TABLE OF ALTITUDES on Canal Survey, along the White Water Valley, in 1834.

LOCALITY OF OBSERVATION.	COUNTY.	STATE.	Feet above Lake Erie.	Feet above Ocean.
Surface West fork White Water at mouth of Nettle creek	Wayne	Indiana	409	982
Surface ground at court house in Connersville	Fayette	Indiana	272	845
Surface White Water at Brookville, junction with East fork	Franklin	Indiana	47	620
Surface White Water at Harrison, State line between Ohio and Indiana	Dearborn	Indiana	Below 57	516
Surface of high water of Ohio at Lawrenceburg	Dearborn	Indiana	Below 69	504
Surface high table-land between head of White Water and Blue river, sources of Flat Rock, near line between Henry and Randolph counties		Indiana	Above 555	1128

TABLE OF ALTITUDES on Railroad Survey from Terre Haute to Evansville, 1835.

LOCALITY OF OBSERVATION.	COUNTY.	STATE.	Feet above Lake Erie.	Feet above Ocean.
Lebanon—Summit between Bussero creek and the Wabash	Sullivan	Indiana	Below 53	520
Surface of Bussero creek at low water	Sullivan	Indiana	Below 146	427
White river at Robb's; high water	Sullivan	Indiana	Below 161	412
Patoka river at Columbia; high water	Gibson	Indiana	Below 162	411
Door-sill of court house at Princeton	Gibson	Indiana	Below 69	504
Ridge dividing waters of Pigeon creek and the Wabash	Vanderburg	Indiana	Below 104	469
High-water mark of the Ohio at Evansville	Vanderburg	Indiana	Below 190	383

TURNPIKE SURVEY, New Albany to Crawfordsville, made in 1835. Also, some points on line of New Albany and Salem Railroad (now called L., N. A. & Chi.), as Constructed.

LOCALITY OF OBSERVATION.	COUNTY.	STATE.	Feet above Lake Erie.	Feet above Ocean.
Knobs north of New Albany	Floyd	Indiana	Above 357	930
Railroad track at Salem depot	Washington	Indiana	Above 152	725
Summit of ground between Blue river and White river	Washington	Indiana	Above 338	911
Depot at Orleans	Orange	Indiana	Above 64	637
Track at crossing of New Albany & Salem and Ohio & Mississippi Railroad	Orange	Indiana	Above 101	674
Surface of East fork White river; low water	Lawrence	Indiana	Below 104	469
Track at Bedford depot	Lawrence	Indiana	Above 116	689
Surface of Salt creek	Lawrence	Indiana	Below 95	478
Track at Bloomington depot	Monroe	Indiana	Above 180	753
Summit between Clear creek and Jack's defeat	Monroe	Indiana	Above 318	891
Surface of West fork of White river; low water	Owen	Indiana	Below 16	557
Summit between White river and Eel river	Owen	Indiana	Above 202	775

TURNPIKE SURVEY, New Albany to Crawfordsville, 1835, etc.—Continued.

LOCALITY OF OBSERVATION.	COUNTY.	STATE.	Feet above Lake Erie.	Feet above Ocean.
Surface of Eel river	Owen	Indiana	Above 149	722
Summit between Eel river and Deer creek	Putnam	Indiana	Above 239	812
Surface of Deer creek	Putnam	Indiana	Above 64	637
Track at National road	Putnam	Indiana	Above 99	672
Crossing of Walnut fork of Eel river; low water	Putnam	Indiana	Above 106	679
Surface of Raccoon creek	Montgomery	Indiana	Above 161	734
Summit between Raccoon creek and Sugar creek	Montgomery	Indiana	Above 379	952

TABLE OF ALTITUDES on Line of Preliminary Survey, made in 1835, from Indianapolis to Lafayette, via Danville and Crawfordsville.

LOCALITY OF OBSERVATION.	COUNTY.	STATE.	Feet above Lake Erie.	Feet above Ocean.
Summit between Eagle and White Lick creeks	Hendricks	Indiana	293	866
Surface of White Lick creek	Hendricks	Indiana	207	780
Surface between heads of White Lick creek and Eel river	Hendricks	Indiana	481	1054
Surface of east fork of Eel river	Hendricks	Indiana	308	881
Surface of west fork of Eel river	Hendricks	Indiana	308	881
Summit between Eel river and Raccoon creek	Hendricks	Indiana	373	946
Surface of Raccoon creek	Montgomery	Indiana	253	826
Surface of Sugar creek, one-half mile from Crawfordsville	Montgomery	Indiana	97	670
Summit between Sugar creek and Wea creek	Montgomery	Indiana	276	849
Surface of Wea creek	Tippecanoe	Indiana	159	732
Surface of Wea creek four miles south of Lafayette	Tippecanoe	Indiana	52	625

RAILROAD SURVEY direct from Indianapolis to Lafayette—Survey in 1835.

LOCALITY OF OBSERVATION.	COUNTY.	STATE.	Feet above Lake Erie.	Feet above Ocean.
Surface of Eagle creek	Boone	Indiana	183	756
Summit between Eagle and Sugar creeks	Boone	Indiana	406	979
Surface of Sugar creek near Thorntown	Boone	Indiana	233	806
Summit between Sugar creek and Wabash river	Tippecanoe	Indiana	262	835

CANAL SURVEY from Indianapolis to Wabash, Wabash county, in 1835.

LOCALITY OF OBSERVATION.	COUNTY.	STATE.	Feet above Lake Erie.	Feet above Ocean.
Surface of ground at court house in Noblesville	Hamilton	Indiana	197	770
Surface of White river at Anderson	Madison	Indiana	176	749
Surface of White river at Muncie	Delaware	Indiana	373	946
Surface of Mississinewa northwest of Muncie	Delaware	Indiana	348	911
Surface of Mississinewa at Marion	Grant	Indiana	238	801
Summit between White river and Mississinewa southeast of Marion, level table land at head of Pipe creek (ground)	Madison	Indiana	319	882

TABLE OF SURVEYS in Various Parts of Indiana, ascertained by the Random Level Party, Preparatory to the Canal and Railroad Surveys, Ordered by the Legislature in 1835.

LOCALITY OF OBSERVATION.	COUNTY.	STATE.	Feet above Lake Erie.	Feet above Ocean.
Surface of White river at Indianapolis	Marion	Indiana	118	691
Summit between Indianapolis, in White river valley, and Franklin, in Blue river valley	Marion	Indiana	242	815
Door-sill of court house in Franklin	Johnson	Indiana	171	744
Surface of Muskatatuck at mouth of Graham's fork	Jefferson	Indiana	Below 10	563
Surface of Pigeon Roost creek at Vienna	Scott	Indiana	Below 2	571
Surface of ground at Collin's gap in ridge between White river and the Ohio	Clarke	Indiana	Below 57	516
Top of knob in road from Salem to Lexington, eight miles west of Vienna	Washington	Indiana	446	1019
Surface of ground in Livonia	Washington	Indiana	214	787
Ridge at crossing of New Albany and Paoli road	Washington	Indiana	307	870
Surface of the Patoka at mill dam above Jasper	Dubois	Indiana	Below 123	450
Surface of East fork of White river at Hindostan	Martin	Indiana	Below 135	438
Summit of Prairie between Anderson and Pendleton	Madison	Indiana	316	889
Surface of Mississinewa on State road from Indianapolis to Fort Wayne	Grant	Indiana	236	809
Surface of Salamonie on State road from Indianapolis to Fort Wayne	Huntington	Indiana	235	808
Surface of Salamonie eight miles above road from Indianapolis to Fort Wayne	Wells	Indiana	250	823
Surface of Rock creek at crossing of road from Indianapolis to Fort Wayne	Wells	Indiana	233	806
Surface of Wabash river at crossing of road from Indianapolis to Fort Wayne	Wells	Indiana	207	780
Surface of Wabash river eight miles above road from Indianapolis to Fort Wayne	Wells	Indiana	219	792

TABLE OF ALTITUDES on Canal Survey from Indianapolis to Evansville, in 1835.

LOCALITY OF OBSERVATION.	COUNTY.	STATE.	Feet above Lake Erie.	Feet above Ocean.
Surface of White river sixteen miles below Indianapolis	Morgan	Indiana	63	636
Surface of White river at mouth of Bean Blossom creek	Monroe	Indiana	Below 22	551
Surface of White river at Bloomfield	Green	Indiana	Below 83	490
Surface of White river opposite Washington	Daviess	Indiana	Below 148	425
Surface of White river at junction of east and west forks	Daviess	Indiana	Below 177	396
Lowest depression in ridge dividing White river and Patoka	Pike	Indiana	Below 104	469
Surface of Patoka river	Pike	Indiana	Below 163	410
Summit between Patoka and the Ohio, six miles east of Princeton	Gibson	Indiana	Below 104	469

TURNPIKE SURVEY from New Albany to Vincennes, in 1835.

LOCALITY OF OBSERVATION.	COUNTY.	STATE.	Feet above Lake Erie.	Feet above Ocean.
Low water of the Ohio at New Albany, just below the falls	Floyd	Indiana	Below 198	375
Ground at court house in New Albany	Floyd	Indiana	Below 125	448
Summit between Big Blue river and east fork of White river	Harrison	Indiana	Above 355	928
Town of Greenville	Floyd	Indiana	Above 208	781
Surface of Blue river	Washington	Indiana	Above 18	591
Paoli court house	Orange	Indiana	Above 48	611
Surface of Lost river	Orange	Indiana	Below 124	449
Low water of east fork of White river at Mt. Pleasant	Martin	Indiana	Below 120	453
Ground in Mt. Pleasant	Martin	Indiana	Above 33	606
Ground in Washington	Daviess	Indiana	Below 59	514
Low water of west fork of White river, west of Washington	Daviess	Indiana	Below 143	430
Summit between White river and the Wabash	Knox	Indiana	Below 000	573

TABLE OF ALTITUDES on Railroad Survey from Indianapolis to Lawrenceburg, in 1835.

LOCALITY OF OBSERVATION.	COUNTY.	STATE.	Feet above Lake Erie.	Feet above Ocean.
Summit between White river and Sugar creek	Marion	Indiana	297	870
Surface of Sugar creek	Shelby	Indiana	193	766
Surface of Blue river at Shelbyville	Shelby	Indiana	188	761
Ground at Shelbyville	Shelby	Indiana	206	779
Surface of Flat Rock creek	Shelby	Indiana	246	819
Summit between Flat Rock creek and Clifty creek	Decatur	Indiana	343	916
Surface of Clifty creek	Decatur	Indiana	308	881
Ground in Greensburg	Decatur	Indiana	393	966
Surface of Sand creek	Decatur	Indiana	362	935
Summit between Sand creek and Salt creek	Decatur	Indiana	506	1079
Surface of Laughery creek	Ripley	Indiana	360	933
Summit between Laughery creek and head of Ripple creek	Ripley	Indiana	450	1023
Sources of Hogan creek	Dearborn	Indiana	445	1018
Head of Tanner's creek	Dearborn	Indiana	462	1035
Main street in Lawrenceburg	Dearborn	Indiana	Below 78	495

RAILROAD SURVEY from Indianapolis to Madison, in 1835.

LOCALITY OF OBSERVATION.	COUNTY.	STATE.	Feet above Lake Erie.	Feet above Ocean.
Summit between the East and West forks of White river	Marion	Indiana	312	885
Surface of Sugar creek	Johnson	Indiana	109	682
Surface of Blue river	Johnson	Indiana	89	662
Town of Edinburg	Johnson	Indiana	104	677
Surface of Flat Rock creek	Bartholomew	Indiana	51	624

Town of Columbus	Bartholomew	Indiana	70	643
Town of Vernon	Jennings	Indiana	88	661
Surface of Muskakatack at Vernon	Jennings	Indiana	48	621
Surface of Graham fork at Vernon	Jennings	Indiana	119	692
Surface of Big creek	Jefferson	Indiana	174	747
Surface of Middle fork of Big creek	Jefferson	Indiana	182	755
Summit between the Muskakatack and the Ohio river	Jefferson	Indiana	327	900
High water mark of the Ohio at Madison	Jefferson	Indiana	Below 101	472

TABLE OF ALTITUDES—Miscellaneous Levels in Indiana and Adjoining States, Collated from Various Sources.

LOCALITY OF OBSERVATION.	COUNTY.	STATE.	Feet above Lake Erie.	Feet above Ocean.
Low water of St. Joseph river at its junction with St. Mary's which two rivers form the Maumee	Allen	Indiana	144	737
Low water of pool of St. Joseph's feeder dam of Wabash and Erie canal	Allen	Indiana	194	763
Low water of St. Joseph river at Leo, above dam	Allen	Indiana	202	775
Low water of St. Joseph river at crossing of Baltimore and Ohio railroad	Allen	Indiana	217	
Low water of St. Joseph river at crossing of Michigan Southern Air Line railroad at Edgerton station	Williams	Ohio	234	
Track of Michigan Southern Air Line railroad at Edgerton	Williams	Ohio	266	
Summit (track) dividing Elkhart and Cedar creek waters on Grand Rapids and Indiana railroad, two and one-half miles southeast of Kendallville	Noble	Indiana	440	
Summit (track) Air Line Michigan Southern railroad, three miles southeast of Kendallville	Noble	Indiana	445	
Summit (track) Baltimore and Ohio railroad, on divide between Cedar creek and Elkhart river, one and one-half miles west of Avilla	Noble	Indiana	442	
Track at Albion station, on Baltimore and Ohio railroad	Noble	Indiana	354	
Track at Cromwell station, on Baltimore and Ohio railroad (summit)	Noble	Indiana	365	
Track at Syracuse station, on Baltimore and Ohio railroad	Kosciusko	Indiana	295	
Surface of Turkey lake, west of Syracuse	Kosciusko	Indiana	291	
Track of Baltimore and Ohio railroad at Hicksville summit	Defiance	Ohio	276	
Track of Baltimore and Ohio railroad at Hicksville	Defiance	Ohio	182	
Low water of Maumee river at Ohio state line		Ohio	140	
Track at Bryan depot, Michigan Southern Air Line railroad	Williams	Ohio	198	
Track at Adrian depot, Southern Michigan railroad	Lenawee	Michigan	247	
Track at Osseo depot, Southern Michigan railroad	Hillsdale	Michigan	540	
Track at Hillsdale, Southern Michigan railroad	Hillsdale	Michigan	520	

TABLE OF ALTITUDES—Miscellaneous Levels in Indiana and Adjoining States, etc.—Continued.

LOCALITY OF OBSERVATION.	COUNTY.	STATE.	Feet above Lake Erie.	Feet above Ocean.
Track one mile west of Jonesville, Southern Michigan railroad—highest point on road	Hillsdale	Michigan	560	....
Track at White Pigeon, Southern Michigan railroad	St. Joseph	Michigan	250	....
Track at South Bend, Southern Michigan railroad	St. Joseph	Indiana	156	....
Marsh a few miles west of South Bend, forming head of Kankakee river, canal survey of 1835	St. Joseph	Indiana	138	....
Level table land on the summit between Kankakee and Tippecanoe rivers, through which Stansberry's (U. S. Engineer) canal survey was run in 1829	St. Joseph	Indiana	138	....
Surface of Big St. Joseph at mouth of the Elkhart, canal survey of 1835	Elkhart	Indiana	147	
Surface of Fish lake, source of Fish creek, a branch of Little St. Joseph, near south line of Steuben county, canal survey by Stansberry, U. S. Engineer, 1827	Steuben	Indiana	314	....
Surface of Pigeon lake, near Pleasant lake station, on Ft. Wayne, Jackson and Saginaw railroad, canal survey, 1827	Steuben	Indiana	382	....
Surface of Wolf and Bear lakes, sources of Tippecanoe river, W. J. Ball's canal survey, 1840	Noble	Indiana	330	....
General level water shed between Little St. Joseph and Elkhart rivers, canal surveys in 1835 and 1840	Noble	Indiana	400	....
Track at Laporte, on Southern Michigan railroad	Laporte	Indiana	250	....
Water shed between the Tippecanoe and Kankakee rivers, seven miles north of Winamac	Pulaski	Indiana	137	710
Railroad track at Kokomo (I., P. and C. railroad)	Howard	Indiana	266	839
Railroad track at Muncie (Bee Line railroad)	Delaware	Indiana	386	959
Railroad track at Anderson (Bee Line railroad)	Madison	Indiana	322	895
Railroad track at Pendleton (Bee Line railroad)	Madison	Indiana	273	846
Union depot at Indianapolis	Marion	Indiana	148	721
Track at depot of Terre Haute and Indianapolis railroad at Greencastle	Putnam	Indiana	276	849
Track at depot of Terre Haute and Indianapolis railroad (Vandalia route) at Terre Haute	Vigo	Indiana	74	647
Track of Terre Haute and Indianapolis railroad nine and one-half miles east of Greencastle, highest point on the road	Putnam	Indiana	333	906
Ground at court house in Danville	Hendricks	Indiana	392	965
Ground at Findly (seat of justice)	Hancock	Ohio	208	781
Highest table land between Wabash and Eel rivers at North Manchester	Wabash	Indiana	256	829
Railroad track at Rochester	Fulton	Indiana	217	790
Tippecanoe river near Rochester	Fulton	Indiana	105	678
Ground at court house in Renssalaer	Jasper	Indiana	107	680
East line of Indiana on line of Tiffin and Ft. Wayne railroad	Allen	Indiana	190	763
Bank of Auglaise river on line of Tiffin and Ft. Wayne railroad	Paulding	Ohio	140	713
Crossing of Dayton and Michigan railroad at Leipsic, 46 miles west of Tiffin	Putnam	Ohio	185	758
Summit between Blanchard's fork and Sandusky river	....	Ohio	215	788

Ground at Tiffin	Seneca	Ohio	180	753
Track of Baltimore and Ohio railroad near Havanna	Seneca	Ohio	315	888
Shelby, on Cleveland and Columbus railroad	Richland	Ohio	545	1118
Greenwich, on Cleveland and Columbus railroad	Huron	Ohio	470	1043
New London, on Cleveland and Columbus railroad	Huron	Ohio	410	983
Wellington, on Cleveland and Columbus railroad	Lorain	Ohio	286	859
Berea, on Cleveland and Columbus railroad	Cuyahoga	Ohio	208	781
Cleveland Bluffs	Cuyahoga	Ohio	90	663
Track of Atlantic and Great Western railroad, eight miles west of Mansfield	Richland	Ohio	802	1375
Track of Atlantic and Great Western railroad at Gallion—crossing Bellefontaine railroad	Crawford	Ohio	590	1163
Bellefontaine depot	Logan	Ohio	642	1215
High table-land a few miles northeast of Bellefontaine; highest ground in Ohio; source of Scioto and Miami rivers	Logan	Ohio	975	1548
Bellefontaine ("Bee Line") Railroad track crossing summit, four milest east of Bellefontaine	Logan	Ohio	773	1346
Youngstown, on the Mahoning river	Mahoning	Ohio	290	863
Ohio and Pennsylvania State line, six miles east of Youngstown	Mahoning	Ohio	252	825
Warren	Trumbull	Ohio	317	890
Atwater	Trumbull	Ohio	560	1133
Summit of land in Atwater township	Trumbull	Ohio	603	1176
Track of Atlantic and Great Western Railroad at Ravenna	Portage	Ohio	530	1103
Track of Atlantic and Great Western Railroad at Talmadge	Summit	Ohio	527	1100
Track of Atlantic and Great Western Railroad at Akron	Summit	Ohio	430	1003
Summit level of the Ohio canal at Akron	Summit	Ohio	395	968
Track of Atlantic and Great Western Railroad at Saville	Medina	Ohio	403	976
Walhalding river, one mile below Killbuck creek, from survey of 1822		Ohio	282	855
Licking summit, divide between the Scioto and Muskingum waters	Fairfield	Ohio	346	919
Low water Ohio river at Pittsburg	Alleghany	Pennsyl'a	127	700
Low water Ohio river at Steubenville	Jefferson	Ohio	59	632
Low water Ohio river at Muskingum	Washington	Ohio	5	578
Low water Ohio river at Scioto	Scioto	Ohio	Below 101	472
Low water Ohio river at Cincinnati	Hamilton	Ohio	Below 133	440
Low water Ohio river at Lawrenceburg	Dearborn	Indiana	Below 139	434
Low water Ohio river at mouth of Wabash river	Posey	Indiana	Below 260	313
Low water Ohio river at Cairo	Alexander	Illinois	Below 282	291
Low water Wabash river at Vincennes	Knox	Indiana	Below 159	414
Summit between Grand river and Saginaw bay, near the source of Shewassee river. (This is much the lowest summit between the two lakes in the State of Michigan)		Michigan	160	733

TABLE OF ALTITUDES—Lowest Summits along Water Shed, between Lake Erie and the Ohio River. See Preliminary Surveys in 1822, Preparatory for Location of Ohio Canals.

LOCALITY OF OBSERVATION.	COUNTY.	STATE.	Feet above Lake Erie.	Feet above Ocean.
Divide between tributaries of Grand river of Lake Erie and the Mahoning waters, five miles northwest of Warren	Trumbull	Ohio	362	935
Divide between sources of Cuyahoga and Tuscarawas rivers, near Akron; summit levil of Ohio canal	Summit	Ohio	404	977
Divide between sources of Black river of Lake Erie and Killbuck creek of the Muskingum	Medina	Ohio	340	913
Divide between sources of Sandusky and Scioto rivers at Tyamochtee summit	Crrawford	Ohio	360	933
Divide between sources of St. Mary's and Big Miami rivers, Loramie's summit, of Miami & Erie canal	Shelby	Ohio	370	943
Divide between the Maumee and Wabash rivers, four miles southwest of Ft. Wayne, being summit level of Wabash and Erie canal, first surveyed in 1826 by United States Engineer	Allen	Indiana	*197	770

* NOTE.—The highest floods of St. Mary's river at the bridge of Pittsburg, Ft. Wayne and Chicago Railroad, as the water backs to the summit of the canal aqueduct, lack but five feet of flowing over this summit into the Wabash and thence to the Ohio. Across this divide was the historic nine-mile portage, over which pack-horses carried the furs, etc., between the small boats on each side. When civilization came the canoes were hauled across on wagons.

POINTS OF GREATEST DEPRESSION in the Crest of Allegheny Mountains, Pennsylvania, from Surveys for Locating Pennsylvania Railroad, in 1848.

LOCALITY OF OBSERVATION.	COUNTY.	STATE.	Feet above Lake Erie.	Feet above Ocean.
Average of 21 gaps, covering a distance of 44 miles, from the divide between the Potomac and Castleman's rivers on the south to the divide between the West branch of Susquehanna and Allegheny rivers on the north				2383

Highest point of the 21 gaps, divide between Potomac and Castleman's rivers, summit of Chesapeake and Ohio canal survey				2759
Lowest depression, Emigh's gap, divide between the Little Juniatta and the Moshannon				2043
Sugar Run gap, through which Pennsylvania Railroad is constructed; ground surface				2283
Track of Pennsylvania Railroad in the mountain tunnel west of Altoona				2154
Crest of the mountain ridge at the divide between the West branch of Susquehanna and Allegheny, on the Bennett's branch line				1650
Railroad track in the mountain tunnel of the Bennett's branch line				1440
Grade of railroad track of Allegheny Valley road along the Allegheny river at the mouth of Red Bank creek, 64 miles from Pittsburg				825
Grade of railroad track at Driftwood, Bennett's branch line				787

TABLE OF ALTITUDES on Detroit and Milwaukee Railroad, from Detroit to Grand Haven.

LOCALITY OF OBSERVATION.	COUNTY.	STATE.	Feet above Lake Erie.	Feet above Ocean.
Detroit river	Wayne	Michigan	2	575
Detroit and Milwaukee and Fr. Junction	Wayne	Michigan	58	631
Grand Trunk Junction	Wayne	Michigan	57	630
Royal Oak	Oakland	Michigan	91	664
Birmingham	Oakland	Michigan	204	777
Summit east of Pontiac	Oakland	Michigan	386	959
East crossing of Clinton river (track)	Oakland	Michigan	359	932
Drayton Plains	Oakland	Michigan	397	970
Clinton river crossing, near Drayton Plains (track)	Oakland	Michigan	392	965
Summit west of Clarkston	Oakland	Michigan	452	1020
Holly	Oakland	Michigan	365	938
Gaines	Genesse	Michigan	284	857
Vernon	Shiawasse	Michigan	195	768
Sheawassee river near Vernon; track on bridge	Shiawasse	Michigan	202	775
Owosso	Shiawasse	Michigan	170	743
Maple river near Ovid; track on bridge	Clinton	Michigan	154	727
St. John's	Clinton	Michigan	195	768

TABLE OF ALTITUDES on Detroit and Milwaukee Railroad, from Detroit to Grand Haven.—Continued.

LOCALITY OF OBSERVATION.	COUNTY.	STATE.	Feet above Lake Erie.	Feet above Ocean.
Lost creek; track on bridge	Clinton	Michigan	145	718
West crossing of Maple river; track on bridge	Ionia	Michigan	77	650
Grand river, west of Ionia; track on bridge	Ionia	Michigan	75	648
Saranac	Ionia	Michigan	74	647
Lowell	Kent	Michigan	66	639
Thornapple river; track on bridge	Kent	Michigan	72	645
Summit between Thornapple river and Grand Rapids	Kent	Michigan	221	194
Grand river; track on bridge	Kent	Michigan	57	630
Indian Mill creek; track on bridge	Kent	Michigan	162	735
Sand creek near Berlin; track on bridge	Ottawa	Michigan	107	680
Center creek at Coopersville; track on bridge	Ottawa	Michigan	69	642
Crooked creek; track on bridge	Ottawa	Michigan	41	614
Nunica	Ottawa	Michigan	57	630
Spring lake	Ottawa	Michigan	22	595
Lake Michigan			13	586

TABLE OF ALTITUDES on Marietta and Cincinnati Railroad, from Cincinnati to Marietta.

LOCALITY OF OBSERVATION.	COUNTY.	STATE.	Feet above Lake Erie.	Feet above Ocean.
Low water in Ohio river at Cincinnati	Hamilton	Ohio	Below 133	440
High water in Ohio river at Cincinnati in 1832	Hamilton	Ohio	Below 62	510
High water in Ohio river at Cincinnati in 1847	Hamilton	Ohio	Below 62	510
M. and C. tracks at Plum street depot in Cincinnati	Hamilton	Ohio	Below 50	523

Cincinnati, Hamilton and Dayton railroad tracks in Cincinnati, at crossing of M. and C.	Hamilton	Ohio	Below 61	512
Summit between Mill creek and Little Miami river, near Norwood, 10 miles from Cincinnati	Hamilton	Ohio	52	625
Second crossing of Duck creek, near Madisonville, 13 miles from Cincinnati	Hamilton	Ohio	1	574
Summit at Madeira, 16½ miles from Cincinnati, between two tributaries of Little Miami river	Hamilton	Ohio	187	760
Crossing of Little Miami river at Loveland, 25 miles from Cincinnati	Clermont	Ohio	19	592
Crossing of Little Miami railroad at Loveland	Clermont	Ohio	18	591
Pleasant Plain, 34 miles from Cincinnati	Warren	Ohio	329	902
Blanchester, 40½ miles from Cincinnati, junction of Hillsborough Branch	Clinton	Ohio	402	975
Summit between Little Miami and Scioto rivers, 58 miles from Cincinnati, near New Vienna	Clinton	Ohio	607	1180
Crossing of Paint creek at Greenfield, 74 miles from Cincinnati	Highland	Ohio	320	893
Main street, Chillicothe, at station, 98 miles from Cincinnati	Ross	Ohio	65	638
Crossing of Scioto river, 102 miles from Cincinnati	Ross	Ohio	50	623
Summit between Scioto river and Raccoon creek, 125 miles from Cincinnati	Vinton	Ohio	222	795
Junction of Portsmouth Branch, near Hamden, 127 miles from Cincinnati	Jackson	Ohio	146	719
Summit between Raccoon creek and Hocking river at Marshfield, 151 miles from Cincinnati	Athens	Ohio	251	824
Crossing of Hocking river near Athens, 157 miles from Cincinnati	Athens	Ohio	83	656
Junction of Baltimore Short Line railway, 164 miles from Cincinnati	Athens	Ohio	62	635
Coolville, on Baltimore Short Line railway, 181 miles from Cincinnati	Athens	Ohio	57	630
Torch, on Baltimore Short Line railway, 183 miles from Cincinnati	Athens	Ohio	150	723
Little Hocking, on Baltimore Short Line railway, 187 miles from Cincinnati	Washington	Ohio	62	635
Belpse hotel, on Baltimore Short Line railway, 194 miles from Cincinnati	Washington	Ohio	67	640
Low water in Ohio river at Parkersburg October 1, 1863, (probably not extreme low water)	Wood	West Va.	1	574
High water in Ohio river at Parkersburg in 1832, 132 miles above Cincinnati	Wood	West Va.	51	624
Bridge over Ohio river at Parkersburg	Wood	West Va.	91	664
Crossing of Muskingum river at Marietta	Washington	Ohio	67	640
Low water in Muskingum river at Marietta September 5, 1856	Washington	Ohio	9	583
Hillsborough, at eastern terminus of Hillsborough Branch, extending from Blanchester to Hillsborough, 21½ miles	Highland	Ohio	502	1075

TABLE OF ALTITUDES on Southern Minnesota Railroad, (from the Report of State Survey, 1872).

LOCALITY OF OBSERVATION.	COUNTY.	STATE.	Feet above Lake Erie.	Feet above Ocean.
Low water in Mississippi river at LaCrosse		Wisconsin		626
Grand Crossing		Wisconsin		638
Rushford				723
Lanesborough				843
Isinour's				900
Fountain				1301
Grand Meadow				1337
Ramsay				1217
Hayward				1250
Winnebago City				1101
Blue Earth river, one mile west of Winnebago City, (water)				1074
Fairmont	Martin			1191
Des Moines river (water)				1290
Heron lake				1371
Graham lake				1413

TABLES OF ALTITUDES on Union and Central Pacific Railroads, from Missouri River to Sacramento.

LOCALITY OF OBSERVATION.	COUNTY.	STATE.	Feet above Lake Erie.	Feet above Ocean.
Track on High bridge across Missouri river at Omaha, 52 feet above high water		Nebraska		1036
Divide between Missouri river and Papillon creek		Nebraska		1148
Papillon creek		Nebraska		1021
Elkhorn bridge		Nebraska		1131

Junction of North and South Platte rivers		Nebraska		2760
Lodge Pole creek		Nebraska		3513
Pine Bluffs		Nebraska		5033
Crow creek		Nebraska		6035
Eastern base of Rocky Mountains, as fixed by the President of the United States, as provided in the Pacific railroad act				6431
Summit of Black Hill range				8242
Western base of Black Hill range				7241
Little Laramie river				7048
Divide between the Little Laramie and Rock creek				7167
Rock creek				6666
Divide between Rock creek and Medicine Bow river				6791
Medicine Bow river				6543
Rattle Snake summit				7123
North Platte river				6475
Divide between North Platte river and Separation creek				6911
Separation creek				6653
Divide of continent—Dodge's pass				7100
Red Desert basin				6659
Bitter creek summit—Williams' pass				6990
Green river, longest branch of Colorado river of the Pacific				6061
Divide between Green river and Black fork				6398
Black fork				6152
Eastern Rim of Utah basin—Reed's pass				7458
Bear river of Salt lake				6676
Wasatch range				6804
Mouth of Weber canon—Devil's gate				4575
Ogden City				4333
Bear river at crossing of railroad				4273
Surface of Salt Lake; (this lake is the lowest depression in the continet between Lodge pole creek and Humboldt river—1,250 miles)				4239
Average of grade lines of railroad, which follows for 25 miles the north shore of lake, about 12 to 16 feet above water				4250
Red Dome pass				4744
Terrace pass				4744
Promontory mountain				4889
Toano mountains, Valley pass				6099
Peoguop pass				6180
Cedar pass				6193
Humboldt wells				5667
Shoshone Point				4668
Humboldt river, being the lowest point between the eastern base of Black Hill range and western base of Sierra Nevada range, a distance of 1,200 miles				3969
Big bend of Truckee river, near Humboldt sink				4104

TABLE OF ALTITUDES on Union and Central Pacific Railroads, etc.—Continued.

LOCALITY OF OBSERVATION.	COUNTY.	STATE.	Feet above Lake Erie.	Feet above Ocean.
On the eastern slope of Sierra Nevada				4819
On the western slope of Sierra Nevada				5849
Summit of Sierra Nevada mountains				7044
Pino station, on western slope of the Sierra Nevada range, near its base				418
Sacramento river near Sacramento City				56

TABLE OF ALTITUDES on Northern Pacific Railroad, from Lake Superior to Puget's Sound.

LOCALITY OF OBSERVATION.	COUNTY.	STATE.	Feet above Lake Erie.	Feet above Ocean.
Lake Superior				598
Junction with St. Paul and Duluth railroad				1080
Summit east of Mississippi river				1300
Mississippi river, ground (Brainerd), 115 miles west of Duluth on Lake Superior				1204
Mississippi river, low water				1144
Crow Wing river, ground				1124
Crow Wing river, low water				1107
Summit, ground				1442
Otter Tail river, ground				1344
Otter Tail river, surface of river				1328
Buffalo river, surface of ground				1149
Buffalo river, surface of river				1139
Red river, ground at Moorhead				888
Red river, high water				876

Red river, low water at Fargo, 252 miles west of Duluth				1842
Grove creek, low banks of creek				933
Summit, ground				1436
Cheyenne river, grade				1228
Cheyenne river, surface of river at Cheyenne				1198
James river at Jamestown				1406
James river, surface of river				1391
Summit, ground				1861
Prairie, flat				1793
Summit, ground				1900
River bottom				1632
Missouri river at Bismarck, 450 miles west of Duluth				1640
Heart river valley				2530
Summit beyond Heart river				2703
Little Missouri				2270
Divide of Glendive's creek				2815
Mouth of Glendive's creek, surface of Yellowstone river				2010
Mouth of Powder river, in the valley of the Yellowstone				2300
Mouth of Big Horn river, in the valley of the Yellowstone				2830
Valley in the valley of the Yellowstone				3080
Medicine Bow creek, in the valley of the Yellowstone				3673
Beaver creek, in the valley of the Yellowstone				3800
Sweet Grass creek, in the valley of the Yellowstone				3956
Big Timber creek, in the valley of the Yellowstone				4076
Cottonwood creek, in the valley of the Yellowstone				4253
Hot springs, in the valley of the Yellowstone				4282
Yellowstone river, in the valley of the Yellowstone, 993 miles west of Duluth				4432
Shield's river, in the valley of the Yellowstone				4446
Bozeman's pass, divide on the belt range				5800
Vicinity of Fort Ellis, head of the Gallatin valley				4883
Vicinity of Bozeman City, in the Gallatin valley				4827
Mouth of Gallatin river—Three forks, or head of Missouri—about 4,300 miles by river from the mouth of the Mississippi, and 1,063 miles west of Duluth				4079
Vicinity of Helena, Montana Territory, foot hills of Rocky mountains, 1,133 miles from Duluth				4280
Summit of Rocky mountains				6000
Mouth of Blackfoot, near outlet of Deer Lodge valley				4464
Missaula, on waters of Clark's fork of Columbia				3300
Cabinet rocks, on waters of Clark's fork of Columbia				2200
Lake Pend d'Oreille; (Clark's fork flows through Lake Pend d'Oreille)				2080
Columbia Plains, on Undulating Columbia Plains				2300
Near mouth of Snake or Lewis river, and near Columbia river				450
Cascades, head of the fall, on Columbia river				50
Cascades, foot, on Columbia river, tide water				0
Kalama, on Columbia river, tide water				0

TABLE OF ALTITUDES on Northern Pacific Railroad, from Lake Superior to Puget's Sound—Continued.

LOCALITY OF OBSERVATION.	COUNTY.	STATE.	Feet above Lake Erie.	Feet above Ocean.
Cowlitz river, a tributary of Columbia river	....	....	....	60
Summit between Columbia river and Puget's Sound	....	....	....	480
Plains, moderately undulating	....	....	....	200
Tacoma, terminus; Commencement bay on Puget Sound, Washington Territory, 2,038 miles west of Duluth	....	....	....	0

TABLE OF ALTITUDES on Atlantic and Pacific Railroad, from St. Louis to San Francisco. From the Surveys of J. Blickensderfer, Engineer.

LOCALITY OF OBSERVATION.	COUNTY.	STATE.	Feet above Lake Erie.	Feet above Ocean.
Union depot at St. Louis	....	Missouri	....	486
Jerome—low water in Gasconade river	....	Missouri	....	656
Summit of Ozark mountains near Marshfield	....	Missouri	....	1482
Springfield—surface of ground	....	Missouri	....	1332
Grand river—low water	....	....	....	706
Arkansas river—low water	....	....	....	574
North fork Canadian river—low water	....	....	....	1423
Canadian river—low water	....	....	....	1880
Canon Blanco—summit	....	....	....	6960
Albuquerque—surface of ground	....	....	....	4836
Campbell's pass—surface of ground (continental divide)	....	....	....	7152
Tonto pass—surface of ground	....	....	....	7519

Wallapi pass—surface of ground				3440
Mohaw gap—surface of ground				1475
Colorado river—low water at the crossing of this line at "The Needles," 400 miles from the mouth				355
Piute summit—surface of ground				2579
Perry basin—surface of ground				728
Mohaw river				2400
Soledad pass—summit of Sierra Nevada				3215
San Luis summit—surface of ground in the Santa Luzia range, 236 miles south of San Francisco				1561

ELEVATIONS of Several Passes on the Coast Range.

LOCALITY OF OBSERVATION.	COUNTY.	STATE.	Feet above Lake Erie.	Feet above Ocean.
Pechaco				1302
Big Panoche				2115
San Benito				2821
Worthen Canon				2380
Pollonia				1738

TABLE OF ALTITUDES on Texas Pacific Railway, from Shreveport, Louisiana, to San Diego, California, (1685 miles).

LOCALITY OF OBSERVATION.	COUNTY.	STATE.	Feet above Lake Erie.	Feet above Ocean.
Shreveport		Louisiana		204
Marshall	Harrison	Texas		390
Terrell, 45 miles west of Marshall	Kaufman	Texas		553
Trinity river at Dallas	Dallas	Texas		481
Fort Worth	Tarrant	Texas		629
Moore's gap	Parker	Texas		1195
Fort Phantom Hill	Jones	Texas		1597
Red fork of Colorado river	Scurry	Texas		2177
Sulphur Springs	Martin	Texas		2847
Sand hills		Texas		2377
Pecos river		Texas		2711
Guadalupe pass (or Hurd's pass)		Texas		4493
Pass through Hueco mountains		Texas		5327
Fort Bliss (El Paso del Norte)		Texas		3800
Continental divide, 100 miles west of the Rio Grande				4900
Pass through Peloncillo range, 145 miles west of the Rio Grande				4446
Rio San Simon				3562
Railroad pass, Chiricahua range, 184 miles west of the Rio Grande				4388
Pimas villages, Gila river, 349 miles west of the Rio Grande				1291
St. Valentine's pass				1517
Fort Yuma, crossing of Colorado river				145
Bed of Dry lake				Bel. 290
San Gorgonio pass				2621
Head of Temecula pass				954
San Bernardo river				20
San Diego				16

MISCELLANEOUS ELEVATIONS in British Possessions, in or near Line of Canadian Pacific Railway, from Lake Superior, Westward.

LOCALITY OF OBSERVATION.	COUNTY.	STATE.	Feet above Lake Erie.	Feet above Ocean.
Lake Superior				598
Fort William, on Thunder bay				603
Lofoden station				1070
Upsala station				1559
English river				1515
Keewatin, in the territory of Keewatin				1092
Selkirk, Manitoba				750
Cartier				849
Sussex, Northwest territory				1048
Livingston, Northwest territory				1612
Assiniboine, Northwest territory				1707
Saskatchewan, Northwest territory, near crossing of South Saskatchewan river				1845
Battleford, Northwest territory				1615
Grizzly Bear, Northwest territory				2145
Edmonton				2413
Root river				2921
Grand Portal, British Columbia				3245
Summit Meadow, British Columbia, highest point on line of the road, about 500 miles east of Pacific terminus				3828
Fraser river, British Columbia				3409
Tete Jaune Cache, British Columbia				2780
Lake Nipigon, north of Lake Superior				850
Lake of the Woods, territory of Keewatin				1042
Lake Manitoba				751
Lake Winnepegosis, territory of Keewatin				770
*Lake Winnepeg				710

* NOTE.—A plausible hypothesis has been suggested by geologists, viz.: That the basin of Lake Winnepeg, now drained into Hudson's Bay, was, at a time far back, but since the Glacial period, an extension of the Minnesota valley, finding its drainage to the ocean through the Mississippi. This idea is adopted by Gen. Warren, U. S. Topographical Engineer, in his report on this region in 1874.

ELEVATIONS along the Minnesota and Red River Valleys.

LOCALITY OF OBSERVATION.	COUNTY.	STATE.	Feet above Lake Erie.	Feet above Ocean.
Water surface at junction of Minnesota and Mississippi rivers	....	Minnesota.	....	695
Water surface of Minnesota river at the Great Bend at Mankato	....	Minnesota.	....	765
Lake Traverse, near the divide between the Minnesota and Red river of the north	....	Minnesota.	....	1000