GEOLOGICAL SURVEY OF OHIO
WILBER STOUT, State Geologist

Fourth Series, Bulletin 41

MARL, TUFA ROCK, TRAVERTINE, AND BOG ORE IN OHIO

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CONTENTS

Page

Definition of terms 7
  Marl 7
  "Marl" of Adams County 8
  Calcareous tufa or travertine 9
  "Marl" of Pennsylvanian and Permian systems 10
  Bog iron ore 10
  Ferruginous tufa or ferruginous travertine 11
  Manganese ores 12

Distribution and composition of marl 14
  Summit County 14
  Portage County 14
  Geauga County 15
  Holmes County 15
  Ashland County 15
    Tests, Ashland Reduction Co., Sec. 15, Lake Township 15
    Tests on land of Frank Divelbiss, Sec. 35, Madison Twp. 16
  Knox County 17
    Test on Fred J. Marriott farm near Centerburg 17
  Erie County 19
    Tests, Castalia Portland Cement Co. near Castalia 19
    Tests, Medusa Portland Cement Co., two miles north of Castalia 21
  Seneca County 22
  Fulton County 22
  Williams County 22
  Auglaize County 23
  Champaign County 23
  Logan County 24
    Tests on the L. D. Musselman farm north of Rush Lake 24
    Tests on land of Columbus Mutual Life Insurance Company near Rush Lake 26
  Miami County 27
    Tests at plant of Ohio Marl and Humus Company at Silver Lake 27

Page
Greene County.. 30
Pickaway County.. 30
Tests on land of Ray Lockard, south of Circleville...... 30

Distribution and composition of the Adams County type of "marl" 32
"Marl" in Adams, Pike, and Highland counties
Test on the Simpson West property near Sinking Springs 32

Distribution and composition of calcareous tufa and travertine.. 34
Erie County.. 34
Tests of tufa from Charles Eggert, Castalia............ 34
Cuyahoga, Mahoning, Portage, and Summit counties....... 35
Crawford County.. 35
Medina County.. 36
Champaign County.. 36
Test of stalactite, Ohio Caverns.................... 36
Greene County.. 37
Tests of tufa on land of Morton R. Grinnell, Section 13, Miami Township.............................. 37
Tests of travertine at Yellow Springs................ 39

Distribution of manganese ore.............................. 42
Geauga County.. 42

Distribution and composition of bog ore.................... 43
Ashtabula County.. 43
Lake County.. 43
Tests of bog ores south of Madison.................. 43
Cuyahoga County.. 46
Lorain County.. 46
Fulton County.. 47
Seneca County.. 47
Williams County.. 48
Wood County.. 48
Lucas County.. 49
Crawford County.. 49
Morrow County.. 50
Putnam County.. 50
Richland County.. 50

Page
Knox County.. 51
    Tests on ore from Reynolds farm..................... 51
Clermont County.................................... 52

Distribution and composition of ferruginous tufa or travertine... 54
Champaign County................................... 54
    Tests on tufa from Ohio Caverns..................... 54
Delaware County.................................... 55
    Tests on ore from Satterfield property............... 55

DEFINITION OF TERMS

MARL

The term marl is used in a rather loose way to define a kind of rock varying much in origin, texture, and composition. In Webster's New International Dictionary we find the following definition: "Marl, strictly, an earthy, crumbling deposit consisting chiefly of clay mixed with calcium carbonate in varying proportions. Also, any of various other soft, or even compact, deposits; as, greensand marl, shell marl, etc." Stress is thus laid on the porous nature of the material and on the clay component. The latter, however, in many marls is a small part of the whole.

The Encyclopedia Britannica states: "Marl, a calcareous clay, or mixture of calcium carbonate and argillaceous matter. The term is applied to a great variety of rocks and soils with a considerable range of composition. Marls pass, on the one hand, into clays by diminution in the amount of lime, and on the other, into argillaceous limestone; in popular usage, however, many substances are called marls which would be better termed sandy clays. Typical marls are soft, earthy, and of a white, gray, or brownish color. The lime in some is present in the form of shells, whole or broken; in others it is a fine impalpable powder mixed with the clay. Sand is usually not abundant, but is rarely absent. A large variety of accessory minerals may be proved by microscopic examination to exist in marls. While marls are frequently shallow-water marine deposits, many well known examples are of fresh water origin."

Much the same definition is given by Dana:[1] "Calcareous marl is a soft earthy deposit, often hardly at all consolidated, with or without distinct fragments of shells; it generally contains much clay, and graduates into a calcareous clay." This describes very well most of the marls in the fresh-water lakes of Ohio.

In this State marls, in the strict sense of loosely consolidated deposits composed largely of calcium carbonate with subordinate quantities of other materials, are confined almost entirely to the fresh-water lakes in the glaciated area, totaling approximately 29,700 square miles. In fact with few exceptions the lakes are within the boundary of the Wisconsin drift which covered some 26,460 square miles in northern and southwestern Ohio. Such lakes are well distributed over this area but are most concentrated in Hardin, Wyandot, Crawford, Seneca, Huron, Wayne, Stark, Summit, Portage, Geauga, Ashtabula, Logan, Champaign, and

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[1] Dana, James Dwight, The System of Mineralogy, p. 268.

Licking counties. These vary in size from small marshy depressions of a few square rods in the glacial drift to natural open-water lakes covering from 500 to 2,500 acres.

In such lakes and marshes the common deposit is peat and peaty clays. Marls are local in extent but are widely distributed. The lacustrine deposits, however, may consist of either material separately or of almost any combination of these. Usually the marls are overlain by peat or peat muck and are sharply differentiated from the organic materials. Marl through diminution of the calcium carbonate may gradate into calcareous clays.

Much has been written on the origin of marls both in this country and abroad. The description best fitting such deposits in Ohio is that given by Dachnowski in his report on the peat deposits of Ohio. He states:[1] "Chara and also crustaceans and mollusks withdraw calcium bicarbonate (soluble $CaCO_3.H_2CO_3$) from the water and deposit it upon their bodies by precipitation as calcium carbonate ($CaCO_3$). Upon the death of the organisms the lime (calcium carbonate, $CaCO_3$) permanently settles upon the floor of the lake or pond. In some lakes and peat deposits the accumulations of fine-grained **Chara** marl or of the comminuted particles of shell marl reach to several feet in thickness. Such deposits are illustrated by areas in which Portland cement works are located, as for instance near Sandusky, where beds of cream-colored **Chara** marl and sheets of calcareous tufa alternating with layers of peat average more than 6 feet in thickness over an area of several square miles. In the Brimfield bog of Portage County and in many other peat deposits **Chara** seems to have held the entire bottom of these ancient lakes. By its growth the plant filled the depression with marl to a depth of 3 to 4 feet before other plants were able to establish themselves. Where clay or sand forms the substratum the lower layers of marl are usually impregnated with them."

"MARL" OF ADAMS COUNTY

The so-called "marl" of Adams, Highland, and Pike counties is not marl in the precise sense as it is a true marine deposit in origin, a relatively pure dolomite in composition, and stony in structure. In fact it is only a local modification of the Peebles (Niagara) dolomite where in local areas this formation has been made soft and porous through weathering and leaching. Such deposits are confined to the area of overlap, that particular area where all the strata from the Peebles dolomite to the Ohio shale are missing. Here the consolidated rock through elevation and

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[1] Geol. Survey Ohio, 4th Ser., Bull 16, p. 225, 1912.

long ages of exposure was locally made friable and porous or was reduced to a marly condition. This modification, however, was not regional for the "marl" occurs only in patches throughout the area of overlap. Elsewhere the Peebles dolomite is well consolidated and has the normal open, grainy texture characteristic of this formation. Iron ore, found in pockets on the upper surface of the Peebles formation and formerly worked by the charcoal furnaces and refining forges of Adams and Ross counties, is closely related to the "marl" in origin and in distribution. In general the term "marl," if applicable, is confined to the material in the upper part of the formation or to such parts that were long exposed to leaching and solution. Downward the "marl" gradates into normal dolomite.

In color the "marl" is light gray, to buff, to bluish gray, depending on the state of decomposition and recent weathering. The parts most completely reduced are earthy or sand-like in texture. It has little plasticity but considerable binding power on compaction. Mainly the material is a friable, crumbling, cavernous rock, breaking readily into small fragments when quarried. Locally thin irregular lenses of hard stone appear in the "marl." In parts of the formation fossils are abundant but poorly preserved.

CALCAREOUS TUFA OR TRAVERTINE

The terms, travertine and tufa, are also used rather loosely, but in general they refer to a particular kind of deposit originating through the chemical deposition of calcium carbonate from springs, streams, seeps in caverns, and flowing water at waterfalls. As defined by Webster, "Travertine, a white concretionary calcium carbonate, soft and chalk-like to hard and semi-crystalline, deposited from the waters of springs or streams holding lime in solution." And "tufa, a porous rock formed as a deposit from springs or stream:—usually applied to calcareous deposits [travertine], in the phrase calcareous tufa." Hence tufa appears to be only a kind of travertine with an open porous texture.

The general description of the terms by Clarke follows[1]: "Some limestone, the variety known as calcareous tufa or travertine, is a chemical precipitate, but in its larger masses the rock is generally of organic origin . . . When waters charged with calcium carbonate, ($CaH_2(CO_3)_2$) are allowed to evaporate, they deposit their load in the form of sinter, or tufa. This process can be observed at many thermal and 'petrifying' springs, and also in the formation of stalactites and stalagmites in limestone caverns . . .

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[1] Clarke, Frank Wigglesworth, The Data of Geochemistry, U. S. Geol. Survey, Bull. 330, pp. 470, 471, 1908.

"In 1864 Ferdinand Cohn studied the formation of travertine at the waterfalls of Tivoli. He found that many aquatic plants, especially species of Chara, mosses, and algae, became incrusted with calcium carbonate, ($CaCO_3$)—a fact which he attributed to their activity in absorbing carbon dioxide (CO_2) and so setting the carbonate free; that is, plants consume carbon dioxide (CO_2) and exhale oxygen (O_2). When they do this in water containing calcium bicarbonate ($CaH_2(CO_3)_2$), they deprive that salt of its second molecule of carbonic acid (H_2CO_3), and the insoluble neutral carbonate ($CaCO_3$) is thrown down."

Orton and Peppel describe travertine in Ohio as follows[1]: "Travertine.—Associated with the marl beds in the Castalia district is a layer of travertine, or calcareous tufa, deposited probably from former overflows of the great Castalia spring, which wells forth in volume sufficient to make a small stream. This underground river, for it is nothing else, maintains at present a considerable lake or pond, and in times past probably made a much larger area of swamp land. Over this area, the travertine has been deposited, in some places as much as 3 or 4 feet thick, though generally much less. It is substantially pure carbonate of lime, showing a content of 99.4 per cent calcium carbonate ($CaCO_3$). It is deposited as carbonate, from the breaking down of calcium bicarbonate as it emerges from the underground water-course, and is exposed to the air, heat and motion of the stream."

"MARL" OF PENNSYLVANIAN AND PERMIAN SYSTEMS

The fresh-water limestones in the upper half of the Conemaugh and the Monongahela series of the Pennsylvanian system and in the Washington and Greene series of the Permian are often referred to as marls or as marly in character. This is especially true when they appear as a group of small nodules or assume a powdery form. Such materials may appear as stratified deposits alone or along with hard limestone in large nodules or in regular beds. The origin of such "marls" was certainly very similar to that being deposited in fresh water lakes and marshes of today.

BOG IRON ORE

Bog iron ore is another rock formed through precipitation. It was deposited from shallow surface and spring waters in swales and swamps. The ferruginous component was gathered from the soils and consolidated rocks on the uplands through the action of acids from decaying organic matter, was held in solution as the

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[1] Geol. Survey Ohio, 4th Ser., Bull 3, page 97, 1904.

soluble ferrous bicarbonate $FeH_2(CO_3)_2$, and was precipitated in shallow water in the form of a yellowish or orange-colored sediment which on consolidation became ore. This change came about through general chemical activity, aided possibly by "iron bacteria." In this reaction soluble ferrous bicarbonate oxidizes and hydrates to limonite. The reaction follows:

$$4FeH_2(CO_3)_2 + O_2 = 2Fe_2O_3.3H_2O + 8\ CO_2 + H_2O$$

Bog ore is open and spongy in texture, generally yellowish brown in color, and usually more or less contaminated with impurities, chief of which is clay matter. The ore bodies are uncertain in lateral extent and variable in thickness. In size they vary from scattered nodules to sheets of several acres. The thickness ranges from a few inches to several feet but usually averages between 1 and 2 feet. In northern and especially northeastern Ohio the bog ores formerly played an important part in iron making. Such ore was most abundant along the Beach Ridges from Cleveland to the Pennsylvania-Ohio line.

Throughout northern Ohio from Lorain to Conneaut the bog ores were the only source of iron for a number of charcoal furnaces built between 1825 and 1860. These furnaces were generally successful and did much to develop the area. Generally the metal produced was cast directly into ware such as stove plate, pots, kettles, stew pans, and irons, gridirons, machine castings, engine cylinders, plow points, mill wheels, and many other articles useful in the home, on the farm, or in the industries. The ore was mined most largely by hand labor with pick and shovel and was cleaned from clay matter by washing in a log washer or by exposure to the elements for several months. At most furnaces the ore was roasted in kilns with wood before use. The calcination eliminated organic matter and hydroscopic water and changed the limonite to a soft spongy hematite that reduced readily in the furnace. According to the records, the bog ore used gave a yield of 25 to 35 per cent iron and produced a soft foundry iron of excellent quality.

FERRUGINOUS TUFA OR FERRUGINOUS TRAVERTINE

Ferruginous tufa, ferruginous travertine, or ocherous deposits are commonly laid down from chalybeate or iron-bearing carbonate waters, with ions of ferrous oxide, by loss of carbon dioxide, CO_2, oxidation of the ferrous oxide, FeO, to ferric oxide, Fe_2O_3, and hydration of the ferric oxide to ferric hydroxide or limonite, $2Fe_2O_3.3H_2O$. In steps the reaction may be written:

$$FeCO_3.H_2CO_3 = FeO + H_2O + 2CO_2$$
$$2FeO + O = Fe_2O_3, \text{ hematite}$$
$$2Fe_2O_3 + 3H_2O = 2Fe_2O_3.3H_2O, \text{ limonite}$$

In many cases, however, the reaction does not proceed to limonite but only to hematite or to a mixture of the two.

Ferruginous deposits of this character occur around chalybeate springs where a constant supply of the ferruginous component is present. The precipitation of the iron mineral appears to be due to temperature changes, to evaporation of water changing the concentration to oxidation from contact with the air, and to precipitation through the formation of a stable insoluble compound.

Such deposits of ferruginous tufa or travertine vary considerably in both physical and chemical properties. The common colors are dark buff, orange, reddish brown and dark brown. Other shades as light yellow, greenish buff, nearly black, etc. are occasionally found. The coloring pigments include the various oxides and hydrates of iron, peaty or carbonaceous matter, and small quantities of manganese salts, ferrous carbonate, and sulphur impurities. In texture the ferruginous tufas and travertines vary from soft spongy through open porous, earthy and grainy to hard dense rock. The compactness depends on original precipitation and on secondary cementation after deposition.

Such tufas and travertines have found little application economically. Although the ore is of good quality the quantity available was too small to be attractive even for iron making in the pioneer furnaces. Some ore, however, was apparently used in the early forges. Where other stone was scarce or lacking, the pioneers often employed tufas and bog ores for the hearth and backwall of their fireplaces. The stone sintered to a dense mass, did not spall or pop, and was resistant to fusion from ashes. Also to a small extent these ores were used as paint pigments, through grinding to impalpable powders and mixing with oil. The color was permanent and generally pleasing.

MANGANESE ORES

Manganese in some form but in minor quantities is present in most sedimentary rocks in Ohio. This is especially true in limestone, dolomite, shale, and iron ores. Like the other carbonate salts—$CaCO_3$, $MgCO_3$, $FeCO_3$—manganous carbonate, $MnCO_3$, is soluble in water containing organic acids. On issuing in bogs and swamps such waters may deposit manganese ores much the same as bog iron ore. Manganese ores are thus secondary in origin, formed through solution and precipitation. The common ores are pyrolusite, MnO_2, and psilomelane, $MnO_2.H_2O$, often occurring as mixtures. Wad is a low grade manganese ore, brown to black in color, earthy or argillaceous in character, and bearing from 15 to 40 percent manganese, Mn.

DISTRIBUTION AND COMPOSITION OF MARL

In Ohio marl deposits are confined almost entirely to the lake and swamp areas of the Wisconsin drift. They are usually associated with peat, commonly occurring below such a mantle of organic material. The swamp may contain marl with little peat or peat with no marl. Tufa is a common associated material with the marl where the calcareous matter is largely of spring origin. As yet no thorough survey for marl has been made in Ohio.

SUMMIT COUNTY

In the reports of the Geological Survey of Ohio the first mention of marl is by Mather in 1838[1] where he discusses its origin and use as a land fertilizer. The shell marl of Summit County is described by Newberry in 1873 as follows: "Deposits of shell marl are frequently found underlying peat in 'cat swamps' and filled up lakelets. This marl is composed of the remains of the shells of mollusks, which after the death of the animals that inhabited them, have accumulated at the bottom of the water. In some instances these marls are white, and nearly pure lime; in others they are mixed with more or less earthy and vegetable matter. Such deposits occur in nearly every township of the county, but they have attracted little attention, and their valuable fertilizing properties have been very sparingly made available. The deposit of shell marl on the road between Hudson and Stow is at least twelve feet deep and very pure. Similar marl beds, though less extensive, are known in Hudson, Northampton and other parts of the county. Usually a sheet of peat or muck covers the marl, and it is not likely to be discovered, unless by ditching or special search."[2]

Marl is reported by Roger M. Thomas, County Agricultural Agent, Summit County, on the farm formerly operated by Simon Young and located just north of the Reservoir. The land belongs to the city of Akron. It, like the marl in Suffield, is under muck.[3]

PORTAGE COUNTY

Similar material is mentioned in a general way throughout the lake region of Portage County.

"The peat in many bogs is frequently underlaid by Chara and shell marl."[4] In the Brimfield bog about two miles southwest of

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[1] Mather, W. W., Geol. Survey Ohio, First Annual Report, pp. 13, 14. 1838.

[2] Geol. Survey Ohio, Vol. 1, p. 207, 1873.

[3] Personal letter from Roger M. Thomas, July 20, 1940.

[4] Geol. Survey Ohio, 4th Ser., Bull. 16, p. 105, 1912.

Brimfield in Brimfield Township, the thickness of marl reported is from 2 to 5 feet of Chara and shell marl. The area of the bog is given as about 200 acres.[1]

GEAUGA COUNTY

Many glacial lakes and bogs are present in Geauga County. Most of these contain peat and a few are also reported to contain marl. The lake region with somewhat similar conditions extends eastward into Ashtabula, Trumbull, and northern Columbiana counties and southward into Stark.

HOLMES COUNTY

In the valley region between Loudonville and Shreve in Ashland, Wayne, and Holmes counties large deposits of marl underlie the peat. South of Bonnett Lake in northcentral Section 26, Washington Township, Holmes County, marl is present and has been mined in a small way on the farms of J. C. Drumm and A. W. Mitchhart. The deposits are reported to be from 3 to 6 feet or more in thickness and of good quality. It is the fine-grained Chara type of marl.

ASHLAND COUNTY

Marl is regularly prepared for the market by the Ashland Reduction Company, Incorporated, in the southeastern part of Section 15, Lake Township, Ashland County. The marl occurs in the swampy land east of Lake Fork at an elevation of about 930 feet. The section worked and reported by the firm is as follows:

Peat	1 to 3 feet
Marl	3 to 15 feet

The marl is prepared for the market by drying in a revolving drum, 75 feet long, operated by steam power and heated by slack coal for the fuel. The product is sacked and sold for various purposes. A sample of crude marl from the pit was taken July 10, 1935, by Wilber Stout. The analysis follows: Analyst, Downs Schaaf.

Silica, SiO_2	3.21
Alumina, Al_2O_3	0.70
Ferric oxide, Fe_2O_3	0.08
Ferrous oxide, FeO	0.56
Pyrite, FeS_2	0.05
Magnesium oxide, MgO	1.40
Calcium oxide, CaO	50.82
Strontium oxide, SrO	∠0.01

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[1] Idem, p. 107.

Sodium oxide, Na_2O	∠0.01
Potassium oxide, K_2O	0.01
Water, hydroscopic, H_2O-	0.78
Water, combined, H_2O+	0.25
Carbon dioxide, CO_2	41.83
Titanic oxide, TiO_2	0.04
Phosphorus pentoxide, P_2O_5	0.02
Sulphur trioxide, SO_3	∠0.01
Manganous oxide, MnO	0.07
Carbon, organic, C	0.47
Total	100.29

The mineral components, as calculated from the analysis (Stout), are as follows:

Sericite, $K_2O.3Al_2O_3.6SiO_2.2H_2O$				0.08
Kaolinite, $Al_2O_3.2SiO_2.2H_2O$				1.70
Quartz or free silica, SiO_2				2.38
Limonite, $2Fe_2O_3.3H_2O$				0.09
Pyrite, FeS_2				0.05
Rutile, TiO_2				0.04
Apatite, $3CaO.P_2O_5$				0.04
Marl	Main components	$MgO.CO_2$	2.93	
		$CaO.CO_2$	90.67	
				93.60
	Parts in solid solution	$FeO.CO_2$	0.90	
		$MnO.CO_2$	0.11	
				1.01
Water, hydroscopic, H_2O-				0.78
Carbon, organic, C				0.47
Unbalanced parts (excess CO_2, H_2O,)				−0.05
Total				100.29

In the swamps along a southern tributary of Rocky Fork in the southwestern part of the northeast quarter of Section 35, Madison Township, Ashland County, on the farm of Frank Divelbiss, marl is regularly present under a coating of organic matter. The marl is reported to be from 1 to 6 feet in thickness. Parts contain considerable sand and clay matter. The deposit was sampled October 2, 1935, by Wilber Stout and Frank Divelbiss. The results of the analysis follow: Analyst, Downs Schaaf.

Silica, SiO_2	13.71
Alumina, Al_2O_3	2.75
Ferric oxide, Fe_2O_3	0.25
Ferrous oxide, FeO	0.68
Pyrite, FeS_2	0.10
Magnesium oxide, MgO	0.92
Calcium oxide, CaO	41.60
Sodium oxide, Na_2O	0.21

Potassium oxide, K_2O	0.38
Water, hydroscopic, H_2O-	1.98
Water, combined, H_2O+	0.90
Carbon dioxide, CO_2	34.03
Titanic oxide, TiO_2	0.14
Phosphorus pentoxide, P_2O_5	0.07
Sulphur trioxide, SO_3	0.02
Manganous oxide, MnO	0.05
Carbon, organic, C	2.05
Hydrogen, organic, H	0.27
Total	100.11

The mineral components in this marl, as determined by calculation (Stout) from the analysis, are as follows:

Sericite, $(K, Na)_2O.3Al_2O_3.6SiO_2.2H_2O$				5.80
Kaolinite, $Al_2O_3.2SiO_2.2H_2O$				1.22
Quartz or free silica, SiO_2				10.47
Limonite, $2Fe_2O_3.3H_2O$				0.29
Pyrite, FeS_2				0.10
Rutile, TiO_2				0.14
Apatite, $3CaO.P_2O_5$				0.15
Anhydrite, $CaO.SO_3$				0.03
Marl	Main components	$MgO.CO_2$	1.92	
		$CaO.CO_2$	74.09	
				76.01
	Parts in solid solution	$FeO.CO_2$	1.10	
		$MnO.CO_2$	0.08	
				1.18
Water, hydroscopic, H_2O-				1.98
Hydrocarbons, C_nH_{2n+2}				2.32
Unbalanced parts (lacking CO_2, H_2O)				+0.42
Total				100.11

KNOX COUNTY

On the Fred J. Marriott and adjacent farms one and one-half miles west of Centerburg in Hilliar Township, Knox County, marl occurs in a number of swamps, usually under a covering of peat. Test holes indicate that the marl is from 1 to 6 feet in thickness and is of fair quality. It is mainly of the Chara type, fine in grain and light in color.

A sample was taken on the Fred J. Marriott farm, July 17, 1940, by Wilber Stout and Fred J. Marriott. The test was taken south of the farm home, about two miles west of Centerburg, one and one-fourth miles southwest of Rich Hill and three-fourths mile northwest of School No. 1. The section follows:

	Ft.	In.
Lake clay, bluish color, sticky and plastic, some dark peaty layers	5	0
Marl, with clay layers	5	0
Gravel and sand	.	.

The marl here contains much clay matter but locally is reported to be of fair grade. The composition of the sample taken is as follows, analyst Downs Schaaf:

Silica, SiO_2	27.38
Alumina, Al_2O_3	7.58
Ferric oxide, Fe_2O_3*	1.25
Pyrite, FeS_2	1.55
Magnesium oxide, MgO	1.40
Calcium oxide, CaO	26.68
Strontium oxide, SrO	∠0.01
Barium oxide, BaO	∠0.01
Sodium oxide, Na_2O	0.28
Potassium oxide, K_2O	0.72
Water, hydroscopic, H_2O-	4.40
Water, combined, H_2O+	2.35
Carbon dioxide, CO_2	22.80
Titanic oxide, TiO_2	0.27
Phosphorus pentoxide, P_2O_5	0.15
Sulphur trioxide, SO_3	0.44
Manganous oxide, MnO	0.04
Carbon, organic, C	1.50
Hydrogen, organic, H	0.16
Total	98.95

*All Fe calculated to Fe_2O_3 since the high organic matter precludes an accurate FeO determination. The Fe, however, is largely held as FeO.

The mineral components in the argillaceous marl on the Fred J. Marriott property near Centerburg, as determined by calculation (Stout) from the analysis, are as follows:

Sericite, $(K, Na)_2O.3Al_2O_3.6SiO_2.2H_2O$				9.26
Kaolinite, $Al_2O_3.2SiO_2.2H_2O$				10.08
Quartz or free silica, SiO_2				18.45
Limonite, $2Fe_2O_3.3H_2O$				0.00
Pyrite, FeS_2				1.55
Rutile, TiO_2				0.27
Apatite, $3CaO.P_2O_5$				0.33
Anhydrite, $CaO.SO_3$				0.75
Marl	Main components	$MgO.CO_2$	2.93	
		$CaO.CO_2$	46.74	
			——	49.67
	Parts in solid solution	$FeO.CO_2$	1.81	
		$MnO.CO_2$	0.06	
			——	1.87
Water, hydroscopic, H_2O-				4.40
Hydrocarbons, C_nH_{2n+2}				1.66
Unbalanced parts (lacking CO_2, H_2O, O_2)				+0.66
Total				98.95

ERIE COUNTY

The most continuous and extensive marl deposits known in Ohio are in the swamp areas—Castalia Prairie, Margaretta Township, Erie County. These have been worked for Portland cement for many years. Dachnowski states:[1]

"Castalia Prairie—A marshy prairie of about 3,500 acres extends from Castalia to the west and north. There are moderately elevated hills to the south of the prairie, but the northern portions slope gradually toward Sandusky Bay. The peat over the greater part of the prairie is very shallow . . . .

"The northwestern portion of the prairie has been artificially drained. The water from subterranean springs formerly flowed through the prairie . . The water contains much carbonate of lime and has given rise to extensive marl deposits which are now used on a large scale for Portland cement. The deposit of this material covers an area of several square miles . . .

"Test borings were made at a point about one mile west of the Portland cement factory, and indicate the following cross section. At a depth varying from 1 to 2 feet below the marly surface occurs a layer of peat 10 inches in thickness. Below this is a fine-grained, cream-colored marl consisting principally, it seems, of Chara nodules. The thickness of the bed is 4 feet."

The composition of this marl is shown in the following analyses:[2]

	No. 1 marl from Castalia	No. 2 marl from Castalia
Silica, SiO_2	0.075	0.110
Alumina, and ferric oxide, $Al_2O_3+Fe_2O_3$	0.362	0.102
Calcium carbonate, $CaCO_3$	97.726	92.410
Magnesium carbonate, $MgCO_3$	1.481	2.853
Barium sulphate, $BaSO_4$	0.356	....
Water and loss on ignition	....	4.525
Total	100.000	100.000

No. 1 is from a small inclosure of about 20 acres.
No. 2 was taken nearly a mile east from the first sample.

Recently, June 4, 1940, these marl deposits were again sampled by Charles F. Krueger, of the Castalia Portland Cement Company, and Wilber Stout. In this area Mr. Krueger reports that the marl varies from 1 to 13 feet but averages about 6 feet. The samples, Nos. 284 and 285, were taken at different places west of the fac-

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[1] Geol. Survey Ohio, 4th Ser., Bull. 16, p. 56, 1912.
[2] Geol. Survey Ohio, Vol. II, p. 195, 1874.

tory. The compositions of these are given below. Analyst, Downs Schaaf.

	No. 285 Largely Chara marl	No. 284 About average marl
Silica, SiO_2	0.03	0.03
Alumina, Al_2O_3	0.02	0.02
Ferric oxide, Fe_2O_3*	0.10	0.11
Ferrous oxide, FeO	......	......
Pyrite, FeS_2	∠0.01	∠0.01
Magnesium oxide, MgO	0.28	0.30
Calcium oxide, CaO	54.66	54.54
Strontium oxide, SrO	∠0.01	∠0.01
Barium oxide, BaO	∠0.01	∠0.01
Sodium oxide, Na_2O	∠0.01	∠0.01
Potassium oxide, K_2O	∠0.01	∠0.01
Water, hydroscopic, H_2O-	0.60	0.69
Water, combined, H_2O+	∠0.01	∠0.01
Carbon dioxide, CO_2	42.45	42.34
Titanic oxide, TiO_2	∠0.01	∠0.01
Phosphorus pentoxide, P_2O_5	∠0.01	∠0.01
Sulphur trioxide, SO_3	1.56	1.60
Manganous oxide, MnO	0.03	0.03
Carbon, organic, C	0.20	0.18
Hydrogen, organic, H	0.02	0.02
Total	99.95	99.86

*All iron, Fe, calculated to Fe_2O_3, since the high organic matter precludes an accurate FeO determination.

The mineral components in the Chara marl, Sample No. 285, as determined by calculation (Stout) from the analysis, are as follows:

Sericite, $(K, Na)_2O.3Al_2O_3.6SiO_2.2H_2O$				0.00
Kaolinite, $Al_2O_3.2SiO_2.2H_2O$				0.05
Quartz or free silica, SiO_2				0.01
Limonite, $2Fe_2O_3.3H_2O$				0.00
Pyrite, FeS_2				0.00
Rutile, TiO_2				0.00
Apatite, $3CaO.P_2O_5$				0.00
Anhydrite, $CaO.SO_3$				2.65
Marl	Main components	$MgO.CO_2$	0.59	
		$CaO.CO_2$	95.60	
				96.19
	Parts in solid solution	$FeO.CO_2$	0.15	
		$MnO.CO_2$	0.05	
				0.20
Water, hydroscopic, H_2O-				0.60
Hydrocarbons, C_nH_{2n+2}				0.22
Unbalanced parts (lacking CO_2, H_2O)				+0.03
Total				99.95

The mineral components in the marl of average quality, Sample No. 284, as determined by calculation (Stout) from the analysis, are as given below:

Sericite, $(K, Na)_2O.3Al_2O_3.6SiO_2.2H_2O$				0.00
Kaolinite, $Al_2O_3.2SiO_2.2H_2O$				0.05
Quartz or free silica, SiO_2				0.01
Limonite, $2Fe_2O_3.3H_2O$				0.00
Pyrite, FeS_2				0.00
Rutile, TiO_2				0.00
Apatite, $3CaO.P_2O_5$				0.00
Anhydrite, $CaO.SO_3$				2.72
Marl	Main components	$MgO.CO_2$	0.62	
		$CaO.CO_2$	95.34	
				95.96
	Parts in solid solution	$FeO.CO_2$	0.16	
		$MnO.CO_2$	0.05	
				0.21
Water, hydroscopic, H_2O-				0.69
Hydrocarbons, C_nH_{2n+2}				0.20
Unbalanced parts (CO_2, H_2O)				+0.02
Total				99.86

A sample of marl was also taken from the pit of the Medusa Portland Cement Company located two miles northwest of Castalia. The sample was taken from a train of cars by the pit foreman of the Medusa Portland Cement Company and Wilber Stout, June 4, 1940. The thickness of the marl along the cut was from 4 to 7 feet with an average of about 6 feet. The composition of this marl is given below. Analyst, Downs Schaaf

Silica, SiO_2	0.04
Alumina, Al_2O_3	0.02
Ferric oxide, Fe_2O_3*	0.10
Ferrous oxide, FeO	.....
Pyrite, FeS_2	∠0.01
Magnesium oxide, MgO	0.29
Calcium oxide, CaO	54.55
Strontium oxide, SrO	∠0.01
Barium oxide, BaO	∠0.01
Sodium oxide, Na_2O	∠0.01
Potassium oxide, K_2O	∠0.01
Water, hydroscopic, H_2O-	0.68
Water, combined, H_2O+	∠0.01
Carbon dioxide, CO_2	42.35
Titanic oxide, TiO_2	∠0.01
Phosphorus pentoxide, P_2O_5	∠0.01
Sulphur trioxide, SO_3	1.62
Manganous oxide, MnO	0.03

Carbon, organic, C	0.22
Hydrogen, organic, H	0.03
Total	99.92

*All iron, Fe, calculated to Fe_2O_3. since the high organic matter precludes an accurate FeO determination.

The mineral composition of the marl from the pit of the Medusa Portland Cement Company, as determined by calculation (Stout) from the analysis, is as given below.

Sericite, $(K, Na)_2O.3Al_2O_3.6SiO_2.2H_2O$				0.00
Kaolinite, $Al_2O_3.2SiO_2.2H_2O$				0.05
Quartz or free silica, SiO_2				0.02
Limonite, $2Fe_2O_3.2H_2O$				0.00
Pyrite, FeS_2				0.00
Rutile, TiO_2				0.00
Apatite, $3CaO.P_2O_5$				0.00
Anhydrite, $CaO.SO_3$				2.75
Marl	Main components	$MgO.CO_2$	0.61	
		$CaO.CO_2$	95.34	
				95.95
	Parts in solid solution	$FeO.CO_2$	0.15	
		$MnO.CO_2$	0.05	
				0.20
Water, hydroscopic, $H_2O -$				0.68
Hydrocarbons, C_nH_{2n+2}				0.24
Unbalanced parts $(CO_2.H_2O)$				+0.03
Total				99.92

SENECA COUNTY

In Honey Creek bottom, in the southeast quarter of Section 31, Hopewell Township, Seneca County, a deposit of shell marl underlies the peat but not in quantity for economic use.[1]

FULTON COUNTY

In the geology of Fulton County Gilbert states:[2] "Marl is found in marshes, upon the borders of the sand areas, where there has been some drainage from the clay land, but it is not to be expected in depressions entirely surrounded by sand hills." He further states:[3] "Marl exists in moderate quantity in the swales of the clay land, but unfortunately is not known in the swamps of the sandy district where it would be most useful as a land dressing."

WILLIAMS COUNTY

Marl in small quantities is present in Williams County in the northwestern part of the State. Dachnowski's description is of

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[1] Geol. Survey Ohio, 4th Ser., Bull. 16, p. 115, 1912.

[2] Geol. Survey Ohio, Vol. 1, p. 571, 1873.

[3] Geol. Survey Ohio, Report of 1870, p. 492.

interest:[1] "The topography of the county is generally rolling. Marshes and bogs abound on the surface of the unmodified drift, for the county is divided into two somewhat marked soil provinces by the shore line of glacial Lake Erie (Lake Maumee and Lake Whittlesey). Two ancient lake beaches, only one of which is well marked, (Maumee) cross in a northeast-southwest direction, just east of the St. Joseph River. West of the upper beach (Maumee) the surface consists of unmodified glacial clay with enough sand to render it permeable. Swales and water basins without natural drainage are relatively frequent. East of the upper beach and the second lake ridge near it (Whittlesey), the surface presents the features of the Black Swamp—a plain of rich, friable clay loam, entirely free from gravel and stones and derived from the glacial clay. The general slope is to the southeast and the descent is gentle and uniform throughout.

"It is interesting to note that the majority of tamarack bogs are west of the St. Joseph River in St. Joseph, Florence, Superior, and Madison townships . . . In these swamps shell marl is found mingled in all proportions with clay but it occurs only in small quantities. It is said that beds of bog iron ore have been found interstratified with the marl. As yet none has been encountered of sufficient magnitude and quality for commercial purposes."

AUGLAIZE COUNTY

Auglaize County, crossed or affected by the St. Johns, Wabash, and Fort Wayne moraines of the Wisconsin glacier, is well dotted with lakes and swamps occupying depressions in the drift. Most of these originated from stranded blocks of ice. Dachnowski states:[2] "Beds of peat and marl are common in this county but they are small—from one to five acres in area . . .

"A mastodon was found in 1870 in Clay Township in the Muchinippi swamp, two and one-half miles east of the village of St. Johns. The depth of the swamp at the point at which the discovery was made is about 8 feet of which the upper third is of peat and the remainder of marl or marly clay."

CHAMPAIGN COUNTY

The surface of Champaign County was made very irregular with hummocks and depressions on the great mass of drift piled up along the junction of the Scioto and Miami lobes of the Wisconsin ice sheet. Small lakes and bogs are much in evidence. The rec-

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[1] Geol. Survey Ohio, 4th Ser., Bull. 16, p. 134, 1912.

[2] Idem., p. 38.

ords show:[1] Dallas Arbor Vitae Bog, 6 miles south of Urbana, in sections 31 and 32, Urbana Township.—"Test borings indicate a surface layer of black non-fibrous peat about 2 feet thick, resting on a cream-colored, fine grained marl, 3 feet in depth and underlaid by sandy gravel. The marl is frequently of the nature of calcareous tufa." Another deposit is noted in Mosquito Lake in Section 16, Johnson Township.[2] "The area of the peat and marl deposits is 300 acres. The deposits contain a fine-grained, well humified peat, varying between 1 and 6 feet in thickness and resting on a bluish colored shell marl that is underlaid with drift."

LOGAN COUNTY

Marl deposits of importance are present along Rush Creek in the southwestern part of Rush Creek Township, Logan County. The main body of marl is north of Rush Lake and extends along the valley for about three miles. Its width is from one-fourth to about one mile. The marls of both the Chara and shell types are overlain by thin deposits of peat. Formerly these deposits supported two Portland cement plants, the Buckeye at Harper and the Alta at Rushsylvania.

Two samples of marl were taken on the L. D. Musselman farm July 9, 1940, by Wilber Stout and J. H. Crevison (West Mansfield). Sample No. 291 was secured two-fifths of a mile south of Marl City (Old Buckeye cement plant) west of Rush Creek, Rush Creek Township, Logan County. The marl lies close to the surface, is from 3 to 4 feet in thickness, and contains thin lenses of clay matter. It is largely a Chara marl but parts are largely fresh water shells. The composition is given below. Analyst, Downs Schaaf.

Silica, SiO_2	9.66
Alumina, Al_2O_3	2.84
Ferric oxide, Fe_2O_3*	1.04
Pyrite, FeS_2	∠0.01
Magnesium oxide, MgO	1.10
Calcium oxide, CaO	43.17
Strontium oxide, SrO	∠0.01
Barium oxide, BaO	∠0.01
Sodium oxide, Na_2O	0.10
Potassium oxide, K_2O	0.25
Water, hydroscopic, H_2O-	2.39
Water, combined, H_2O+	0.82
Carbon dioxide, CO_2	35.56
Titanic oxide, TiO_2	0.10
Phosphorus pentoxide, P_2O_5	0.16
Sulphur trioxide, SO_3	∠0.01
Manganous oxide, MnO	0.04

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[1] Geol. Survey Ohio, 4th Ser., Bull. 16, p. 41, 1912.

[2] Idem., p. 43.

Carbon, organic, C	1.45
Hydrogen, organic, H	0.16
Total	98.84

*All Fe calculated to Fe_2O_3 since the high organic matter precludes an accurate FeO determination.

The mineral components in Sample No. 291, as determined by calculation (Stout) from the analysis, are as given below:

Sericite, $(K, Na)_2O.3Al_2O_3.6SiO_2.2H_2O$				3.33
Kaolinite, $Al_2O_3.2SiO_2.2H_2O$				3.89
Quartz or free silica, SiO_2				6.32
Limonite, $2Fe_2O_3.3H_2O$				0.00
Pyrite, FeS_2				0.00
Rutile, TiO_2				0.10
Apatite, $3CaO.P_2O_5$				0.35
Anhydrite, $CaO.SO_3$				0.00
Marl	Main components	$MgO.CO_2$	2.30	
		$CaO.CO_2$	76.71	
				79.01
	Parts in solid solution	$FeO.CO_2$	1.52	
		$MnO.CO_2$	0.06	
				1.58
Water, hydroscopic, H_2O-				2.39
Hydrocarbons, C_nH_{2n+2}				1.61
Unbalanced parts (lacking CO_2, H_2O, O_2)				+0.26
Total				98.84

Sample No. 292, also on the L. D. Musselman farm and taken by Wilber Stout and J. H. Crevison July 9, 1940, was located one-half mile south of Marl City, west of Rush Creek, one and one-fourth miles east of Harper, one and one-half miles north of Rush Lake, Rush Creek Township, Logan County. The marl here appears at the surface and is from 3 to 4 feet in thickness. It is of an excellent grade, made up largely of Chara marl, with a layer about 1 foot in thickness in the lower part of shells. It is underlain by dark peaty lake clay. The chemical components are as follows: Analyst, Downs Schaaf.

Silica, SiO_2	3.09
Alumina, Al_2O_3	0.70
Ferric oxide, Fe_2O_3*	0.86
Pyrite, FeS_2	∠0.01
Magnesium oxide, MgO	1.14
Calcium oxide, CaO	49.83
Strontium oxide, SrO	∠0.01
Barium oxide, BaO	∠0.01
Sodium oxide, Na_2O	0.05
Potassium oxide, K_2O	0.10
Water, hydroscopic, H_2O-	1.46
Water, combined, H_2O+	0.19

Carbon dioxide, CO_2	40.80
Titanic oxide, TiO_2	0.04
Phosphorus pentoxide, P_2O_5	0.11
Sulphur trioxide, SO_3	∠0.01
Manganous oxide, MnO	0.04
Carbon, organic, C	0.88
Hydrogen, organic, H	0.09
Total	99.38

*All Fe calculated to Fe_2O_3 since the high organic matter precludes an accurate FeO determination.

The mineral components in Sample No. 292, as determined by calculation (Stout) from the analysis, are as follows:

Sericite, $(K, Na)_2O.3Al_2O_3.6SiO_2.2H_2O$				1.87
Kaolinite, $Al_2O_3.2SiO_2.2H_2O$				0.00
Quartz or free silica, SiO_2				2.21
Limonite, $2Fe_2O_3.3H_2O$				0.00
Pyrite, FeS_2				0.00
Rutile, TiO_2				0.04
Apatite, $3CaO.P_2O_5$				0.24
Anhydrite, $CaO.SO_3$				0.00
Marl	Main components	$MgO.CO_2$	2.38	
		$CaO.CO_2$	88.70	91.08
	Parts in solid solution	$FeO.CO_2$	1.24	
		$MnO.CO_2$	0.06	1.30
Water, hydroscopic, H_2O-				1.46
Hydrocarbons, C_nH_{2n+2}				0.97
Unbalanced parts (lacking CO_2, H_2O, O_2)				+0.21
Total				99.38

Large bodies of marl are present in the region north of Rush Lake. A sample was taken for testing on land of the Columbus Mutual Life Insurance Company (Columbus), July 9, 1940, by Wilber Stout and J. H. Crevison. The test hole was made just east of Rush Creek, three-fifths of a mile north of Rush Lake, Rush Creek Township, Logan County. The marl is at the surface, is from 4 to 6 feet in thickness and is underlain by lake clay. The quality is good, being a mixture of Chara and shell marl. The composition is as given below. Analyst, Downs Schaaf.

Silica, SiO_2	2.71
Alumina, Al_2O_3	0.59
Ferric oxide, Fe_2O_3*	0.62
Pyrite, FeS_2	∠0.01
Magnesium oxide, MgO	1.22
Calcium oxide, CaO	49.11
Strontium oxide, SrO	∠0.01
Barium oxide, BaO	∠0.01

Sodium oxide, Na_2O	0.04
Potassium oxide, K_2O	0.09
Water, hydroscopic, H_2O-	2.11
Water, combined, H_2O+	0.17
Carbon dioxide, CO_2	40.15
Titanic oxide, TiO_2	0.01
Phosphorus pentoxide, P_2O_5	0.12
Sulphur trioxide, SO_3	∠0.01
Manganous oxide, MnO	0.06
Carbon, organic, C	1.65
Hydrogen, organic, H	0.18
Total	98.83

*All Fe calculated to Fe_2O_3 since the high organic matter precludes an accurate FeO determination.

The mineral components in sample No. 294, as determined by calculation (Stout) from the analysis, are as given below:

Sericite, $(K, Na)_2O.3Al_2O_3.6SiO_2.2H_2O$				1.26
Kaolinite, $Al_2O_3.2SiO_2.2H_2O$				0.26
Quartz or free silica, SiO_2				2.01
Limonite, $2Fe_2O_3.3H_2O$				0.00
Pyrite, FeS_2				0.00
Rutile, TiO_2				0.01
Apatite, $3CaO.P_2O_5$				0.26
Anhydrite, $CaO.SO_3$				0.00
Marl	Main components	$MgO.CO_2$	2.55	
		$CaO.CO_2$	87.40	
				89.95
	Parts in solid solution	$FeO.CO_2$	0.90	
		$MnO.CO_2$	0.10	
				1.00
Water, hydroscopic, H_2O-				2.11
Hydrocarbons, C_nH_{2n+2}				1.83
Unbalanced parts (lacking CO_2, H_2O, O_2)				+0.14
Total				98.83

MIAMI COUNTY

Miami County contains few lakes and no large areas of swampy lands as it is mostly well drained by the Miami River and its tributaries. However, in a few areas peat and marl deposits are present. The Ohio Marl and Humus Company of New Carlisle is working one of these located at Silver Lake in the south central part of Section 6, Bethel Township. The peat overlying the marl is reported to vary from 0 to 6 feet in thickness, but to average less than 2 feet. The marl is of the shell type and varies from 1 to 15 feet. The marl is light colored and, except for the shells, fine grained. Samples were taken August 9, 1937 by Wilber Stout and Walter Stout.

Sample No. 86 consisted of parts taken from the pit being worked and from places along the front of the lake.

Sample No. 87 screened shells, made up principally of the shells of fresh-water snails.

Sample No. 88. Sample of marl prepared for the trade. Material ground and partially dried.

The chemical components in these three samples are as follows: Analyst, Downs Schaaf.

	No. 86	No. 87	No. 88
Silica, SiO_2	0.70	4.92	2.88
Alumina, Al_2O_3	0.11	0.33	0.14
Ferric oxide, Fe_2O_3	0.01	0.03	0.03
Ferrous oxide, FeO	0.22	0.27	0.25
Pyrite, FeS_2	∠0.01	∠0.01	∠0.01
Magnesium oxide, MgO	1.90	1.75	1.83
Calcium oxide, CaO	51.91	49.49	50.65
Strontium oxide, SrO	∠0.01	∠0.01	∠0.01
Barium oxide, BaO	∠0.01	∠0.01	∠0.01
Sodium oxide, Na_2O	∠0.01	∠0.01	∠0.01
Potassium oxide, K_2O	∠0.01	∠0.01	∠0.01
Water, hydroscopic, H_2O-	1.03	1.16	1.01
Water, combined, H_2O+	0.03	0.10	0.04
Carbon dioxide, CO_2	42.83	40.79	41.77
Titanic oxide, TiO_2	0.01	0.07	0.05
Phosphorus pentoxide, P_2O_5	0.17	0.17	0.18
Sulphur trioxide, SO_3	0.10	0.08	0.11
Manganous oxide, MnO	0.03	0.025	0.03
Carbon, organic, C	0.64	0.65	0.70
Hydrogen, organic, H	0.08	0.08	0.09
Total	99.77	99.915	99.76

The mineral components in Sample No. 86, general sample of marl, as determined by calculation (Stout) from the chemical analysis, are as follows:

Sericite, $(K, Na)_2O.3Al_2O_3.6SiO_2.2H_2O$				0.00
Kaolinite, $Al_2O_3.2SiO_2.2H_2O$				0.28
Quartz or free silica, SiO_2				0.57
Limonite, $2Fe_2O_3.3H_2O$				0.01
Pyrite, FeS_2				0.00
Rutile, TiO_2				0.01
Apatite, $3CaO.P_2O_5$				0.37
Anhydrite, $CaO.SO_3$				0.17
Marl	Main components	$MgO.CO_2$	3.97	
		$CaO.CO_2$	92.17	
				96.14
	Parts in solid solution	$FeO.CO_2$	0.36	
		$MnO.CO_2$	0.03	
				0.39

Water, hydroscopic, H_2O –	1.03
Hydrocarbons, C_nH_{2n+2}	0.72
Unbalanced parts (lacking, H_2O, CO_2)	+0.08
Total	99.77

The mineral components in Sample No. 87, screened shells, as determined by calculation (Stout) from the analysis, are as given below:

Sericite, $(K, Na)_2O.3Al_2O_3.6SiO_2.2H_2O$				0.00
Kaolinite, $Al_2O_3.2SiO_2.2H_2O$				0.84
Quartz or free silica, SiO_2				4.53
Limonite, $2Fe_2O_3.3H_2O$				0.04
Pyrite, FeS_2				0.00
Rutile, TiO_2				0.07
Apatite, $3CaO.P_2O_5$				0.37
Anhydrite, $CaO.SO_3$				0.14
Marl	Main components	$MgO.CO_2$	3.66	
		$CaO.CO_2$	87.87	91.53
	Parts in solid solution	$FeO.CO_2$	0.44	
		$MnO.CO_2$	0.035	0.475
Water, hydroscopic, H_2O –				1.16
Hydrocarbons, C_nH_{2n+2}				0.73
Unbalanced parts (lacking CO_2, H_2O)				+0.03
Total				99.915

The mineral components in Sample No. 88 marl, as prepared for the trade, as determined by calculation (Stout) from the analysis, are as follows:

Sericite, $(K, Na)_2O.3Al_2O_3.6SiO_2.2H_2O$				0.00
Kaolinite, $Al_2O_3.2SiO_2.2H_2O$				0.35
Quartz or free silica, SiO_2				2.72
Limonite, $2Fe_2O_3.3H_2O$				0.04
Pyrite, FeS_2				0.00
Rutile, TiO_2				0.05
Apatite, $3CaO.P_2O_5$				0.39
Anhydrite, $CaO.SO_3$				0.19
Marl	Main components	$MgO.CO_2$	3.83	
		$CaO.CO_2$	89.88	93.71
	Parts in solid solution	$FeO.CO_2$	0.40	
		$MnO.CO_2$	0.04	0.44
Water, hydroscopic, H_2O –				1.01
Hydrocarbons, C_nH_{2n+2}				0.79
Unbalanced parts (lacking $H_2O.CO_2$)				+0.07
Total				99.76

GREENE COUNTY

In Greene County shell marl in thin layers is reported to be present in the peat in Simm's Bog, located near Simm's Station in sections 1 and 2, Bath Township.[1] The quantity of marl, however, is small and of no commercial value.

PICKAWAY COUNTY

The Kibler Lime Plant formerly prepared considerable marl for agricultural purposes from a depression in the glacial drift south of Circleville, Pickaway County. The best of the marl is reported to be exhausted. The thickness varied from a few inches to 6 feet or more. A sample was taken by Wilber Stout July 20, 1940, in the swamp on the Ray Lockard farm just east of the Norfolk and Western Railway about one and one-fourth miles southeast of the center of Circleville in the west central part of Section 29, Circleville Township, Pickaway County. The section of the test hole follows:

	Ft.	In.
Soil, marly	1	0
Marl, good, sampled	.	8
Peat, part very fibrous	3	0
Sand and gravel	1	0

The composition of the marl is given below. Analyst, Downs Schaaf.

Silica, SiO_2	1.35
Alumina, Al_2O_3	0.10
Ferric oxide, Fe_2O_3*	0.38
Pyrite, FeS_2	∠0.01
Magnesium oxide, MgO	1.15
Calcium oxide, CaO	48.88
Strontium oxide, SrO	∠0.01
Barium oxide, BaO	∠0.01
Sodium oxide, Na_2O	∠0.01
Potassium oxide, K_2O	∠0.01
Water, hydroscopic, H_2O-	3.60
Water, combined, H_2O+	0.03
Carbon dioxide, CO_2	39.72
Titanic oxide, TiO_2	0.02
Phosphorus pentoxide, P_2O_5	0.10
Sulphur trioxide, SO_3	0.05
Manganous oxide, MnO	0.04
Carbon, organic, C	2.40
Hydrogen, organic, H	0.25
Total	98.07

*All Fe calculated to Fe_2O_3, as the high organic matter precludes an accurate FeO determination.

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[1] Geol. Survey Ohio, 4th Ser., Bull. 16, pp. 68, 69, 1912.

The mineral components in the marl from the Lockard property as determined by calculation (Stout) from the analysis, are as follows:

Sericite, $(K, Na)_2O.3Al_2O_3.6SiO_2.2H_2O$				0.00
Kaolinite, $Al_2O_3.2SiO_2.2H_2O$				0.26
Quartz or free silica, SiO_2				1.23
Limonite, $2Fe_2O_3.3H_2O$				0.00
Pyrite, FeS_2				0.00
Rutile, TiO_2				0.02
Apatite, $3CaO.P_2O_5$				0.22
Anhydrite, $CaO.SO_3$				0.09
Marl	Main components	$MgO.CO_2$	2.40	
		$CaO.CO_2$	86.96	
				89.36
	Parts in solid solution	$FeO.CO_2$	0.55	
		$MnO.CO_2$	0.06	
				0.61
Water, hydroscopic, H_2O-				3.60
Hydrocarbons, C_nH_{2n+2}				2.65
Unbalanced parts (lacking CO_2, H_2O)				+0.03
Total				98.07

DISTRIBUTION AND COMPOSITION OF THE ADAMS COUNTY TYPE OF "MARL"

The so-called "marl" of Adams, Highland, and Pike counties is, as previously stated, only a phase of the Peebles dolomite of the Niagara formation where this rock has been made soft and porous through weathering and solution along a pronounced unconformity. Its origin is definitely marine and not fresh water, its composition that of a relatively pure dolomite, its stratification characteristics that of a consolidated, bedded rock, and its lateral gradation that of the normal dolomite. Such deposits are found in local areas in southeastern Highland, western Pike, and eastern Adams counties. As they are not true marls and should not be considered as such, only one analysis will be given to show the composition and mineral components.

SIMPSON WEST QUARRY

The quarry is located east of the Sinking Springs-Bainbridge road, Route 41, near the junction of this road with the Sinking Springs-Hillsboro road, Route 124, about one mile north of Sinking Springs, in the southeastern part of Brush Creek Township, Highland County. The material has been used mainly for road stone. The formation was sampled October 17, 1933, by Wilber Stout. The section of the pit is given below:

	Ft.	In.
Soil and weathered material	2	0
Peebles Formation		
Dolomite, massive in structure, light to drab colored, marly in character, open to vuggy in texture, crystalline, some poorly preserved fossils. Locally known as marl. Sample No. 1	23	0

The analysis of the 23 feet of marly Peebles dolomite follows: Analyst, Downs Schaaf.

Silica, SiO_2	0.33
Alumina, Al_2O_3	0.12
Ferric oxide, Fe_2O_3	0.36
Ferrous oxide, FeO	0.14
Pyrite, FeS_2	0.09
Magnesium oxide, MgO	21.35
Calcium oxide, CaO	30.03
Strontium oxide, SrO	none
Barium oxide, BaO	none
Sodium oxide, Na_2O	∠0.01
Potassium oxide, K_2O	∠0.01
Water, hydroscopic, H_2O-	0.11
Water, combined, H_2O+	0.07
Carbon dioxide, CO_2	47.15

Titanic oxide, TiO_2	0.006
Phosphorus pentoxide, P_2O_5	0.05
Sulphur trioxide, SO_3	none
Manganous oxide, MnO	0.01
Vanadium oxide, V_2O_5	∠0.01
Zinc oxide, ZnO	∠0.01
Carbon, organic, C	0.40
Hydrogen, organic, H	0.05
Total	100.27

The mineral components, as determined by calculation (Stout) from the above analysis, are given below:

Sericite, $(Na, K)_2O.3Al_2O_3.6SiO_2.2H_2O$				0.00
Kaolinite, $Al_2O_3.2SiO_2.2H_2O$				0.30
Quartz or free silica, SiO_2				0.19
Limonite, $2Fe_2O_3.3H_2O$				0.42
Pyrite, FeS_2				0.09
Rutile, TiO_2				0.006
Apatite, $3CaO.P_2O_5$				0.11
Anhydrite, $CaO.SO_3$				0.00
Dolomite	Main components	$MgO.CO_2$	44.65	
		$CaO.CO_2$	53.49	
				98.14
	Parts in solid solution	$FeO.CO_2$	0.23	
		$MnO.CO_2$	0.02	
				0.25
Water, hydroscopic, H_2O –				0.11
Hydrocarbons, C_nH_{2n+2}				0.45
Unbalanced parts (lacking CO_2, H_2O)				+0.20
Total				100.27

DISTRIBUTION AND COMPOSITION OF CALCAREOUS TUFA AND TRAVERTINE

In small quantities tufa rock is rather widely distributed in western and northern Ohio. It may occur almost any place throughout the area of springs bearing a high content of soluble carbonates. However, deposits of size are relatively few and are confined to the immediate areas of large springs.

ERIE COUNTY

The one great source for tufa rock in Ohio is the plains north and northwest of Castalia in Erie County, involving an area of more than 4,000 acres. Throughout this plain the tufa is very irregularly deposited. Locally it may be absent. Where present the irregularly shaped masses bedded in or on the marl vary from a few inches to 4 feet or more in thickness. A common thickness is about 1 foot. The tufa may be very open and porous in texture, due to the nature of the plants around which it was deposited, or quite dense, more in the nature of common calcite deposits.

A sample of tufa rock was taken June 4, 1940, by Wilber Stout from a large pile collected from various places throughout the Castalia plains for marketing purposes by Charles Eggert of Castalia. The chemical results follow. Analyst, Downs Schaaf.

Silica, SiO_2	0.03
Alumina, Al_2O_3	0.02
Ferric oxide, Fe_2O_3*	0.10
Pyrite, FeS_2	∠0.01
Magnesium oxide, MgO	0.19
Calcium oxide, CaO	54.77
Strontium oxide, SrO	∠0.01
Barium oxide, BaO	∠0.01
Sodium oxide, Na_2O	∠0.01
Potassium oxide, K_2O	∠0.01
Water, hydroscopic, H_2O-	0.60
Water, combined, H_2O+	∠0.01
Carbon dioxide, CO_2	42.45
Titanic oxide, TiO_2	∠0.01
Phosphorus pentoxide, P_2O_5	∠0.01
Sulphur trioxide, SO_3	1.55
Manganous oxide, MnO	0.03
Carbon, organic, C	0.16
Hydrogen, organic, H	0.02
Total	99.92

*All iron, Fe, calculated to Fe_2O_3, since the high organic matter precludes an accurate FeO determination.

The mineral components in the tufa rock, Sample No. 283, as determined by calculation from the analysis (Stout), are as given below:

Sericite, $(K, Na)_2O.3Al_2O_3.6SiO_2.2H_2O$				0.00
Kaolinite, $Al_2O_3.2SiO_2.2H_2O$				0.05
Quartz or free silica, SiO_2				0.01
Limonite, $2Fe_2O_3.3H_2O$				0.00
Pyrite, FeS_2				0.00
Rutile, TiO_2				0.00
Apatite, $3CaO.P_2O_5$				0.00
Anhydrite, $CaO.SO_3$				2.64
Tufa rock	Main components	$MgO.CO_2$	0.40	
		$CaO.CO_2$	95.81	
				96.21
	Parts in solid solution	$FeO.CO_2$	0.15	
		$MnO.CO_2$	0.05	
				0.20
Water, hydroscopic, H_2O-				0.60
Hydrocarbons, C_nH_{2n+2}				0.18
Unbalanced parts (lacking, CO_2, H_2O)				+0.03
Total				99.92

CUYAHOGA, MAHONING, PORTAGE, SUMMIT COUNTIES

Under the heading of "Tufa" in the report of 1838 Whittlesey states:[1] "This imperfect limerock is observed at Cuyahoga Falls; at Brandywine mills, in Northfield (Cuyahoga County); and at the falls of Mill Creek, at Youngstown; and also on lot 45, tract No. 1, Orange Township, Cuyahoga County. When remote from regular beds it may be turned to some account. It accumulates about the mineral springs in Edinburg, Freedom (Portage County), and Hudson (Summit County), and unquestionably exists in many places not noticed, but in very limited quantities. It may be easily recognized by its porous, sponge-like structure."

CRAWFORD COUNTY

Caleb Briggs in December, 1838, gives the following report on "Calcareous Tufa" in Crawford County.[2] "This is deposited from water holding carbonate of lime in solution by means of carbonic acid. The excess of the latter escapes while the former is deposited, in the form of an impure, porous carbonate of lime, known by the name of tufa or travertine. Sticks, leaves, etc., are often incrusted with this substance.

"Two localities of this tufa have been observed: the first is near Bucyrus, on the left bank of the river. Large masses of this

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[1] Geol. Survey Ohio, Second Annual Report, 1838, p. 65.

[2] Idem., p. 125.

material lie on the surface, and contain shells of the Genus Helix. It is too porous and friable for a building material but may be advantageously used for burning into quick lime, which is now (1838) brought to Bucyrus from a distance. The second is on the south-east corner of the Wyandot Reservation. It is found in loose blocks on the surface."

MEDINA COUNTY

The formation of travertine is mentioned in the geology of Medina County by Wheat:[1]

"Travertine is being deposited in a lot owned by Col. Robert English. It is a mile from Lodi by the north-east road. Some of the masses are large, and they are quite numerous about the spring which issues from a hillside."

CHAMPAIGN COUNTY

In the Ohio Caverns, located in Salem Township, Champaign County, are many fine stalactites and stalagmites in all stages of development. Most of them are living growing formations. In order to determine the composition, a typical specimen of stalactite was furnished by Mr. I. E. Smith of the Ohio Caverns. The composition is as given below. Analyst, Downs Schaaf.

The chemical components in the stalactites follow: Analyst, Downs Schaaf.

Silica, SiO_2	∠0.01
Alumina, Al_2O_3	∠0.01
Ferric oxide, Fe_2O_3	∠0.01
Ferrous oxide, FeO	0.02
Pyrite, FeS_2	none
Magnesium oxide, MgO	1.05
Calcium oxide, CaO	54.77
Strontium oxide, SrO	∠0.01
Barium oxide, BaO	∠0.01
Sodium oxide, Na_2O	∠0.01
Potassium oxide, K_2O	∠0.01
Water, hydroscopic, H_2O-	∠0.01
Water, combined, H_2O+	∠0.01
Carbon dioxide, CO_2	44.14
Titanic oxide, TiO_2	∠0.01
Phosphorus pentoxide, P_2O_5	∠0.01
Sulphur trioxide, SO_3	0.04
Manganous oxide, MnO	∠0.01
Carbon, organic, C	∠0.01
Total	100.02

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[1] Geol. Survey Ohio, Vol. 111, p. 368, 1878.

The mineral components in the stalactite, as determined by calculation (Stout) from the analysis, are as given below:

Sericite, $(K, Na)_2O.3Al_2O_3.6SiO_2.2H_2O$				0.00
Kaolinite, $Al_2O_3.2SiO_2.2H_2O$				0.00
Quartz or free silica, SiO_2				0.00
Limonite, $2Fe_2O_3.3H_2O$				0.00
Pyrite, FeS_2				none
Rutile, TiO_2				0.00
Apatite, $3CaO.P_2O_5$				0.00
Anhydrite, $CaO.SO_3$				0.07
Calcite	Main components	$MgO.CO_2$	2.20	
		$CaO.CO_2$	97.70	
				99.90
	Parts in solid solution	$FeO.CO_2$	0.03	
		$MnO.CO_2$	0.00	
				0.03
Water, hydroscopic, H_2O-				0.00
Hydrocarbons, C_nH_{2n+2}				0.00
Unbalanced parts (wanting, $H_2O.CO_2$)				+0.02
Total				100.02

GREENE COUNTY

A deposit of tufa rock is present along the outcrop of the Brassfield limestone on the property of Morton R. Grinnell, near the Grinnell Mill, on the north bluff of the Little Miami River, in the southeastern part of Section 13, Miami Township, Greene County. Samples were taken May 7, 1940, by Wilber Stout.

Section	Ft.	In.
Tufa rock, soft and marly to open, porous, massive stone, gray to dark gray in color, fine to medium grain. Sample No. 265 from face	18	0

Sample No. 266 was taken from a pile of tufa crushed to a fine powder and sold for land fertilization. This sample contained more fine and surface material than the one above. The analyses of these follow: Analyst, Downs Schaaf.

	Sample No. 265	Sample No. 266
Silica, SiO_2	0.24	0.90
Alumina, Al_2O_3	0.03	0.35
Ferric oxide, Fe_2O_3	0.01	0.01
Ferrous oxide, FeO	0.08	0.12
Pyrite, FeS_2	0.01	0.03
Magnesium oxide, MgO	1.07	1.05
Calcium oxide, CaO	54.35	53.55
Strontium oxide, SrO	∠0.01	∠0.01
Barium oxide, BaO	∠0.01	∠0.01
Sodium oxide, Na_2O	∠0.01	0.01
Potassium oxide, K_2O	0.01	0.03

Water, hydroscopic, H_2O-	0.25	0.44
Water, combined, H_2O+	0.01	0.10
Carbon dioxide, CO_2	43.86	43.22
Titanic oxide, TiO_2	0.01	0.02
Phosphorus pentoxide, P_2O_5	0.05	0.07
Sulphur trioxide, SO_3	∠0.01	0.01
Manganous oxide, MnO	0.02	0.03
Carbon, organic, C	0.05	0.10
Total	100.05	100.04

The mineral components in Sample No. 265 of the more solid tufa rock, as determined by calculation (Stout) from the analysis, are as follows:

Sericite, $(K, Na)_2O.3Al_2O_3.6SiO_2.2H_2O$				0.08
Kaolinite, $Al_2O_3.2SiO_2.2H_2O$				0.00
Quartz or free silica, SiO_2				0.20
Limonite, $2Fe_2O_3.3H_2O$				0.01
Pyrite, FeS_2				0.01
Rutile, TiO_2				0.01
Apatite, $3CaO.P_2O_5$				0.11
Anhydrite, $CaO.SO_3$				0.00
Tufa rock	Main components	$MgO.CO_2$	2.24	
		$CaO.CO_2$	96.90	
			——	99.14
	Parts in solid solution	$FeO.CO_2$	0.13	
		$MnO.CO_2$	0.03	
			——	0.16
Water, hydroscopic, H_2O-				0.25
Hydrocarbons, C_nH_{2n+2}				0.05
Unbalanced parts (lacking CO_2, H_2O)				+0.03
Total				100.05

The mineral components in the ground tufa, Sample No. 266, as determined by calculation (Stout) from the analysis, are as given below:

Sericite, $(K, Na)_2O.3Al_2O_3.6SiO_2.2H_2O$				0.39
Kaolinite, $Al_2O_3.2SiO_2.2H_2O$				0.51
Quartz or free silica, SiO_2				0.48
Limonite, $2Fe_2O_3.3H_2O$				0.01
Pyrite, FeS_2				0.03
Rutile, TiO_2				0.02
Apatite, $3CaO.P_2O_5$				0.15
Anhydrite, $CaO.SO_3$				0.02
Tufa	Main components	$MgO.CO_2$	2.19	
		$CaO.CO_2$	95.42	
			——	97.61
	Parts in solid solution	$FeO.CO_2$	0.19	
		$MnO.CO_2$	0.05	
			——	0.24

Water, hydroscopic, H_2O-	0.44
Hydrocarbons, C_nH_{2n+2}	0.10
Unbalanced parts (lacking CO_2, H_2O)	+0.04
Total	100.04

The large deposit of ferruginous travertine at Yellow Springs, Greene County, was sampled June 24, 1940, by A. C. Swinnerton, Professor of Geology, Antioch College, and his assistant, William K. Gealey. The sample was taken from a shaft approximately in the center of the mound about 100 feet from the Spring. The shaft was dug to provide ventilation for the tunnel: it represents roughly the same layers that would be found in the tunnel. The section sampled and as recorded by these geologists is as follows:

Description	Depth from surface in feet
Dark brown soil	0 to 1.1
Hard, brown, porous, irregularly nodular travertine	1.1 to 1.95
Soft, brown, earthy travertine	1.95 to 3.1
Hard, rusty-colored travertine	3.1 to 4.45
Soft, brown, earthy travertine, clayey	4.45 to 5.5
Hard, moderately porous, brown travertine	5.5 to 6.7
Soft, chocolate travertine	6.7 to 7.05
Soft, brittle, brown travertine	7.05 to 7.55
Soft, brown, earthy travertine	7.55 to 9.5
Hard, slightly porous, red brown travertine	9.5 to 10.4
Soft, red brown travertine	10.4 to 12.2
Earthy, brittle, brown travertine	12.2 to 12.7
Mossy white travertine, medium hardness	12.7 to 12.85
Soft, earthy, brown travertine	12.85 to 14.55
Hard, porous, chocolate travertine	14.55 to 15.85
Soft, mealy, red brown travertine	15.85 to 17.65 plus

The results from a chemical analysis of this travertine are as given below. Analyst, Downs Schaaf.

Silica, SiO_2	1.45
Alumina, Al_2O_3	1.17
Ferric oxide, Fe_2O_3	6.40
Ferrous oxide, FeO	0.16
Pyrite, FeS_2	∠0.01
Magnesium oxide, MgO	0.80
Calcium oxide, CaO	48.10
Strontium oxide, SrO	∠0.01
Barium oxide, BaO	∠0.01
Sodium oxide, Na_2O	∠0.01
Potassium oxide, K_2O	∠0.01
Water, hydroscopic, H_2O-	2.22
Water, combined, H_2O+	0.45
Carbon dioxide, CO_2	38.77
Titanic oxide, TiO_2	0.01

Phosphorus pentoxide, P_2O_5	0.17
Sulphur trioxide, SO_3	∠0.01
Manganous oxide, MnO	0.32
Carbon, organic, C	∠0.01
Total	100.02

The mineral composition of the travertine at Yellow Springs, as determined by calculation (Stout) from the analysis, is as follows:

Sericite, $(K, Na)_2O.3Al_2O_3.6SiO_2.2H_2O$				0.00
Kaolinite, $Al_2O_3.2SiO_2.2H_2O$				2.96
Quartz or free silica, SiO_2				0.07
Limonite, $2Fe_2O_3.3H_2O$				0.28
Hematite, Fe_2O_3				6.16
Pyrite, FeS_2				0.00
Rutile, TiO_2				0.01
Apatite, $3CaO.P_2O_5$				0.37
Anhydrite, $CaO.SO_3$				0.00
Travertine	Main components	$MgO.CO_2$	1.67	
		$CaO.CO_2$	85.49	
				87.16
	Parts in solid solution	$FeO.CO_2$	0.26	
		$MnO.CO_2$	0.52	
				0.78
Water, hydroscopic, H_2O-				2.22
Hydrocarbons, C_nH_{2n+2}				0.00
Unbalanced parts (lacking, $H_2O.CO_2$)				+0.01
Total				100.02

Professor A. C. Swinnerton, of Antioch College, Yellow Springs, used the iron tufa in estimating post-glacial time:[1]

"Among the problems met in the study of the Post-Pleistocene is one concerning the time period involved. The solution of the problem is important in many ways. Geologists are more keenly aware of the events which have occurred in this period than in any other. Hence close estimates of the length of time involved will contribute to a more accurate geological conception of the absolute rapidity of various physiographic processes.

"Several estimates of the length of post-glacial time are commonly known. Taylor, following Lyell, Spencer and others, estimated the period occupied on the recession of Niagara Falls. DeGeer reached his conclusions from his studies of varied clays. Other estimates have been based on the erosion of the pedestals beneath erratics and on the comparative weathering of drift materials of different ages. The variation in these estimates emphasizes the importance of additional methods of calculating the Post-Pleistocene time interval.

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[1] Swinnerton, A. C. Science, New Ser., Vol. LXII, No. 1616, Dec. 18, 1925, p. 566.

"At Yellow Springs, Ohio, there is located a chalybeate spring which has built at its point of issuance in the Cedarville (Niagaran) limestone a large mound of ferriferous travertine which extends some hundred yards into the Yellow Springs Creek valley. The valley lies nearly north and south and is located within the most extended moraines of the Wisconsin glaciation; not, however, within the terminal moraines of the last Wisconsin invasion. The ice moved from a northwesterly direction; the deposit is located on the east side of the valley—hence, it is reasonable to suppose that any preglacial deposit would have been removed by ice abrasion. The erosion by the enlarged streams from the melting ice, one of which occupied the valley, undoubtedly aided in eliminating previous and contemporaneous travertine deposits.

"Theoretically, the volume of the present deposit divided by the rate of accumulation should yield the length of time of accumulation as a quotient. The method, as will be readily recognized, involves several complex factors, chief of which are variations in spring flow and in amount of solid material deposited, each influenced in turn by rainfall, temperature and variations in the subsurface spring channels.

"Accurate observations extended over a considerable period of rainfall, spring flow, air and water temperatures, together with studies of the differences in quantity of solids in solution at different points within the area of deposition, should provide a basis for a reasonable estimate of the present rate of deposition. A careful collection of the encrusted vegetation should provide an index of climatic variation, which in turn influenced the rate of deposition in the past.

"A detailed instrumental survey of the bedrock structure has already revealed the presence of a small flexure, or possibly a fault, which undoubtedly explains the location of the spring and leads also to the conclusion that the spring has been relatively permanent.

"The first estimates of the age of the Yellow Spring travertine mound must be regarded as purely tentative. The figures obtained, namely 20,000 to 30,000 years, are intermediate between those given by Taylor and DeGeer. Since trustworthy results of the study of the spring deposit must await the passing of some months, and possibly years, of observation it seemed worth while to publish this method of estimating post-glacial time. It is undoubtedly applicable to many similar travertine deposits. The study of a number of them, in various situations relative to morainal deposits, should contribute materially to the knowledge of the length of the Recent epoch."

DISTRIBUTION OF MANGANESE ORES

GEAUGA COUNTY

In Ohio manganese deposits may be expected in the bogs and swamps of glacial origin. Such deposits in commercial quantities have been found in one place in the State, that in Geauga County. Read's report follows:[1]

"The most interesting surface deposit is found on the farm of John R. Smith, Lot 4, Auburn Township. It is a deposit of black oxyd of manganese, or 'wad', of sufficient purity and in sufficient quantity to be dug and shipped with profit. It covers from three to four acres of swampy ground, fed by copious springs, which bring in, in solution, manganese, iron and lime, and deposits in different parts of the swamp, bog manganese, bog iron ore, and bog limestone or travertine—the latter being found in places from 1 foot 6 inches to 2 feet in thickness; and all in comparative purity. The manganese is, in places, 4 feet 6 inches thick, covered with 1 foot to 1 foot 3 inches of earth, and sells readily for from seven to thirty dollars per ton, according to purity. The process of deposit is going on constantly, and with a good degree of rapidity in the summer months, so that parts of the swamp which have once been stripped fill up anew, and can be reworked after a few years. According to Mr. Smith's observations, the average rate of deposit is a fraction over 2 inches per year. In the neighborhood of this swamp are many small deposits of impure yellow ochre, some of which may prove of value. Prof. Newberry supplies the following formulae of the chemical composition of the best specimens of this manganese:

"No. 1. Air dried	
Oxyd manganese, (MnO_2)	61.85
Silica, alumina and iron, (SiO_2, Al_2O_3, Fe_2O_3)	23.60
Water, (H_2O)	14.55
	100.00
"No. 2. Dried at 250° F.	
Oxyd manganese, (MnO_2)	72.38
Silica, alumina and iron, (SiO_2, Al_2O_3, Fe_2O_3)	23.60
Water, (H_2O)	4.02
	100.00"

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[1] Read, M. C., Geol. Survey Ohio, Report of 1870, p. 470.

DISTRIBUTION AND COMPOSITION OF BOG ORE

In general the bog ores may be expected in any swamp area in the State and especially in those within the boundaries of the Wisconsin drift. Formerly they were used for iron smelting in Ashtabula, Lake, Cuyahoga, Lorain, and Erie counties and have been reported in Crawford, Seneca, Morrow, Wood, and Putnam counties. Undoubtedly many other deposits are present.

ASHTABULA COUNTY

Bog ore constituted the ferruginous part of the burden for Ohio Furnace located near Clark Corners on the Conneaut Creek three miles southeast of Conneaut. The ore was gathered on the Lake Plain near Conneaut. Ohio Furnace was built in 1830 and went out of blast in 1845.

The conditions in Ashtabula County are given by Dachnowski[1] as follows: "By far the greater portion of this county is a broad level plain of stiff clay. The old 'lake ridges' and terraces are well defined in the northern portion of the county. Where exposed by railroad cuts, remains of old swamps can be seen containing fragments of coniferous wood and in places deposits of bog iron. Winds gradually carried beach sand over the crest of the ridge into the swamp basin, burying it in time to a depth of about six feet."

LAKE COUNTY

Lake County was especially rich in bog ore as it supplied six charcoal furnaces, some for many years. The Arcole furnaces, located on the North Ridge east of North Madison, were built in 1825 and operated nearly continuously until 1850. The bog ore used there was found in the swampy lands to the south of the North Ridge. The ore, a true limonite, was mined by pick and shovel and was cleaned of adhering clay by washing. The ore yielded 28 per cent metal in the furnace and was so balanced in phosphorus and manganese that it gave a soft gray foundry iron of excellent quality.

A sample of bog ore was taken July 23, 1940, by L. E. Swick from the Adams farm located one mile south of Madison in the northeast corner of the road forks. The sample was found at the surface near depressions formerly worked for bog ore. The farmers near by frequently strike the ore with their plows and in some cases throw the ore to one side of the field. The composition of this sample follows. Analyst, Downs Schaaf.

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[1] Geol. Survey Ohio, 4th Ser., Bull. 16, p. 83, 1912.

Silica, SiO_2	28.82
Alumina, Al_2O_3	10.75
Ferric oxide, Fe_2O_3*	31.64
Pyrite, FeS_2	0.19
Magnesium oxide, MgO	0.34
Calcium oxide, CaO	0.48
Sodium oxide, Na_2O	0.36
Potassium oxide, K_2O	1.01
Water, hydroscopic, H_2O-	11.25
Water, combined, H_2O+	6.35
Carbon dioxide, CO_2	2.55
Titanic oxide, TiO_2	0.50
Zirconium oxide, ZrO_2	$\angle$0.01
Phosphorus pentoxide, P_2O_5	2.84
Sulphur trioxide, SO_3	0.10
Manganous oxide, MnO	3.04
Carbon, organic, C	0.06
Total	100.28

*All Fe calculated to Fe_2O_3, since the organic matter precludes an accurate FeO determination.

The mineral components, as determined by calculation (Stout) from the analysis, are approximately as follows:

Sericite $(K, Na)_2O.3Al_2O_3.6SiO_2.2H_2O$	13.01
Kaolinite, $Al_2O_3.2SiO_2.2H_2O$	14.38
Quartz or free silica, SiO_2	16.16
Limonite, $2Fe_2O_3.3H_2O$	17.13
Hematite, Fe_2O_3	13.80
Pyrite, FeS_2	0.19
Rutile, TiO_2	0.50
Phosphosiderite, $Fe_2O_3.P_2O_5.3\frac{1}{2}H_2O$	7.29
Anhydrite, $CaO.SO_3$	0.17
Dolomite, $MgO.CO_2$ 0.71	
$CaO.CO_2$ 0.73	1.44
Rhodocrosite, $MnO.CO_2$	4.93
Water, hydroscopic, H_2O-	11.25
Hydrocarbons, C_nH_{2n+2}	0.06
Unbalanced parts (excess $H_2O.CO_2$)	−0.03
Total	100.28

The metals for recovery through smelting are as follows:

Fe, iron	22.13
Mn, manganese	2.35
P, phosphorus	1.24
	25.72

A sample of bog ore was also taken from an old working on land of Charles Lexso, west of the Madison-Thompson road, one and two-fifths miles south of Madison, three-fourths of a mile north of the Grand River in Madison Township, Lake County. The sample was secured by L. E. Swick, July 23, 1940. The composition is as given below. Analyst, Downs Schaaf.

Silica, SiO_2	25.50
Alumina, Al_2O_3	11.65
Ferric oxide, Fe_2O_3*	31.03
Pyrite, FeS_2	0.17
Magnesium oxide, MgO	0.27
Calcium oxide, CaO	0.38
Sodium oxide, Na_2O	0.32
Potassium oxide, K_2O	0.95
Water, hydroscopic, H_2O-	13.03
Water, combined, H_2O+	5.05
Carbon dioxide, CO_2	3.48
Titanic oxide, TiO_2	0.54
Zirconium oxide, ZrO_2	∠0.01
Phosphorus pentoxide, P_2O_5	3.17
Sulphur trioxide, SO_3	0.09
Manganous oxide, MnO	4.65
Carbon, organic, C	0.07
Total	100.35

*All Fe calculated to Fe_2O_3, since the organic matter precludes an accurate FeO determination.

The mineral components, as determined by calculation (Stout) from the analysis, are approximately as given below:

Sericite, $(K, Na)_2O.3Al_2O_3.6SiO_2.2H_2O$	11.99
Kaolinite, $Al_2O_3.2SiO_2.2H_2O$	17.68
Quartz or free silica, SiO_2	11.77
Limonite, $2Fe_2O_3.3H_2O$	4.28
Hematite, Fe_2O_3	23.70
Pyrite, FeS_2	0.17
Rutile, TiO_2	0.54
Phosphosiderite, $Fe_2O_3.P_2O_5.3\frac{1}{2}H_2O$	8.14
Anhydrite, $CaO.SO_3$	0.15
Dolomite, $MgO.CO_2$ 0.56	
$CaO.CO_2$ 0.57	1.13
Siderite, $FeO.CO_2$	0.16
Rhodocrosite, $MnO.CO_2$	7.53
Water, hydroscopic, H_2O-	13.03
Hydrocarbons, C_nH_{2n+2}	0.07
Unbalanced parts (lacking CO_2, H_2O, O_2)	+0.01
Total	100.35

The metals for recovery through smelting are as follows:

Fe, iron	21.70
Mn, manganese	3.60
P, phosphorus	1.39
	26.69

Geauga Furnace, located on the Grand River just east of Painesville in Lake County, was placed in blast in 1825 and ran with much success until 1866. Ore in abundance was gathered mainly on the Lake Plain a few miles east of the works. Such material occurred in the marsh lands along both the North Ridge and the South Ridge between Painesville and Madison and North Madison. As the normal yield of metal from the furnace was from 800 to 1,000 tons annually, the ore requirement was not far from 3,000 tons.

Railroad Furnace, located two miles south of Perry in Lake County, was erected in 1825 and went out of blast in 1833. The ore supply came from the vicinity of Perry. Another of these old charcoal furnaces operated by water power and supplied with bog ore was Concord, located on Big Creek about one mile north of Concord. Its period of activity extended from 1825 to 1835 when destroyed by fire. Bog ore was used entirely. The supply was gathered along the North Ridge and the South Ridge on the Lake Plain in the region around Painesville. It was soft, spongy limonite carrying naturally about 30 per cent iron. Clyde Furnace, located in eastern Madison Township, Lake County, operated only from 1832 to 1835. Its supply of bog ore was gathered in the swamps and marshes along the old Lake beaches south of Geneva.

CUYAHOGA COUNTY

In Cuyahoga County two charcoal furnaces were supplied with bog ore for the ferruginous part of the burden. The most noted of these was Dover Furnace located at Dover and operated nearly continuously from 1832 to 1859. Bog ore was obtained at different places on the north side of the Middle Ridge between Rocky River and Elyria. Middleburgh Furnace was placed on the East Branch of Rocky River just north of Berea and ran somewhat spasmodically from 1835 to 1850. Some bog ore of good quality was obtained from the marshy areas along Abram Creek one to two miles east of the stack. The supply of this, however, was not large.

LORAIN COUNTY

The pioneer furnaces of Lorain County used either completely or partially bog ore for smelting foundry iron. Lorain Furnace, built in 1832 and operating until 1841, at the falls at Elyria, used bog ore gathered in that vicinity. The material was a soft, spongy limonite and gave a metal of good quality for castings. Charleston Furnace at Lorain, active from 1860 to 1871, used some bog ore for a few years.

Vermilion Furnace, located two and one-half miles south of Vermilion and still evident from remnants of the old stack, used bog ore mainly throughout its period of activity from 1834 to 1855. The ore used came from the Scott farm near by and from other deposits found along the old Lake ridges. The ore was a limonite of good quality but the lenses were usually small.

Bog ores thus played an important part in iron making in pioneer days in northern Ohio. The combined period of blast of the twelve stacks was 205 years. Considering that they used 3,000 tons of ore annually, the estimate given for the early furnaces, the total tonnage of ore smelted would be 615,000 tons. Under any estimate they smelted a large volume of ore; and what makes it more important, most of the metal was cast directly into ware thus producing the highest market price. Such ware was sold locally and also was marketed by boat in the settlements along the Lake front.

FULTON COUNTY

In the report on Fulton County by Gilbert, bog ore is listed in the economic products.[1] "Bog iron ore has been found in marshes, upon the borders of the sand areas, and probably exists in considerable beds, to be discovered in the progress of the reclamation of the marshes by deep ditching." Again he states for Lucas County:[2] "Bog iron ore, in small amount, is found in nearly every depression of the sand district, and the existence of extensive accumulations in the larger marshes is highly probable."

SENECA COUNTY

In the geology of Seneca County Winchell[3] makes comments on the quality of bog ore and on its distribution in the area as follows:

"Before the development of the Lake Superior and Missouri iron mines, one of the principal sources of iron in the northwest was the bog ore deposits which are scattered over much of the country. In northwestern Ohio the numerous furnaces which were employed on these deposits along the south shore of Lake Erie, and in the counties farther south and west, rendered bog ore an important item of mineral wealth. It produces an iron known as **cold short,** owing to the presence of phosphorus, which cannot be used for wire or for sheet iron, but is valuable for castings. On the contrary, iron from the ores which contain sulphur as an im-

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[1] Gilbert, G. K., Geol. Survey Ohio, Vol I, p. 571, 1873.

[2] Idem., pp. 582-3.

[3] Winchell, N. H., Geol. Survey Ohio, Vol. I, p. 624, 1873.

purity, or silicon, is friable or brittle while hot and is distinguished as **red short.** When these two qualities occur in close proximity, or in circumstances favorable for transportation, they may be mixed in the process of smelting, and the resulting iron is greatly improved. The Lake Superior ores, which are the only ones smelted in the furnaces of northwestern Ohio, are nearly or quite free from sulphur, and hence at the present time (1873) the bog ores possess but little commercial value. It will be only in connection with the sulphur ores of the Coal Measures, in the southeastern part of the State, that the bog ore can be made of any mineral value.

"In Seneca County bog ore occurs in a number of places. It is usually not in quantities sufficient to invite expenditure of capital, and, in the absence of abundant fuel, it will probably never be of any economical value. It was met with on the farm of William B. Stanley, about two miles southeast of Tiffin, where it underlies a peat bog covering irregularly perhaps fifteen or twenty acres.

"It also occurs on the land of Mr. Foght, S. E. ¼ Section 27, Seneca Township. It has been taken out here in large blocks, roughly cut while wet, and set up for back walls in rude fire-places. On being exposed to the air, or especially to fire, it becomes cemented and very hard. There is also a deposit in Section 11, Clinton Township, exactly on the south line of the Seneca Indian Reservation."

Bog iron ore is mentioned as occurring in irregular patches one and one-half miles south of Tiffin in Section 31, Hopewell Township, Seneca County.[1]

WILLIAMS COUNTY

Williams County contains much swamp land with a variety of deposits. "Shell marl is found mingled in all proportions with clay but it occurs only in small quantities. It is said that beds of bog iron-ore have been found interstratified with the marl."[2]

WOOD COUNTY

In the reports of the Geological Survey of Ohio the first mention of bog iron ore is by C. Briggs, Jr., in the report of 1838 where he states:[3] "Bog Iron Ore—No bog ore was discovered in this county though diligent search was made in places where it was likely to occur. Small quantities, however, are said to have been found a mile or two from Gilead, at a locality which was not examined."

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[1] Geol. Survey Ohio, 4th Ser., Bull. 16, p. 114, 1912.

[2] Idem., p. 134.

[3] Geol. Survey Ohio, Second Annual Report, 1838, pp. 117, 118.

LUCAS COUNTY

Briggs in the examination of Lucas County states:[1]

"It may here be stated that this ore is said to occur in large quantities in Lucas County, four or five miles west of Maumee City. From a very slight examination of this locality, and the information derived from gentlemen who had visited it, I am inclined to believe that it is worthy of a careful examination. Some of the ore was shown me by Mr. Sloane, Auditor of Wood County; and it appears to be of a good quality."

Dachnowski records in Lucas County:[2] "North of Holland in Springfield Township, about one-half mile from the Indiana and Western Electric Road, is an extensive series of swampy depressions, locally known as the old iron ore-bed swamps."

CRAWFORD COUNTY

C. Briggs, Jr., also describes the bog ore of Crawford County:[3] "Bog-iron ore may be regarded as alluvium, as it is now forming in many places. It is deposited from the surface waters and springs, in which it is held in solution, by means of carbonic acid. As the excess of acid escapes, the iron is deposited, generally in the form of a yellowish or orange-colored sediment. The principal sources from which the ferruginous matter is derived are from yellowish and reddish soils, which always contain iron, and from the decomposition of pyrites, which in some of our rock formations —particularly the shale—occurs in great abundance.

"A few deposits formed in this way were observed in Crawford County. It is not improbable that quantities may be found sufficient to justify the erection of iron works. As this region, however, is destitute of coal, and a portion made up of open prairie, the scarcity of fuel would be a serious drawback to such an undertaking.

"**Localities.**—Bog ore occurs on the land of Peter Long, southwest quarter of Section 3, Sandusky Township. Here it is intermixed with sand and pebbles; but portions of it are sufficiently free from these ingredients to answer for smelting. This bed occurs at the outlet of a kind of marsh known as a 'cat swamp.' It has been quarried and used for the back walls of chimneys. I had no means of ascertaining its extent.

"On the northwest quarter of the same section, according to Mr. Long, another bed, presenting similar characteristics, is found.

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[1] Geol. Survey Ohio, Second Annual Report, 1838, pp. 117, 118.

[2] Geol. Survey Ohio, 4th Ser., Bull. 16, p. 94, 1912.

[3] Geol. Survey Ohio, Second Annual Report, 1838, pp. 124-125.

"On the left bank of the Sandusky, about one mile southeast of McCutchensville, bog ore is found of good quality: specimens were procured from masses weighing two or three hundred weight. There are several other localities in this vicinity.

"On the southeast part of the Indian Reservation, on the land of Charles Garret, bog ore was found under a bed of peat: it is of a good quality, and about one foot thick, occupying, apparently, an area of several acres. It is also found in the townships of Sycamore, Lykins, and Chatfield. From these indications, we think that sufficient ore might be found to supply furnaces."

MORROW COUNTY

Some bog ore is also present in the swamps of Morrow County as reported by Winchell.[1] He states: "Several deposits of bog ore were met with in the survey of the county. It occurs on land of Samuel Elder, S. E. ¼ Section 24, Washington Township, and on that of James Thomas, in the same section. The hydrated peroxide which constitutes the ore in most bog deposits here seems to be associated with a considerable spathic iron ore, or carbonate of iron . . . Other deposits of bog ore were seen in the eastern part of the county. One is in Section 5, Franklin Township, land of Calvin Blair and of John Blair."

PUTNAM COUNTY

According to the same authority,[2] "bog ore was encountered in a number of places in Putnam County as follows: Section 16, Liberty Township, land of Adam Hammond; a small deposit so far as known. It is said also to occur about a mile north of Leipsic Station; also on Section 26, Liberty Township. On Section 8, Perry Township, land of E. Demick and Joseph Wollam, there are many indications of a deposit of bog ore. It occurs on Section 16, Sugar Creek Township, land of Cadwallader Jones."

RICHLAND COUNTY

Read's report on Richland County includes the following:[3] "The rocks of Richland County include a few deposits of iron ore, generally of little value, and the surface accumulations of this mineral are rare. In Plymouth Township, on a small stream near the center and west of the railroad, is quite an extensive bed of hydrated oxide of iron, (bog ore) containing large masses of cal-

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[1] Winchell, N. H., Geol. Survey Ohio, Vol. II, p. 270, 1874.

[2] Geol. Survey Ohio, Vol. II, p. 394.

[3] Read, M. C., Geol. Survey Ohio, Vol. III, pp. 315-316, 1878.

careous tufa. No spring of water is apparent which could deposit these minerals, and they probably indicate the bed of an old shallow swamp, now five or six feet above the present channel of the adjacent stream. The stratum is from two to three feet in thickness, but not of sufficient extent to be of any great value."

KNOX COUNTY

Local deposits of bog ore are present in parts of Knox County. In Hilliar Township west and north of Centerburg, bog and tufa ores were used by the settlers for chimneys to their cabins and for fireplaces in sugar camps. Marl, peat, and bog ore are present in the swampy areas.

A sample of bog ore was taken August 22, 1940, by Fred J. Marriott from the Lorin Reynolds farm located one mile southwest of Rich Hill, two and one-half miles west of Centerburg, in west central Hilliar Township, Knox County.

The composition of this ore is as follows. Analyst, Downs Schaaf.

Silica, SiO_2	46.74
Alumina, Al_2O_3	13.15
Ferric oxide, Fe_2O_3*	15.82
Pyrite, FeS_2	0.05
Magnesium oxide, MgO	0.43
Calcium oxide, CaO	1.17
Sodium oxide, Na_2O	0.54
Potassium oxide, K_2O	1.65
Water, hydroscopic, H_2O-	7.40
Water, combined, H_2O+	4.50
Carbon dioxide, CO_2	2.01
Titanic oxide, TiO_2	0.65
Zirconium oxide, ZrO_2	∠0.01
Phosphorus pentoxide, P_2O_5	2.05
Sulphur trioxide, SO_3	0.03
Manganous oxide, MnO	3.88
Carbon, organic, C	0.08
Total	100.15

*All Fe calculated to Fe_2O_3 since the organic matter precludes an accurate FeO determination.

The mineral components, as determined by calculation (Stout) from the above analysis, are as follows:

Sericite, $(K,Na)_2O.3Al_2O_3.6SiO_2.2H_2O$	28.54
Kaolinite, $Al_2O_3.2SiO_2.2H_2O$	4.71
Quartz or free silica, SiO_2	31.25
Limonite, $2Fe_2O_3.3H_2O$	14.03
Hematite, Fe_2O_3	2.61

Pyrite, FeS_2	0.05
Rutile, TiO_2	0.65
Apatite, $3CaO.P_2O_5$	2.12
Phosphosiderite, $Fe_2O_3.P_2O_5.3\frac{1}{2}H_2O$	2.77
Anhydrite, $CaO.SO_3$	0.05
Rhodochrosite, $MnO.CO_2$	5.25
Pyrolusite, MnO_2	0.78
Water, hydroscopic, H_2O-	7.40
Hydrocarbons, C_nH_{2n+2}	0.08
Unbalanced parts (excess O_2)	−0.14
Total	100.15

The metals that may be produced on smelting are as follows:

Fe, iron	11.06
Mn, manganese	3.00
P, phosphorus	0.90
	14.96

CLERMONT COUNTY

In Orton's discussion of Clermont County the following comments are made:[1]

"The general elements of the upland drift of Clermont County are the following, named in descending order:

4. **Surface clays**—generally white, sometimes blackened by swampy conditions, entirely free from gravel, from 1 to 8 feet in thickness.

3. **Yellow clays**—abounding with gravel, with occasional boulders, often constituting the surface instead of No. 4. Thickness seldom exceeds 10 feet.

2. (a) **Forest soil**—a stratum of carbonaceous clay, containing vegetable matter, as leaves and wood, with occasional beds of peat, and in some districts replaced by (b) **Bog iron ore bed**—a seam of ochreous clays that pass into true ores, yielding over 40 per cent of metallic iron. The last division ranges from 1 to 2½ feet in thickness, the former sometimes rises as high as 8 feet. Both divisions are sometimes absent.

1. **Blue boulder clay**, or hard-pan, with occasional layers of sand intercalated, resting upon the rocky floor of the county.

"The seam of ochre and bog ore which replaces the buried soil in a portion of the county, seems to have thus far escaped attention. It is found, as has been said, through all of the flat-lying region that begins in the eastern townships of Clermont and stretches through Brown to the middle of Highland County. It

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[1] Orton, Edward, Geol. Survey, Ohio, Vol. 1, pp. 440, 443, 444, 1873.

consists of ochreous clay holding 10-15 per cent of iron, that passes into a heavy bog ore which yields over 40 per cent of metallic iron. The thickness of the stratum is generally 2-2½ feet. It is covered by 6-8 feet of whitish clays, and is shown in all the slopes of the shallow valleys that are found here. A specimen taken from the farm of Samuel Moorhead, Jackson Township, yields the following results (Wormley):

Specific gravity	2.735
Water, combined, H_2O	11.00
Silicic acid, SiO_2	22.40
Iron sesquioxide, Fe_2O_3	59.60
Alumina, Al_2O_3	3.20
Manganese, MnO_2	1.60
Lime, phosphate, $3CaO.P_2O_5$	0.26
Lime, carbonate, $CaO.CO_2$	0.48
Magnesia, MgO	trace
Sulphur, S	0.00
Total	98.54
Metallic iron, Fe	41.72
Phosphoric acid, P_2O_5	0.12

"This, it will be seen, constitutes an iron ore of average quality. The sample analyzed represents a considerable amount of the formation. Specimens can be found, exceptionally rich, that would doubtless yield a somewhat larger percentage of iron. It has not yet been ascertained just how large a proportion of ore the two feet of the deposit would yield, but the limits will probably be found between 10 and 20 per cent. The iron mines of Clermont County, like its gold mines, seem therefore likely to possess more scientific than economical interest . . . . The iron ore was accumulated where we find it, in the interval of depression that followed the Glacial Epoch, when the area to which it now belongs was a stagnant marsh or shallow lake. Microscopic plants were doubtless the agents by which the iron was extracted from the waters that held it in solution. After its deposition it suffered molecular change and consolidation to considerable extent. It is easy to see that all this involves a long history."

DISTRIBUTION AND COMPOSITION OF FERRUGINOUS TUFA OR TRAVERTINE

Ferruginous tufa or ferruginous travertine is widely distributed in Ohio but usually the quantity is not large. It may occur near the discharge of almost any chalybeate or iron bearing spring. The composition is of interest.

CHAMPAIGN COUNTY

The deposits from soluble materials held in solution in the ground waters in the Ohio Caverns, located in the northeastern part of Salem Township, Champaign County, include stalactites and stalagmites of calcium carbonate but also stalactites and irregular masses of ferruginous tufa. The latter material is precipitated through concentration of the water through evaporation and by the formation of the insoluble iron salts, largely limonite, through oxidation and hydration. A representative sample of the ferruginous tufa was taken by Mr. I. E. Smith, of Ohio Caverns. The analysis follows. Analyst, Downs Schaaf.

Silica, SiO_2	13.30
Alumina, Al_2O_3	1.72
Ferric oxide, Fe_2O_3	43.34
Ferrous oxide, FeO	0.12
Pyrite, FeS_2	∠0.01
Magnesium oxide, MgO	0.50
Calcium oxide, CaO	3.40
Strontium oxide, SrO	∠0.01
Barium oxide, BaO	∠0.01
Sodium oxide, Na_2O	∠0.01
Potassium oxide, K_2O	∠0.01
Water, hydroscopic, H_2O-	20.80
Water, combined, H_2O+	2.41
Carbon dioxide, CO_2	7.40
Titanic oxide, TiO_2	0.08
Phosphorus pentoxide, P_2O_5	0.16
Sulphur trioxide, SO_3	∠0.01
Manganous oxide, MnO	6.59
Carbon, organic, C	∠0.01
Total	99.82

The mineral components in the ferruginous tufa from Ohio Caverns, as determined by calculation (Stout) from the analysis, are as given below:

Sericite, $(K, Na)_2O.3Al_2O_3.6SiO_2.2H_2O$				0.00
Kaolinite, $Al_2O_3.2SiO_2.2H_2O$				4.36
Quartz or free silica, SiO_2				11.27
Limonite, $2Fe_2O_3.3H_2O$				12.44
Hematite, Fe_2O_3				32.70
Pyrite, FeS_2				0.00
Rutile, TiO_2				0.08
Apatite, $3CaO.P_2O_5$				0.35
Anhydrite, $CaO.SO_3$				0.00
Tufa	Main components	$MgO.CO_2$	1.04	
		$CaO.CO_2$	5.73	
				6.77
	Parts in solid solution	$FeO.CO_2$	0.19	
		$MnO.CO_2$	10.68	
				10.87
Water, hydroscopic, H_2O-				20.80
Hydrocarbons, C_nH_{2n+2}				0.00
Unbalanced parts (lacking CO_2, H_2O)				+0.18
Total				99.82

DELAWARE COUNTY

In many places in Ohio small amounts of iron tufa or ferruginous travertine have been deposited by chalybeate springs. If oxidized the ore is yellowish to reddish brown in color and is largely limonite in character. Its purity depends on many factors, such as other ingredients precipitated with the iron oxide, sand and silt and incorporated wash and peaty matter from plant growth.

A sample of iron tufa or ferruginous travertine was secured by Fred J. Marriott, August 22, 1940, from the E. O. Satterfield property located three and one-half miles east of Olive Green, three and one-fourth miles west of Centerburg, in the east central part of Porter Township, Delaware County. The composition of this travertine is given below. Analyst, Downs Schaaf.

Silica, SiO_2	43.23
Alumina, Al_2O_3	5.40
Ferric oxide, Fe_2O_3	30.82
Ferrous oxide, FeO	0.28
Pyrite, FeS_2	0.03
Magnesium oxide, MgO	1.60
Calcium oxide, CaO	2.68
Sodium oxide, Na_2O	0.11
Potassium oxide, K_2O	0.35
Water, hydroscopic, H_2O-	2.96
Water, combined, H_2O+	7.92
Carbon dioxide, CO_2	3.88

Titanic oxide, TiO_2	0.33
Zirconium oxide, ZrO_2	∠0.01
Phosphorus pentoxide, P_2O_5	0.19
Sulphur trioxide, SO_3	0.02
Manganous oxide, MnO	0.15
Carbon, organic, C	0.06
Total	100.01

The mineral components in the precipitated ferruginous tufa, as determined by calculation (Stout) from the analysis, are as given below:

Sericite, $(K, Na)_2O.3Al_2O_3, 6SiO_2.2H_2O$				4.32
Kaolinite, $Al_2O_3, 2SiO_2.2H_2O$				9.41
Silica gel., $SiO_2. XH_2O$ (7 per cent water)				18.19
Quartz or free silica, SiO_2				19.87
Limonite, $2Fe_2O_3.3H_2O$				36.04
Pyrite, FeS_2				0.03
Rutile, TiO_2				0.33
Apatite, $3CaO.P_2O_5$				0.41
Anhydrite, $CaO.SO_3$				0.03
Dolomite	Main components	$MgO.CO_2$	3.34	
		$CaO.CO_2$	4.37	
				7.71
	Parts in solid solution	$FeO.CO_2$	0.45	
		$MnO.CO_2$	0.24	
				0.69
Water, hydroscopic, H_2O-				2.96
Hydrocarbons, C_nH_{2n+2}				0.06
Unbalanced parts (excess $CO_2.H_2O$)				−0.04
Total				100.01

The metals that may be produced by smelting are as follows:

Fe, iron	21.56
Mn, manganese	0.12
P, phosphorus	0.08
	21.76